Optimisation of BMI-based Images for Overweight and Obese Patients – Implications on Image Quality, Quantitative Accuracy and Radiation Dose in Whole Body 18F-FDG PET/CT Imaging.

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Abstract

Background - In PET/CT imaging the amount of ^{18}F -FDG activity injected to patient is mainly based on the patient body weight (BW) or on body mass index (BMI). Imaging overweight and obese patients using standard protocols results quite often in poor diagnostic images. The purpose of this study was to optimise BMI-based whole body ^{18}F -FDG PET images obtained from overweight and obese patients and assess the added value in terms of image quality, quantitative accuracy and radiation dose in comparison to BW-based images.

Methods - The NEMA-IEC-body phantom was scanned on the mCT 128 slices scanner (Siemens Healthineers). The spheres and background were filled with F-18 activity. Spheres-to-background (2.1kBq/mL) ratio was 4:1. Data was reconstructed using the OSEM-TOF-PSF routine reconstruction (2 iterations, 21 subsets, 3mm Gaussian filter). The optimisation was performed by varying number of iterations, number of subsets, filter's size and type and matrix size. The phantom images were assessed using contrast recovery coefficients (CRCs). The optimised reconstruction was applied to 17 overweight and obese patients. The optimised BMI-based images and BW-based images were compared visually and using signal-to-noise ratio (SNR), SUVmax and SUVpeak measurements.

Results - The visual assessment of the optimised phantom images using 1 iteration, 21 subsets, 3mm Hamming filter showed better image quality and CRC values compared to the routine reconstruction. On patient data, the optimised BMI-based images provided better image quality compared to BW-based images in 87.5% of the overweight cases and 66.7% for obese cases. Compared to BW-based images, the optimised BMI-based images resulted in reduction of 18.6% in SUVmax, 10.6% in SUVpeak and 59% in radiation dose for overweight patients. Similar trends were observed in obese patients. SNR improvement on BMI optimised images over BW images was 55% and 59% on overweight and obese patients, respectively.

Conclusions - The optimised BMI-based approach using 1 iteration, 21 subsets, 3mm Hamming filter improves image quality, reduces radiation dose and provides, at least, similar quantitative accuracy compared to the BW-based approach for both overweight and obese patients. These findings are compelling enough support to conducting a full assessment of the approach on a large patient population.

Full Text

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Figures

Figure 1

The optimisation algorithm proposed to obtain the optimal BMI-based images. Step 1: The number of iterations, number of subsets and filter type and size were given initial estimates. Step 2: After reconstruction, image quality (IQ) was assessed: if poor IQ, exclude and stop looping, if good IQ go to step 3. Step 3: Calculate CRCs for all spheres and compare them to the EANM values: if in line with the EANM limits, stop looping and assigned as an Optimal Reconstruction, if Not within EANM limits go to

step 4. Step 4: vary the number of iterations by 1 and reconstruct. Step 5: Vary the filter type and size then reconstruct. Step 6: vary the matrix size then reconstruct. The algorithm is an iterative process which runs until all parameters ranges are explored

Figure 2

Volumes of interest (VOIs) drawn on each sphere on the reconstructed PET images and 4 VOIs of the same size of each sphere were drawn in the background of the phantom

Figure 3

VOIs drawn on the liver (left) and on the mediastinum blood pool (right) for SUVmax and SUVpeak measurements

Figure 4

The routine and optimal reconstructions obtained using the optimisation algorithm in figure 1: (a) routine reconstruction, (b) OSEM-TOF-PSF (1 iteration, 21 subsets, 3mm Gaussian filter), (c) OSEM-TOF-PSF (1 iteration, 21 subsets, 3mm Hamming filter), and (d) OSEM-TOF-PSF (1 iteration, 21 subsets, 3mm Hann filter)

Figure 5

CRC values as a function of sphere size for the optimal reconstructions. 1i21s3mmG stands for: 1 iteration 21 subsets 3 mm Gaussian filter, 1i21s3HM stands for: 1 iteration 21 subsets 3 mm Hann filter, 1i21s3mmHM stands for: 1 iteration 21 subsets 3 mm Hamming filter, 2i21s3mmG stands for: 2 iteration 21 subsets 3 mm Gaussian filter

Figure 6

Percentage improvement in image quality with BMI optimal reconstruction compared to standard BW reconstruction. Only score 1 (BMI-images better than BW-images) and score 2 (BMI-images similar to BW-

images) are shown in this figure

Figure 7

Reconstructed images obtained with the standard BW recon (left column; OSEM-TOF-PSF: 2 iterations, 21 subsets, 3mm Gaussian filter and optimal BMI recon (right column; OSEM-TOF-PSF: 1 iteration, 21 subsets, 3mm Hamming filter). First row sagittal slices and second row axial slices; obtained from an overweight patient. Third row coronal slices and fourth row axial slices; obtained from an obese patient.

Figure 8

Mean percentage difference (MPD) between the BMI-based optimal reconstruction and the standard BW-based reconstruction calculated for SUVmax and SUVpeak. The “minus” sign reflects the reduction, and the “positive” sign indicates the increase of the measured values

Figure 9

Improvement in SNR and reduction in radiation dose for obese and overweight patients