AbstractID: 13085 Title: Quantitative PET imaging of heterogeneous tumors: The dosimetric effect of patient motion on image-based dose painting plans.

Purpose:
Dose-painting requires accurate quantification of tumor characteristics and precise localization of molecular targets within tumors. Imaging with PET provides surrogate markers of molecular activity within sub-tumor volumes; however, quantification is limited by many physical factors, including patient motion during image-acquisition. We have evaluated the dosimetric impact of neglecting respiration-motion management during PET image-acquisition.

Methods and Materials:
PET/CT images were used to generate dose-painting plans of 60Gy base-dose to the entire tumor volume (PTV) and 10Gy boost-dose redistributed within sub-regions of elevated metabolic activity. Spatial distributions of metabolic activity were derived from: (1) heterogeneous phantoms with variable amplitudes of respiration-motion, and (2) respiration-gated and non-gated [^{18}F]FDG PET images of lung-cancer patients.
For each phantom and patient, a reference plan was generated from PET image where minimal motion occurred. For lung patients, these reference plans corresponded to respiration-gated PET of the end-exhalation phase. “Motion-blurred” dose-painting plans were generated from non-gated PET images; however, the PTV contour, boost volume, and integral dose were kept constant.

Results:
Phantom studies characterized the relationship between dosimetric errors and amplitude of motion. For typical respiration-motion (2cm superior-inferior, 1cm anterior-posterior) 10% of PTV voxels showed dose errors exceeding 3Gy (30% of boost-dose). Errors were reduced below 3Gy, when motion amplitude was 1cm or less. For lung-cancer patients, the use of motion-blurred images resulted in dosimetric errors (exceeding 3Gy) within 5% of PTV voxels. Additionally, dose differences up to ±10Gy were observed.

Conclusion:
Respiration-motion during PET acquisition resulted in dosimetric errors throughout PTV for dose-painting plans in phantoms and lung-cancer patients. Magnitudes of these errors were correlated to the amplitude of residual motion within PET images. Motion-management techniques (e.g. gated acquisition, 4D-PET) are necessary to reduce uncertainty in defining heterogeneous dose-distributions and improve efficacy of image-based dose-painting.