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FIRST RESULTS FROM AN MRI COMPATIBLE SMALL ANIMAL PET INSERT OPERATING IN A CLINICAL 3T PET/MRI

Matthew S. Fox[1,2], Vanessa L. Palmer[3], Graham Schellenberg[3], Jarod Matwiy[4], Scott B. King[4], Andrew L. Goertzen[5,6,7], and Jonathan D. Thiessen[1,2]

[1]Imaging Program, Lawson Health Research Institute, London, ON, Canada, [2]Department of Medical Biophysics, University of Western Ontario, London, ON, Canada, [3]Cubresa, Winnipeg, MB, Canada, [4]National Research Council of Canada, Winnipeg, MB, Canada, [5]Department of Radiology, University of Manitoba, Winnipeg, MB, Canada, [6]Departmentof Physics and Astronomy, University of Manitoba, Winnipeg, MB, Canada, [7]PET/CT Imaging Program, Section of Nuclear Medicine, Health Sciences Centre, Winnipeg MB, Canada

INTRODUCTION

- The fusion of pre-clinical molecular imaging methods such as PET and MRI will provide new pathways for discovery in science and medicine by enabling superior spatial and temporal resolution compared to clinical systems.
- We recently evaluated a versatile MR compatible small animal PET insert called NuPET (Fig. 1A) in collaboration with Cubresa Inc. to enable true simultaneous pre-clinical PET/MRI studies.
- Presented here are the first simultaneous images obtained using both imaging modalities in our 3T PET/MRI clinical scanner.

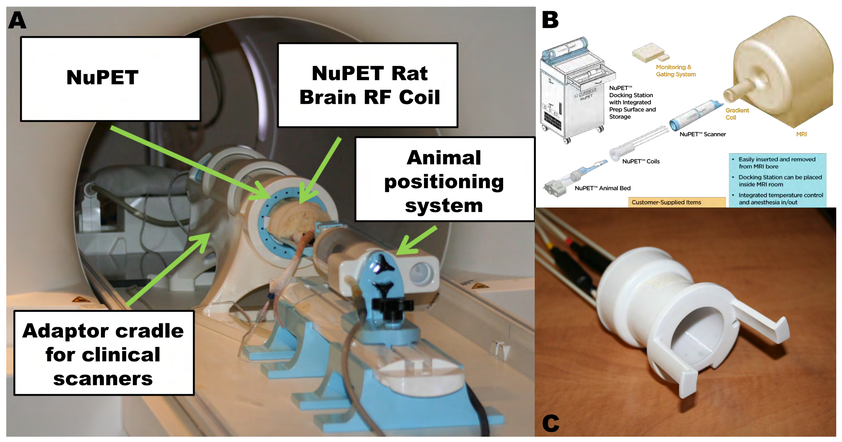

Figure 1: Panel A shows the insertable NuPET detector inside the adaptor cradle together with a rat brain RF coil and translatable animal positioning bed. Panel B, the vendor schematic and panel C is a close-up of the RF coil.

METHODS

- All experiments were performed under approved animal ethics (CCAC) and isotope use licences (CNSC).
- An insertable PET system (NuPET from Cubresa Inc., Fig. 1A) was positioned inside a clinical 3T PET/MRI (Siemens Biograph mMR) together with a rat brain RF coil (Fig. 1C).
- A NEMA NU 4-2008 image quality (IQ) phantom was simultaneously imaged using PET and MRI (Fig. 2). Scan times were 20 min long using 4MBq of [^{18}F]-FDG. Simultaneous PET/MR, MR-only and PET-only imaging was performed.
- A healthy Wistar rat (478g) and a rat (404g) with 1M C6 glioma cells injected and incubated for 12 days within the brain were imaged using simultaneous PET/MRI (Figs. 3 and 4). Rats were injected with 30MBq [^{18}F]-FDG [i.v.] and imaged for 30 min.
- PET images were reconstructed to 0.64 x 0.64 x 0.64mm^3 using a STIR OSMAPOSL algorithm.
- 2D T_2w MRI were acquired sagittally and axially using an FOV of 70x70mm, 0.22 x 0.22mm^2 in-plane resolution, 1.5mm slice thickness, 10% slice spacing, 16 slices, TR/TE 3250/97ms and BW 233 Hz/px.
- Image analysis and manual registration was performed using 3D Slicer. A Gaussian filter was applied to all PET data.

