Study of MR interference in a combined small animal PET/MR scanner and In Vivo Simultaneous Imaging

C. Catana[1], D. Procissi[2], Y. Wu[1], M. S. Judenhofer[3], J. Qi[1], A. V. Demyanenko[2], B. J. Pichler[3], R. E. Jacobs[2], and S. R. Cherry[1]

[1]Biomedical Engineering, University of California, Davis, Davis, CA, United States, [2]Biological Imaging Center, California Institute of Technology, Pasadena, CA, United States, [3]Laboratory for Preclinical Imaging and Imaging Technology, University of Tuebingen, Tuebingen, Germany

Introduction

PET and MRI are two widely utilized imaging techniques that are largely complementary in the information they provide [1]. A multi-slice MR compatible PET scanner insert for a preclinical small animal 7 Tesla MRI system has been built using magnetic field-insensitive position sensitive avalanche photodiode (PSAPD) detectors coupled, via short length of optical fibers, to arrays of scintillator crystals (Figure 1). The short fibers were used to minimize the interference between the two scanners while maintaining their performance [2]. A detailed study of the effect of the PET on the MR data acquisition was performed. The results of these experiments and the first in vivo small animal simultaneous PET/MR studies are presented here.

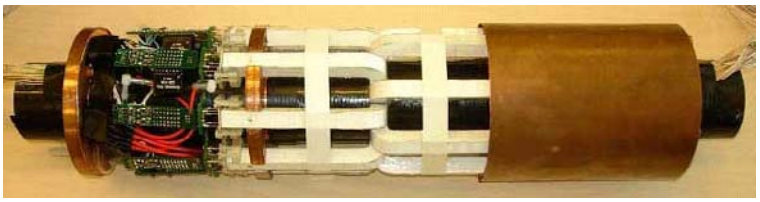

Figure 1. Picture of the MR compatible PET insert

Methods

Homogeneity. The homogeneity of the B_0 field was measured using a uniform signal producing phantom filled with a solution of Prohance® in water (T1=750 ms and T2=180 ms) positioned at the magnet isocenter. The standard Bruker 35 mm birdcage coil was used and spectra from the sample were acquired with and without the PET insert. The FWHM of the spectral peak was measured in each condition.

S/N and uniformity. The signal, noise and uniformity were measured in ROIs placed centrally on the images. The measurements were repeated for axial, coronal and sagittal slices, while running standard SE, RARE and FLASH , with and without the PET insert present. In each case we defined 25 contiguous slices (0.750 slice thickness) and the matrix size was 256 x 256 with a 35 x 35 mm^2 FOV.

High resolution MRI. The acquisition of high resolution MR images in the presence of the powered PET insert was investigated using a structured phantom. The matrix size was 512 x 512 with a FOV of 4 x 4 cm^2. The spatial linearity was assessed by comparing the measured values with the true known values.

Fast MRI acquisition. Two dimensional single shot echo planar imaging was achieved using a spin echo acquisition mode (TR=3000 ms and TE=70 ms) with a spectral width of 250 kHz. The same phantom as above was used and the acquisition time was 3 s. In order to account for Eddy current effects on the EPI images we used a table of preset preemphasis values to drive the gradients.

MR spectroscopy. Volume-selective *in vivo* ^{1}H spectroscopy was performed in the presence of the powered PET insert, with a cubic voxel of size 4 x 4 x 4 mm^3 positioned centrally in the mouse brain. A PRESS sequence with a TE and TR of 21.5 and 2000 ms, respectively, was used. Water suppression was performed using a CHESS sequence. The total acquisition time was 13.3 min.

In vivo imaging. To demonstrate the feasibility of our combined system for performing whole body imaging a mouse was injected with approximately 200 µCi of $^{18}F^-$. Data was acquired for 10 minutes. The PET images were reconstructed with a voxel size of 0.35 x 0.35 x 0.75 mm^3 and overlaid onto the MR images acquired simultaneously using a custom made brain imaging coil. A RARE sequence with TR=1000 ms and TE=12.5 ms was used to acquire 25 slices (0.750 slice thickness) with a FOV=4 x 4 cm^2 and a 256 x 256 matrix size.

Results and Discussions

The FWHM of the spectral peak measured was ~20 Hz and ~29 Hz with and without the PET insert, respectively. The spectra obtained after performing the localized shimming were identical. The S/N and uniformity values measured for RARE, SE and FLASH sequences in all three orientations were compared with and without the PET insert. The maximum average reduction is approximately 8% for S/N and 3% for uniformity. The resulting SE and GE images acquired in the presence of the insert are of exceptional quality and without artifacts. Virtually no change was observed between the measured values for the diameter of the rods and center-to-center distances when compared with the known values. The EPI images acquired are of good quality and no significant difference was observed between the two cases. The peaks present in the normal brain spectrum are clearly identifiable proving that the acquisition of MR spectroscopic data in the presence of the PET insert is possible.

Figure 2 shows the first simultaneous PET and MR images of a live animal using the system. Several slices through the mouse head are shown. The $^{18}F^-$ PET images, despite lack of accurate detector normalization, are good, and show uptake in the bones which registers nicely with the regions on the MR images that correspond to bone.

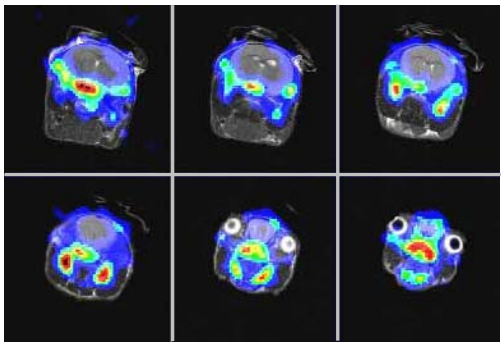

Figure 2. In vivo simultaneously acquired PET and MR images of mouse

References

[1] R. E. Jacobs and S. R. Cherry**,** "*Complementary emerging techniques: high-resolution PET and MRI*", Current Opinion in Neurobiology, vol. **11**, pp. 621-629, 2001

[2] C. Catana, Y. Wu, M.S. Judenhofer, J. Walton, B.J. Peng, J. Willig-Onwuachi, B.J. Pichler and S.R. Cherry, "*Combining PET and MRI – Challenges in Developing an MR Compatible PET insert*" #785, ISMRM 2006.