Evaluation of conventional MR surface coil impact on PET quantification

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Introduction Multi-channel surface coils, custom designed for specific applications, are mandatory to obtain high-quality MR images. However, in recently developed integrated MR/PET systems, only rather conventional MR surface coils were adjusted to minimize interaction with the PET [1-3]. Thus, this study aims to evaluate regional effects from state-of-the-art MR coils not optimized for hybrid imaging on PET and to address whether rather demanding adjustments for usage in MR/PET are needed.

Methods

Image Acquisition: A Ge-68 cylinder phantom (dia/length= 20/25cm) was scanned as a radioactivity emission source, on an integrated whole-body PET/MR and Biograph-64 PET/CT (both Siemens, Erlangen, Germany), without and with a 32-element cardiac surface coil set in anterior and posterior pieces (Invivo Corp., FL, USA). The PET data was reconstructed with 3D-OSEM (3 iterations, 21 subsets) and a Gaussian filter of 4 mm FWHM. The PET attenuation correction (AC) was based either on MR images acquired with a Dixon sequence and segmented using a 2-compartment model on MR/PET (Fig. 1a), or on a low-dose CT (120 kVp, 12 mAs) without and with metal artifact reduction (MAR) on PET/CT (Fig. 1b).

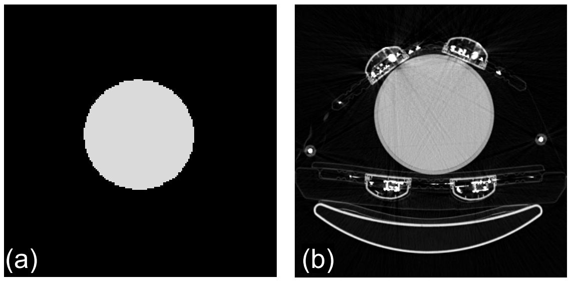

Figure 1. Representative axial slice of the PET AC map based on MR (a) where surface coils were invisible, and a CT (b) axial slice without MAR.

Data Analysis: Circular ROIs were defined in axial slices covering a length of 180mm in the middle of the cylinder: 8 ROIs (diameter = 40mm) evenly distributed in the periphery, 1 ROI (diameter = 70mm) in the center. An inhomogeneity index was defined 1) in the axial plane, as the standard deviation of 8 peripheral ROIs divided by mean of the central ROI, and averaged over axial slices, 2) along the longitudinal axis, as the standard deviation of each peripheral ROI across slices and then divided by mean of the central ROI, and averaged over all 8 ROIs.

Results

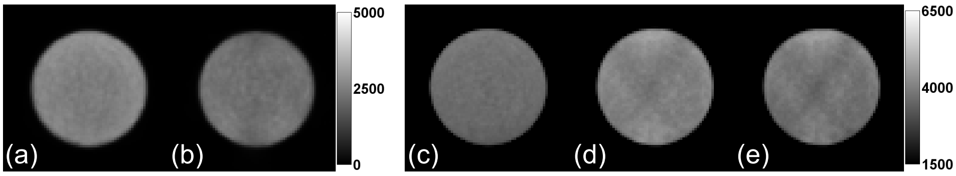

Figure 2. The AC corrected PET images of phantom (a) and phantom+coils (b) acquired on MR/PET, as well as phantom (c), phantom+coils (d) and phantom+coils with CT-MAR (e) acquired on PET/CT.

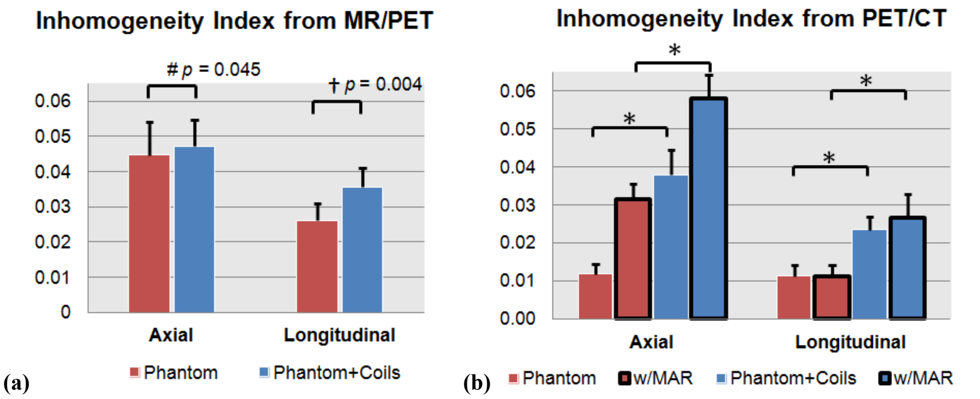

Figure 3. Measurement of the signal homogeneity in the Ge-68 phantom. The difference of inhomogeneity index in reference phantom scans from MR/PET and PET/CT was mainly due to PET scan duration of 5 mins and 20 mins respectively. * p<0.001

The images of mean intensity over axial slices used in data analysis (Fig. 2) illustrate an overall radioactivity underestimation of 12% in MR/PET and overestimation of 4% in PET/CT when the phantom was scanned with coils. Visible metal artifacts propagated in CT-based AC corrected PET images (Fig. 2d,e). The inhomogeneity indices obtained in MR/PET do not differ significantly (p>0.001) with *vs.* without surface coils (Fig. 3a). The presence of surface coils inside a PET/CT system introduced more severe inhomogeneity in the axial plane than along the longitudinal axis (Fig. 3b).

Discussions and Conclusions

The inhomogeneity with the 32-element coil designed for stand-alone MR systems was affected especially in areas obstructed by coil elements (preamplifiers, copper conductors, etc.) in the line of response space. The surface coils in MR/PET do not greatly degrade the PET signal homogeneity, while the overall reduced activity counts could be compensated by longer acquisitions; meanwhile, using CT scan of coils to incorporate into AC map for MR/PET can serve as a template approach, despite the regional signal inhomogeneity, the attenuation loss in the phantom due to surface coils was compensated well in PET/CT. The findings in this study provide insights on how to make compromises to obtain high-quality MR images without degrading PET activity concentration when using coils not specifically optimized for MR/PET.

References [1] Delso G. et al. *Phys Med Biol.* 2010:4361-74. [2] Tellmann L. et al. *Med Phys* 2011:2795-2805. [3] MacDonald L.R.et al. *Med Phys*. 2011:2948-56.