Purpose: The potential role of four-dimensional (4D) positron emission tomography (PET)/computed tomography (CT) in defining the internal target volume (ITV), relative to the standard three-dimensional (3D) PET/CT, was examined.

Methods: Eleven patients with respiratory-induced tumor motion (8 lung, 2 liver, and 1 pancreas) were imaged using 3D and 4D FDG [18F] Fluorodeoxyglucose PET/CT scans while in the radiation therapy treatment position. Both 3D and 4D PET ITV's were manually contoured by two expert radiation oncologists based on their clinical judgment. Similar window and level values were used for both 3D and 4D PET images to ensure consistency in ITV representation. For 4D PET, five breathing phases were used to contour the ITV that would encompass the full tumor motion. Student t-test was performed to determine significance in the 3D and 4D volume difference.

Results: Analysis of 11 patient tumors was conducted for calculation of 3D and 4D PET average volumes, standard deviation, percent difference, and t-test significance. 4D PET average volume values were consistently larger than 3D PET average volumes over all eleven patient cases for both radiation oncologists. Results of radiation oncologist #1 revealed: 4DVOL-AVG = 40.2 +/- 59.8 cc, 3DVOL-AVG = 32.5 +/- 55.5 cc with %DIFF = 32.4 +/- 30.9% and p < 0.05. Likewise, results of radiation oncologist #2 shows: 4DVOL-AVG = 48.1 +/- 66.1 cc, 3DVOL-AVG = 39.9 +/- 60.7 cc with %DIFF = 27.8 +/- 18.7% and p < 0.03. Both t-test results show statistical significance.

Conclusions: The use of 4D PET images may lessen the probability of tumor volume underestimation due to undetected tumor motion when using the 3D PET modality. With 4D PET, a more accurate ITV which includes breathing motion may result in improved radiation treatment delivery to the full, appropriate tumor volume, thus potentially improving treatment outcomes.