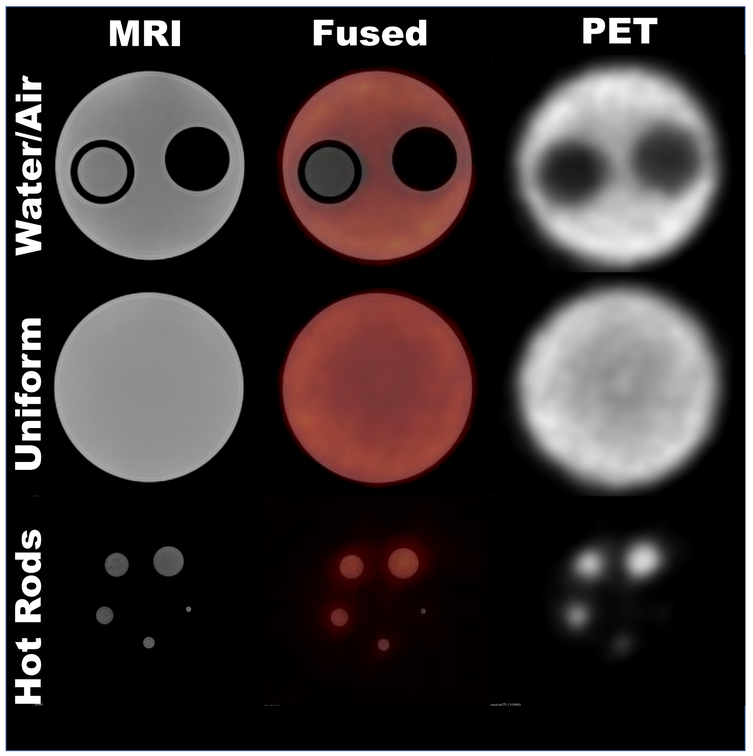

Figure 2: Each column depicts a set of simultaneous PET/MR axial images taken through the NEMA NU 4-2008 IQ Phantom showing regions of water/air, the uniform cavity and the hot rods with diameters 5mm to 1mm.

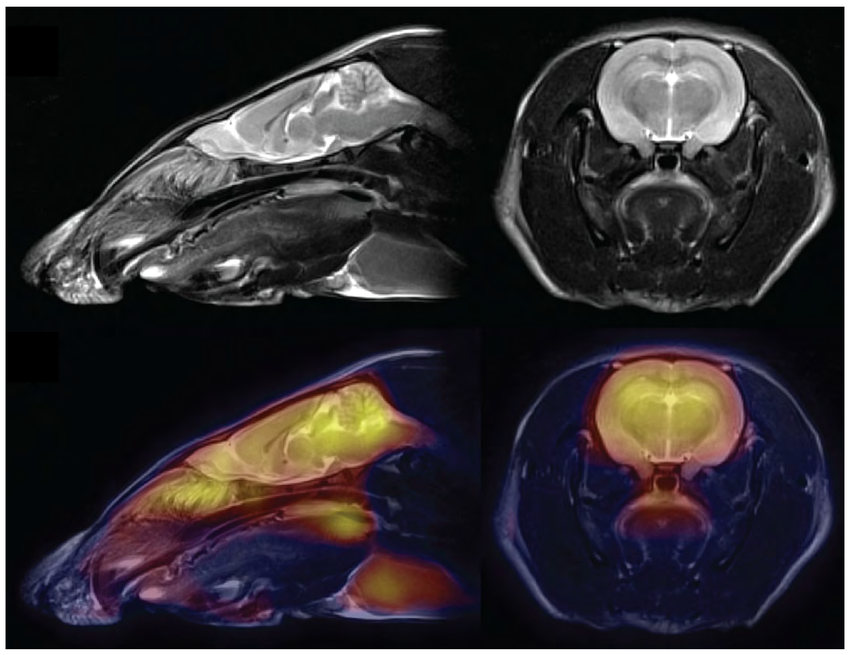

Figure 3: Simultaneous PET/MR within a healthy rat. Top row depicts T_2w MR images in the sagittal and axial planes. Bottom row shows the simultaneous PET data registered to the MR data.

