In vivo simultaneous MR/PET images of the rat brain and mouse heart at 9.4 tesla

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Objectives: Multi-modality *in vivo* imaging has the potential to acquire vital information that has significant diagnostic value in interpreting the diseased conditions in the living body, as compared to stand-alone imaging systems. The integration of Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET) has now become a possibility, which allows us to acquire morphological and physiological information 'in sync' as opposed to sequential scans of combined X-ray Computed Tomography (CT) and PET. Compared to CT, MRI provides better soft tissue contrast information and does not use ionizing radiation. PET inserts that can be used inside MRI have been built to obtain quantitative simultaneous imaging in small animals. We have developed a MRI compatible PET tomograph based on Rat Conscious Animal PET (RatCAP) [1] for simultaneous quantitative acquisition of *in vivo* MR and PET images of rats and mice in a Bruker 9.4 T microMRI scanner. The flexibility to perform both rat brain and mouse cardiac studies using the same PET scanner has been demonstrated despite the limited geometric design of the PET tomograph (ID = 38 mm; axial length = 18 mm), which occupies just enough space inside the MRI scanner.

Methods: The non-magnetic RatCAP PET tomograph [2] comprises of 12 detector blocks. Each block consists of a 4 x 8 array of 2.2 x 2.2 x 5 mm^3 LSO crystals (Agile engineering) read out with a matching non-magnetic APD array (Hamamatsu S8550). All the 12 blocks are plugged into a flexible printed circuit board, which is then rolled and housed in a plastic casing. The detected signals from the read-out chip [3] are received and processed by a signal processing module [4] and is then sent to the PC based data acquisition system. A custom-designed MRI coil is built (ID = 31.1 mm) that can be inserted inside the PET detector (ID = 38 mm). The coil is designed to operate in a fully quadrature transceiver mode by means of a λ/8 hybrid network to attain better uniformity and SNR in MR images. The PET tomograph was not shielded from radiofrequency pulses.

Results: Simultaneous PET/MR phantom, rat brain and mouse cardiac images were acquired in the Bruker 9.4 T microMRI facility, using different PET radiotracers (^{18}F-FDG and ^{11}C-raclopride). Sprague-Dawley rats were used for the rat brain studies, where the radiotracers were administered intravenously through a catheter. For the studies using Swiss-Webster mice, ECG gating was used to extract the individual phases of the mouse cardiac cycle. Ten temporal frames (10 ms duration per frame) were acquired corresponding to ten phases of the cardiac cycle. Minimal visible artifacts were observed on the MR images. Spurious counts in the list-mode PET data stream due to RF pulsing during MRI acquisition are discarded without any significant degradation to the PET image quality.

Conclusions: We have acquired simultaneous multi-slice MRI and PET images of the phantom and rat brain, as well as simultaneous dynamic MRI/PET gated cardiac images of the mouse, for the first time in 9.4 T microMRI scanner. New RF coils with shielding are being constructed to obtain better SNR in MR images and minimize the spurious spikes in PET data. Routine PET/MR imaging studies (including MR spectroscopy) are being pursued to obtain *in vivo* quantitative information from both rats and mice and results will be presented.

References:

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