Dual Mouse 8-Element Coil Array and Bed for Sequential Multimodality PET, SPECT, CT and MRI of Multiple Mice

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Introduction: In PET or SPECT imaging studies of orthotopic or genetically engineered mouse models, registration to MRI is more effective than CT in localizing the source of activity due to the superior soft tissue contrast of MRI. However, hybrid preclinical PET/MR or SPECT/MR systems are not widely available, and they often require a compromise in performance from either modality. Sequential multimodality imaging provides a practical and economical alternative to hybrid imaging systems and it can easily be performed using mouse beds that are compatible with the modalities of interest. In order to increase the throughput of this method and efficiently utilize the short-lived radioactive tracer isotopes, multiple mice can be scanned simultaneously. In this work, we describe the design and application of a multimodality imaging system comprised of an 8-channel coil array for imaging two mice simultaneously and a MR, PET, SPECT, and CT compatible dual mouse bed.

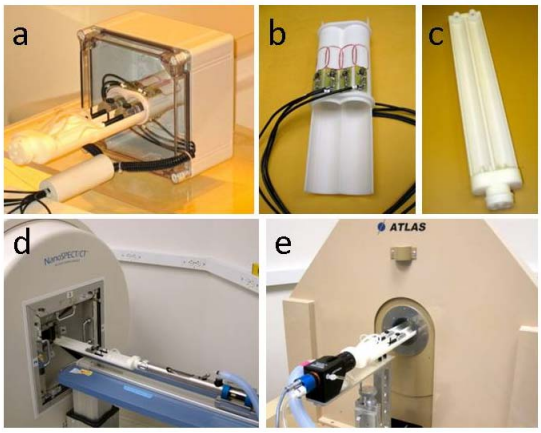

Figure 1. Dual mouse 8-coil array and multimodality bed system for scanning two mice simultaneously: Coil and bed system (a), 8-element coil array (b), dual mouse bed (c), bed in SPECT/CT scanner (d) and bed in PET scanner (e).

Methods: The 3.0 T MRI dual mouse coil (Figure 1a) is comprised of an 8-element array on the outer surface of a former (Figure 1b) designed as two overlapping 42 mm OD tubes and printed out of ABS plastic with a Fused Deposition Modeling (FDM) 3-D printer. Coupling between adjacent elements are minimized by low-impedance decoupling circuit and coil overlap. The double mouse bed design (Figure 1c-e) which was also printed on the 3D printer provides for gas anesthesia, air heating, and respiration sensor. Phantom MRI tests were acquired using a 3D SPGR sequence (Philips 3T Achieva, TR/TE/FA 15/2.0/5º, FOV 40x80x40 mm^3). For the *in vivo* test, athymic nude mice bearing subcutaneous BT474 tumors implanted into the shoulder were injected with ^{68}Ga-DOTA- $Z_{HER2:2891}$ Affibody (180 uCi, 100 µL) and then scanned one hour post injection. *In vivo* images were acquired on two mice at a time using the dual mouse bed first on a PET scanner (Atlas, two 2-cm axial FOV bed positions at 5 min each, FOV 72 mm, 1.125 mm slices, 100 to 700 keV energy window, 2D-OSEM) one hour after injection of the agent and then on the MR scanner (Axial multi-slice TSE TR/TE 5740/40 ms, FOV 72x30 mm^2, 0.562 mm slices) using the coil array. Co-registration and fusion of the PET images to the MR images were performed with Osirix (http://www.osirix-viewer.com/).

Results and Discussion: MR images of two ~28 mm tubes of water in the 8-channel dual mouse coil array are shown in Figure 2. There was some coupling between individual channels which will be improved by mounting low-Z preamplifiers directly on each coil. Fused sequential PET-MR images of two athymic nude mice bearing subcutaneous BT474 tumors implanted into the shoulder one hour after injection of the PET agent via the lateral tail vein are shown in Figure 3. Uptake in tumor (upper left in each animal image) was ~10x less than in the kidney.

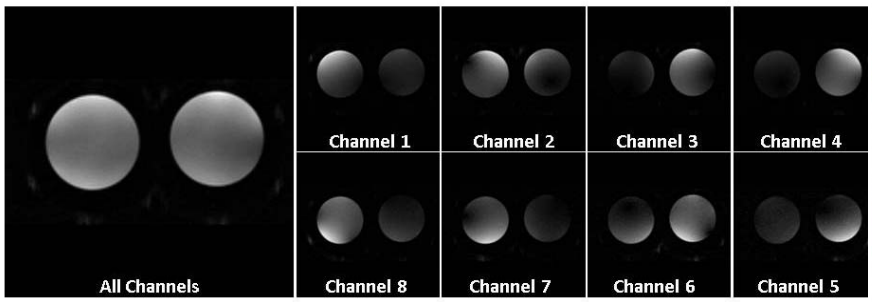

Figure 2: Middle axial slices from the 3D-SPGR image of two tubes of water taken with the 8-channel dual-mouse coil.

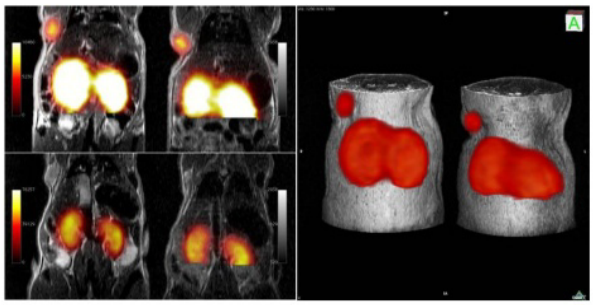

Figure 3: MRI and PET fusion of a coronal slice through the tumors and kidneys of two mice (left) and 3D rendering (right).

Conclusion: Sequential multimodality PET-MR has been demonstrated with a dual mouse 8-channel array and dual mouse bed that doubles throughput without compromising image quality of either modality. Multimodality SPECT/CT-MR studies are also possible. The use of the 8-channel coil increases sensitivity of MRI and it can be used with parallel imaging methods like SENSE to reduce susceptibility distortions in EPI sequences and accelerate gradient and spin echo sequences.