Design and validation of a specific phantom for quality control of uptake measurements with PET

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Introduction

Standardized Uptake Values (SUV) are widely used in positron emission tomography (PET) to quantify [^{18}F]2-fluoro-2-deoxy-D-glucose (FDG) uptake. However, this index depends on many factors and its use is still a subject of debate [1].
It is fundamental to establish a regular quality control to ensure constancy of quantitative indices, even more if used in multicenter trials [2].

Material and Methods

To this aim, a specific phantom (Quali-TEP01) with cylinder-shaped inserts of different sizes (simulating tumors), was developed to be robust and easy to use. This phantom also contains a cylindrical ring to simulate a tumor with a necrotic center and its background is also fillable with activity to simulate uniform activity (e.g. liver).
The phantom sensitivity was studied through SUV and recovery coefficient (RC) measurements with an hybrid PET/CT (Discovery LS device, GEMS) [3]. Several data analysis methods using different definitions for the regions of interest (ROI) were used [4]. Data were reconstructed using clinical routine algorithms (2D/3D). We studied RC variation with cylinder size and relative uptake change (simulating treatment response) for different tumor-to-background activity ratios (TBR). Subsequently, the phantom was also tested with another scanner (Siemens 16 detector-row Biograph).

Results

For all data analysis methods, considerable variations of RC with cylinder (lesion) size was found (about 50%). Measurement methods based on isocontours (automatic-defined ROIs) showed a strong correlation ($R^2 \approx 0.98$). This phantom also allowed measuring a relative change in uptake, which turned out to be independent on the measurement method. Despite a calibration of PET/CT systems, quantification differences of about 20% remained between the two scanners studied.

Discussion

For all data analysis methods, the RC increased with cylinder-shaped insert diameter, due to the reduction of partial volume effects. RC also increased with isocontour values, and was not influenced by the weak background (compared to tumors). Spill-in effects were observed by the emergence of artefactual SUVs in cylinders containing no activity (“cold zones”). Moreover, the linear behaviour between SUVs suggested that, even if different methods were used in different institutes, the values could be compared between each other.
The results obtained, in agreement with other published results [4,5], show the interest of this phantom for following-up a specific installation for constancy of quantitative indices, or in multicenter trials.

References

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