MRI Attenuated Whole Body PET Reconstruction: An in vivo study using animal subjects

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Introduction: In this study we proposed and developed a simple attenuation mapping approach based on magnetic resonance imaging (MRI) for the purpose of reconstructing positron emission tomography (PET) images in PET/MRI imaging devices.

Material and Methods: After experimental development, an in vivo calibration was performed by whole body scanning of five beagles on both a PET/CT (Biograph 16, Siemens) and a 3T MRI (Achieva, Philips). The attenuation was determined by using an automated segmentation algorithm to segment the whole body MRI scans into regions of air, lung, and tissue for a 3 region attenuation assigning them values of 0.002 cm^{-1}, 0.030 cm^{-1}, and 0.098 cm^{-1} respectively. A 4 region attenuation of air, lung, soft tissue, and bone was also done using values of 0.002 cm^{-1}, 0.030 cm^{-1}, 0.098 cm^{-1}, and 0.130 cm^{-1}, respectively.

Results and Discussion: The CT attenuated PET images and MRI attenuated PET images were very similar, and average standardized uptake values (SUV) for most regions of interest differed by only 1-6%. The only exception is bone, where the three region MRI attenuated PET images had an SUV 10% less on average than the CT attenuated images. Also, additional segmentation of bone in the four region MRI attenuated PET images reduced the SUV difference to 3%. However, the differences between the CT and 3 region attenuations were much smaller than the differences between CT attenuated and unattenuated PET images, which had average SUV differences ranging from 1% to 37%. In particular the spine had an average SUV difference of 29%. The tissue that had the greatest difference due to attenuation is lung, which had only a 2-3% difference between the CT and MRI attenuated PET images compared to a 37-42% difference between unattenuated and CT attenuated PET images.

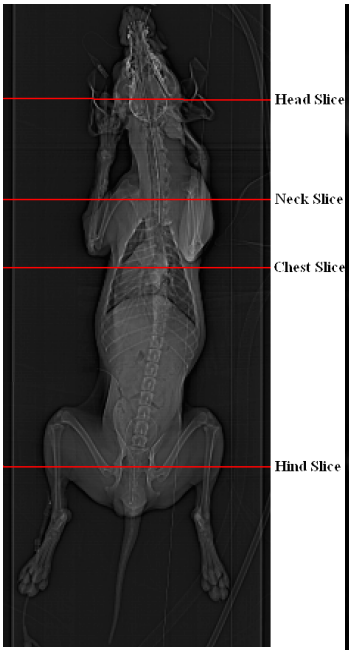

Figure 1: CT topogram indicating the image position in the head, neck, chest, and hind used in Figure 2

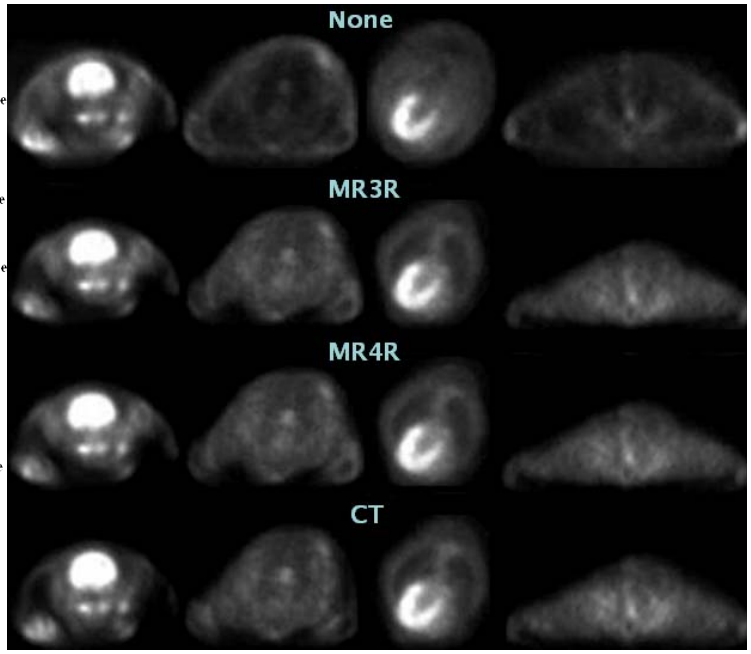

Figure 2: From left to right, PET images of the head, neck, chest, and hind are shown (see Figure 1). From top to bottom, PET was reconstructed using no attenuation (None), MRI 3 region attenuation (MR3R), MRI 4 region attenuation (MR4R), and CT attenuation (CT). The axial images refer to the red lines drawn in Figure 1.

SUV % Diff	CT to MR3R	CT to MR4R	MR3R to MR4R	CT to None	MR3R to None	MR4R to None
Heart	5%	1%	4%	3%	2%	1%
Liver	6%	4%	2%	29%	21%	23%
Lung	2%	3%	1%	37%	42%	41%
Bladder	6%	6%	0.1%	16%	10%	10%
Brain	5%	6%	1%	1%	6%	7%
Kidney	1%	2%	3%	17%	16%	14%
Spine	10%	3%	12%	29%	18%	28%

Table 1: Percent difference of the SUVs of various organs between CT attenuated PET and MRI attenuated PET images

Conclusion: Despite the improvements in the four region segmentation, the three region segmentation without delineation of osseous tissues produces high quality images that are sufficient for most expected clinical purposes of an integrated hybrid MRI/PET system.

References

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