Purpose:To develop and test the design of a new phantom, which is capable of producing experimental models of realistic activity distributions as observed in PET patients, for the evaluation of PET quantification accuracy and image segmentation algorithms.

Methods:A phantom is constructed from thin plastic foils, less than 0.1 mm thick, which are cut along computer generated contours derived from the activity distribution of a large tumor in a patient PET scan. These sheets are used to displace activity inside a rectangular non-uniform activity (NonU) cell (11.6 x 11.4 x 10.1 cm3), filled with a single activity solution of 18F-fluorodeoxyglucose (FDG), thus producing a non-uniform activity distribution with variable activity gradients within a single PET slice or across multiple slices. The NonU cell is centered in a larger cylinder containing background activity. Corrections for omitted or deformed plastic sheets and for trapped air bubbles are applied to recover the known reference activity distribution. The phantom is tested in three different PET/CT scanners and the obtained images are compared to the known reference activity for different slices.

Results:The resulting images retain the features of the selected region of interest of the original PET images of a patient tumor and agree well with the known activity distribution in the phantom. Differences between the known reference activity and the PET scan were found to be strongly dependent on registration and are less than 30% for more than 65% of the voxels for most of the tested slices.

Conclusions:Using the NonU phantom to produce images of known activity distributions derived from clinically realistic activity configurations will aid in more accurate testing of PET quantification accuracy and in the development of image reconstruction, artifact correction and image segmentation algorithms. Improvements of the phantom design based on the test results are suggested.