

Purpose: To examine maximum intensity projections (MIPs) as a method for segmenting lung tumor internal target volumes (ITVs) in positron emission tomography (PET) images using two threshold-based methods, and to assess various parameters that potentially affect the accuracy of tumor segmentation by this technique.

Methods and Materials: An acrylic phantom setup, consisting of a 1.5cm diameter sphere filled with ¹¹C solution inside a cylindrical bath of 18-fluorodeoxyglucose solution, was used for a PET list-mode acquisition. The phantom was attached to a robotic arm that moved according to four patient breathing trajectories via an abdominal breathing bellows device. List-mode data was gated based on the breathing trajectories, and PET-MIPs were created from the reconstructed gated images. ITVs were calculated and compared for both un-gated PET images and PET-MIPs by using varying thresholds of absolute standardized uptake value (SUV) and percentage of maximum SUV. In addition, a simulation of PET-MIPs was performed to examine the effects of tumor size, image smoothing, and tumor trajectory on the accuracy of ITV measurement.

Results: For any given threshold value, PET-MIPs tended to produce larger ITVs than un-gated PET. For optimal percentage thresholds across all trajectories, PET-MIPs measured an ITV to within 5% accuracy in a larger SUV range with lower initial values than un-gated PET for the same accuracy. For both PET-MIP and un-gated PET, a percentage threshold method produced a smaller deviation from true ITV in similar SUV ranges when compared to an absolute threshold method. The PET-MIP simulation demonstrated greater accuracy of ITV measurement with increased image smoothing and sphere size. Breathing trajectories exhibiting baseline drift negatively impacted accurate ITV determination.

Conclusion: Threshold-based ITV segmentation is sensitive to lung tumor volume, trajectory, and SUV. PET-MIPs appear to be a promising tool in the accurate delineation of lung tumor ITV.