

Purpose: The objective of this study was to investigate the impact of tumor size and tracer uptake heterogeneity on the automatic delineation of 18F-FDG PET and CT tumor volumes (TV) in NSCLC.

Methods: 26 NSCLC patients with FDG PET/CT were considered. For 18 cases, the tumor maximum diameter was measured by macroscopic examination. Two observers performed manual delineation of the tumors on the CT images and of the PET uptakes using a fixed threshold (50% of the max), an adaptive threshold and the Fuzzy Locally Adaptive Bayesian (FLAB). Diameters of the delineated volumes were compared to the histopathology reference when available. Uptake heterogeneity was assessed using the coefficient of variation (std.dev/mean) within TV.

Results: High consensus was reached regarding manual delineation of the CT TV (<10% variability). All diameters measured on the delineated images correlated with histopathology ($r > 0.84$, $p < 0.0001$). However, various levels of accuracy were reached depending on the method: manual delineation on CT resulted in large overevaluation ($+30 \pm 40\%$), whereas all delineations on PET images resulted in underevaluation (from $-16 \pm 17\%$ for T50, to $-5 \pm 10\%$ for FLAB). CT-based TV were significantly ($p < 0.05$) larger than PET-based ones. No correlation was found between CT TV and differences between CT-based and PET-based TV. On the other hand, a significant correlation ($r = 0.5$, $p < 0.01$) was found between CT TV and the PET uptake heterogeneity, as well as between this heterogeneity and differences between FLAB and threshold-based delineations ($r > 0.7$, $p < 0.0002$).

Conclusions: 18F-FDG PET has the potential to provide specific tumor targeting for dose boosting/painting in NSCLC. However, threshold-based techniques that have been suggested for the auto contouring of the PET uptake should not be used for tumors above 2-3cm in size, as they fail to address heterogeneous uptakes that tend to occur in these larger volumes. More advanced automatic delineation tools are required in such cases.