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Influence of tumor density on CT attenuation corrected PET:Phantom studies

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The use of external positron emitting sources or single photon emitting sources at energies similar to annihilation photons seems to give acceptable results permitting the quantification of PET data. The attenuation correction based on CT data generates artefacts around metallic prostheses, after use of contrast media and in the pulmonary region near calcifications and on dense lesions. In the present phantom study we investigated the density influence of simulated lesions on attenuation correction based on CT transmission data. A cylindrical phantom of 21 cm diameter and 20 cm height, with two compartments, was used. The lower one with cylinders of 4.0 to 10.0 mm to evaluate the resolution of the system and the upper one with 3 pairs of cylindrical vials of 2.6cm diameter and 4.5 cm height, positioned in a distance of 7 cm from the axis of the cylinder in a way to form an hexagon. The first pair of vials was completed with alcohol solution ($d=0.8$ g), the second one with water ($d=1.0$ g) and the third one with a KJ solution ($d=1.2$ g). The phantom's lower part was filled with water and the upper with water or polystyrene spheres plus water containing 18-FDG. In one vial of each pair equal activities of 18-FDG were added, giving a ratio of 3 with the environment water or water plus polystyrene. An initial acquisition by spiral CT was followed by one bed acquisition of emission and external source transmission data. After reconstruction by using filtered back projection for CT, iterative OSEM algorithms for PET and scaling and segmentation attenuation correction procedures, proposed by the constructors, we measured on transversal slices the activities of the 6 vials by drawing similar ROIs over the vials and one ROI in the centre of the slices to estimate the background activity. On non attenuation corrected (NAC) and CT attenuation corrected (CTAC) images the measured and corrected for attenuation activities are:

First tomograph NAC $d=0.8$: 571 counts $d=1.0$: 480 counts $d=1.2$: 430 counts
CTAC 4966 " 4853 " 7589 "

Second " NAC $d=0.8$: 850 counts $d=1.0$: 661 counts $d=1.2$: 574 counts
CTAC 7421 " 7167 " 18343 "

Third NAC $d=0.8$: 700 counts $d=1.0$: 620 counts $d=1.2$: 590 counts
CTAC 4900 " 3900 " 3300 "

In conclusion the activities on NAC images for all the 3 tomographs are inversely depended on the density of the liquids due to more intense absorption by the denser material. On CT attenuation corrected slices, in the two first tomographs, the estimated activity in denser material of specific activity 1.2g is much higher than the expected due to incorrect attenuation correction procedure. In the third tomograph the CTAC has not the same correctional effect.

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