Direct evaluation of MR-derived attenuation correction maps for PET/MR of the mouse myocardium

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Target Audience Users of preclinical models; multi-modality imagers

Purpose To provide accurate measurements of positron emission tomography (PET) tracer activity concentrations *in vivo*, attenuation correction (AC) must be applied to account for gamma rays absorbed by the subject and surrounding equipment. The gold standard method for deriving AC involves passing a rotating transmission source around the subject. Due to the limited space available in both clinical and preclinical PET/MR scanners, MR-derived AC (MRAC) is often used as a substitute for transmission source scans[1]. This is problematic as the MR tissue signal is not directly related to the amount of gamma radiation absorbed and there has been little exploration of this issue in preclinical PET/MR. Here, we compare preclinical MRAC to gold standard transmission source scans in mice to evaluate its performance in studies of the mouse myocardium.

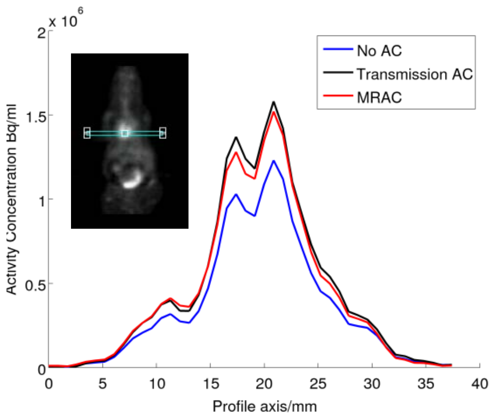

Figure 1: Single subject Line profile (see inset) of activity distribution for each AC method through mouse heart. Central activity peaks indicate myocardium

Methods *Data acquisition* Sequential PET/MRI was conducted on 10 mice[2] to compare the accuracy of PET SUV values achieved using mouse whole body AC maps created from high resolution MR images to gold standard maps from a transmission source. 3D FISP was acquired (4.7T Bruker BioSpec, TR/TE 8/4ms, slice thickness 0.5mm, NEX=2, 0.5mm spacing between slices, in plane resolution 120×120μm^2, matrix 256×256×128) before the mouse was transferred on its standard Bruker animal bed (with single loop surface coil, Bruker T7027, *in situ*) to the Cambridge split magnet PET/MR[3] (F120 PET camera) and a 10 minute single pass transmission scan (^{68}Ge) was performed. Emission listmode data was acquired for 45 minutes following ~25MBq (^{18}F-FDG) tracer administration and reconstructed using 3DRP, both with and without transmission based attenuation correction applied.

MRAC comparison PET and MR images were co-registered using the SPMmouse toolbox[4]. MR data were then forward projected into 3D PET sinograms using ASIPRO (Siemens Medical Solutions) and thresholded to create an AC map from the outline of the mouse body, defined as a single region of tissue with uniform attenuation co-efficient of 0.095cm^{-1}. SUV values calculated from the summed PET images (last 20 minutes) were then compared on a voxel by voxel basis between images without AC, with transmission source AC, and with MRAC.

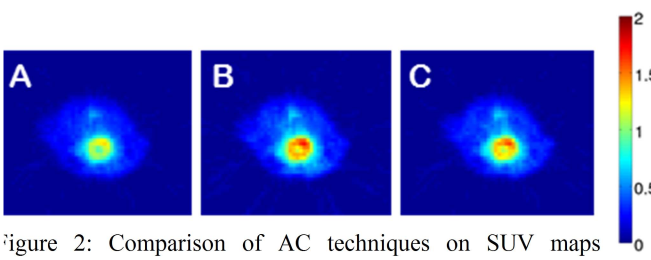

Figure 2: Comparison of AC techniques on SUV maps (transverse view) of mouse heart for single subject. (A) No AC applied, (B) Transmission AC, (C) MRAC. Improvement seen with AC applied, although base of mouse (closest to coil) corrected to lesser extent in MRAC

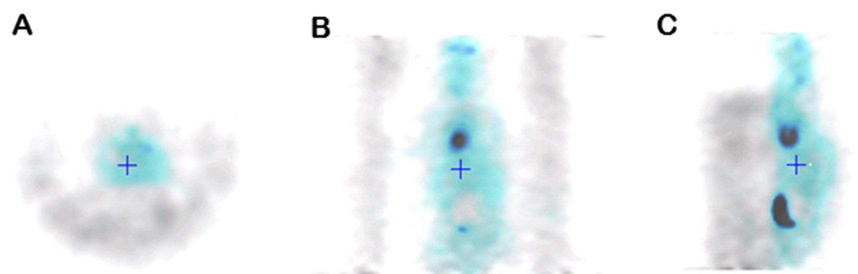

Figure 3: Fusion of PET emission (blue) and transmission (grey) images showing mouse, coil and bed attenuation. (A) Transverse view, (B) coronal and (C) sagittal

Results and Discussion Line profiles (see Figure 1) and voxel by voxel analysis indicate a 22.6 ± 0.9% (mean ± SD) improvement in the mouse myocardium SUV values by applying transmission AC and a mean 18.5 ± 0.9% improvement using MRAC. Figure 2 shows the SUV maps created by each AC technique. The global attenuation correction over the whole mouse body was 20.7 ± 0.7% when using transmission AC and 16.5 ± 1.3% when using MRAC. SUV difference maps found MRAC SUV values were within 10% of transmission AC for the mouse torso, although differences of up to 40% (mean: 30.1 ± 4.4%, range: 27-40%) were noted in the lower body directly adjacent to the coil and bed (bed and coil shown in grey in Figure 3). The MRAC approach also suffered in areas near the FOV edge due to the limited range of the surface coil used for whole body acquisitions.

Conclusion A simple, one region MRAC approach for quantitative PET/MR has been validated against gold standard transmission scanning for 10 mice. MRAC was found to provide the required AC for myocardial imaging in mice, although the addition of CT templates of coils and animal beds to future MRAC approaches are recommended for absolute whole body quantification.

References [1] Wagenknecht et al., *Magn Reson Mater Phy*, 26, 99-113, (2013), [2] Buonincontri et al, *NIMA A*, in press, DOI: 10.1016/j.nima.2013/08.066, [3] Lucas et al., *IEEE Nucl Sci Symp Record*, 2345-8, (2006), [4] Sawiak et al. *Proc. ISMRM.*, 17, (2009).