	PET (Relative Signal)		MRI (SNR)	
ROI	MRI ON x 10^{-3}	MRI OFF x 10^{-3}	PET ON	PET OFF
1	9.92	9.78	150.64	153.56
2	11.78	11.04	152.92	155.81
3	11.67	12.10	153. 80	156.63
4	12.11	11.68	154.58	157.58
5	12.44	12.54	156. 70	158.07

Table 1: Summary of PET and MRI data measured from 5 different ROIs within the uniform region of the IQ phantom for four different cases: PET acquired while MRI was ON/OFF and MRI acquired while PET was ON/OFF. Values differed on average by only 0.84±0.23% and 1.59±1.11% respectively by percent difference.

RESULTS

- Figure 2 demonstrates good image quality and co-registration between simultaneously acquired PET and MR images of the NEMA IQ phantom.
- Table 1 demonstrates each systems effect on the other system from images acquired using PET with MRI ON/OFF, and MRI with PET ON/OFF. Comparison of PET data (normalized signal) and MRI data (SNR values) showed an average agreement within 0.84±0.23%, 1.59±1.11% for both ON/OFF cases.
- Figure 3 depicts [^{18}F]-FDG static PET image showing uniform co-localized uptake within the rat brain.
- Figure 4 depicts [^{18}F]-FDG static PET images within a model of C6 Glioblastoma demonstrating enhanced uptake within the tumour region relative to normal brain tissue.

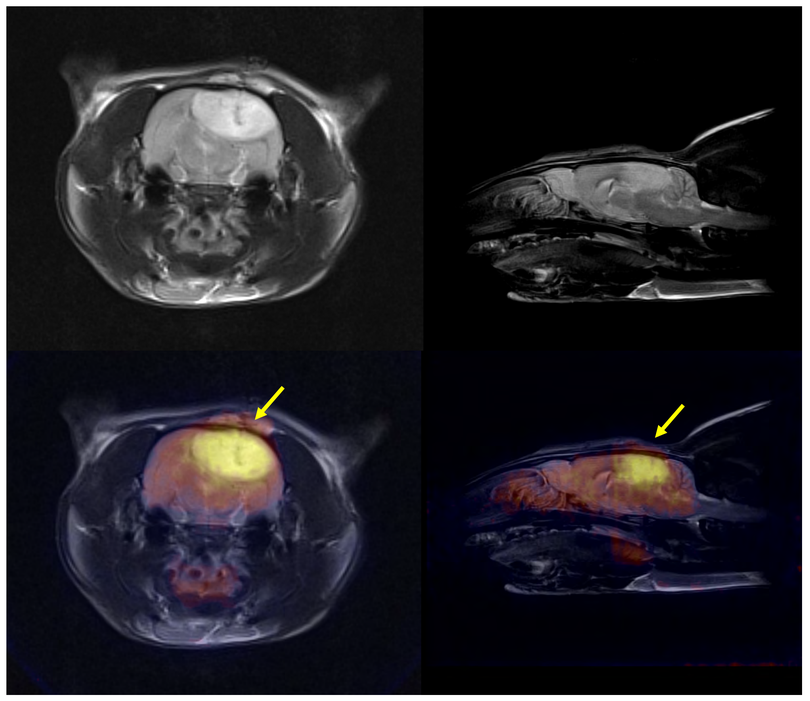

Figure 4: Simultaneous PET/MR using a model of C6 Glioblastoma. Top row depicts T_2w MR images in the axial and sagittal planes. Bottom row shows the simultaneous PET data registered to the MR data.

DISCUSSION

- We have demonstrated the first results from an MR compatible small animal PET insert operating within a clinical 3T PET/MRI.
- Qualitatively, image quality was good and no artifacts were observed during simultaneous imaging. Quantitative analysis demonstrated no significant changes in intensity values due to the effect of one modality on the other.
- Demonstrations of simultaneous static PET/MRI in a healthy rat and a rat with C6 glioma appeared to have good image quality, tumour contrast.
- With further testing and full NEMA characterization under a variety of situations we will work towards improvement of sensitivity and enable finer dynamic PET imaging.

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Contact: matthew.s.fox.4@gmail.com