Influence of detector parameters on lesion detectability for PET scanners with long axial FOV

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1. Objectives

The axial field-of-view (AFOV) of commercial PET scanners varies between 15 and 25 cm. However, increasing the AFOV improves the scanner sensitivity and enables new applications as whole-body dynamic imaging. We performed Monte-Carlo simulations of a 2 m long AFOV PET scanner to evaluate the influence of several scanner design parameters on lesion detectability.

2. Methods

The geometry was modeled in GATE as a cylindrical system with an inner diameter of 76 cm and an AFOV of 2 m. A cylindrical water phantom (D = 35, L = 60 cm) was filled with activity (1 kBq/ml) and placed at the axial center. It contained 90 spheres (d = 5 mm) with activity-uptake-ratio of 8:1. The variable design parameters were the transverse pixel size (2 and 4 mm), the time-of-flight (TOF) resolution (600, 400 and 200 ps) and the number of depth-of-interaction (DOI) layers (no, 2 and 4). The simulation data was reconstructed with listmode ML-EM. The non-prewhitening SNR was calculated to compare the lesion detectability of different designs. For one realistic design (4 mm, 400 ps and no DOI) we determined the SNR for maximum ring differences (MRD) of 100, 60 and 20 cm.

3. Results

The following design was taken as reference: 2 mm, 600 ps and no DOI. Improving the TOF resolution from 600 to 200 ps increases the SNR by 51.9 ± 5.9%. Four and 2 layer DOI result in increases of 46.4 ± 5.6% resp. 28.4 ± 5.2%. Changing the pixel size from 2 to 4 mm decreases the SNR by 9.7 ± 4.3%. Considering the influence of the MRD for the realistic design, we obtained the largest increase for an MRD of 60 cm (24.4 ± 5.2%).

4. Discussion and conclusions

It has already been shown that DOI correction plays a limited role in current whole-body PET scanners with an AFOV of ~20 cm. Our results show that the relative importance of this effect is larger for a 2 m long AFOV PET scanner and that it has a similar potential to improve lesion detectability as the TOF resolution. The best lesion detectability is obtained for an MRD of ~60 cm. Decreasing the MRD to 60 cm gives a comparable effect as the implementation of 2 layer DOI.

[1] Thoen Hendrik, Vincent Keereman, Pieter Mollet, Roel Van Holen, and Stefaan Vandenberghe. "Influence of detector pixel size, TOF resolution and DOI on image quality in MR-compatible whole-body PET." Physics in medicine and biology 58, no. 18 (2013): 6459.

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