4D-PET for Abdominal Tumor Target Volume Generation

**Innovation/Impact:** The effect of 4D-PET on abdominal tumor radiotherapy planning has not been sufficiently explored. The advent of respiratory-correlated computed tomography in the early 2000s enabled the concept of the internal target volume (ITV) in lung cancer radiotherapy. The ITV concept improved tumor coverage and reduced normal tissue irradiation by replacing population-based motion margins with patient-specific margins based on each tumor’s actual motion. The ITV paradigm has not permeated radiotherapy planning for abdominal tumors, in part due to the fact that abdominal tumors are often difficult to visualize in 4D-CT images due to the similarity of tumor and normal-tissue densities. The purpose of this study is to quantify the effect of the use of 4D-PET on abdominal tumor target volume generation.

**Materials and Methods:** As part of a continuing IRB-approved protocol, four upper-abdominal radiotherapy patients underwent respiratory-correlated list-mode FDG-PET/CT (4D-PET/CT) on a Siemens Biograph 64 PET/CT scanner. The list-mode data was gated into 4-6 windows according to the amplitude of a respiratory surrogate (abdominal bellows), and reconstructed using Siemens proprietary reconstruction software in a clinical configuration. Tumors were contoured by a radiation oncologist who is a specialist in gastro-intestinal radiotherapy, using the end-inhale and end-exhale phases of 4D-PET. For comparison, the tumors were also contoured using un-gated PET. The two ITVs thus generated were compared to assess the impact of 4D-PET on radiotherapy planning.

**Results:** Of the four patients imaged in this study to date, two had tumors that were both FDG-avid and showed motion amplitudes of at least 5 mm on 4D-PET images. 4D and un-gated PET images of one of these tumors are shown below (Figure 1). Target volumes created from 4D-PET images were 28% and 21% larger than the un-gated PET volumes.

![END-EXHALE 4D PHASE](image1)
![END-INHALE 4D PHASE](image2)
![UNGATED PET](image3)

**Figure 1:** 4D and un-gated PET coronal images slices of a patient with a 3.5 cm diameter colorectal metastasis to the liver. 4D and un-gated target volumes are shown in red and blue lines, respectively.

**Conclusion:** Use of 4D-PET increases the size of target volumes compared to un-gated PET in a subset of upper-abdominal cancer patients. Direct measurement of tumor motion and deformation by 4D-PET imaging could allow the use of patient-specific margins rather than population-based margins, potentially leading to increased target coverage and reduced normal tissue irradiation.