Simultaneous Perfusion MRI and FET-PET

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Abstract

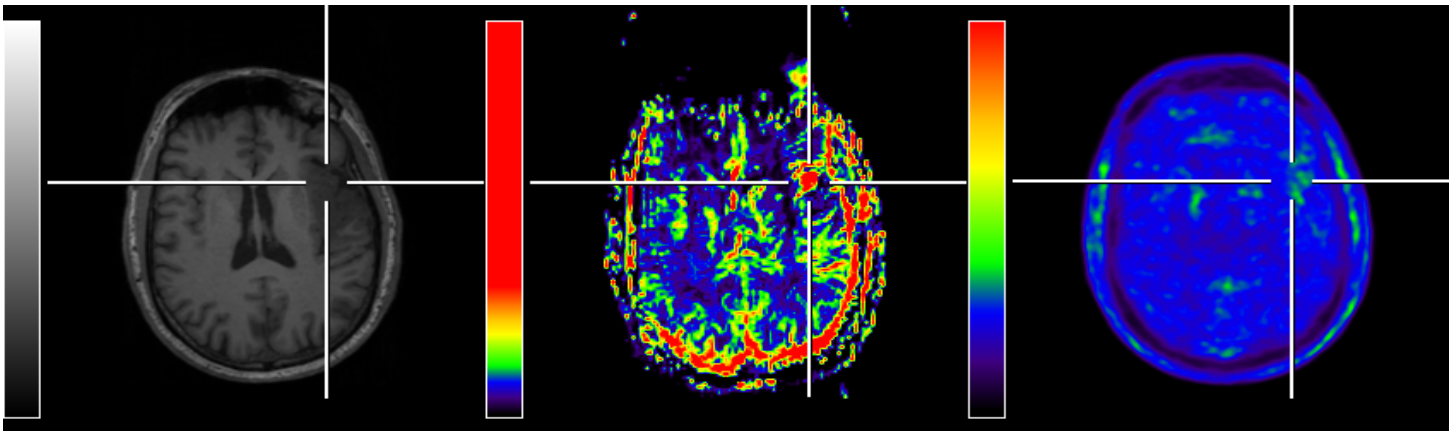
PET imaging using radiolabelled amino acids tracer can specifically deliver valuable information about tumour extent, malignancy, and tumour recurrence. Perfusion MRI, which measures microcirculatory parameters such as cerebral blood flow (CBF) and cerebral blood volume (CBV), can precisely investigate vascular malformation, and help classify and grade brain tumours. In this study, FET-PET and perfusion MRI data were simultaneously acquired using a hybrid 3T MR-PET scanner [1,2]; data from a representative human brain tumour case are presented. After combination with MP-RAGE, this technique offers the opportunity to establish a reliable diagnosis of brain tumours and assessment of metabolism after therapy.

Introduction

Currently, positron emission tomography (PET) has been the most widely used method for metabolic brain imaging. However, its disadvantages are poor spatial and temporal resolution. MRI is capable of providing exquisite anatomy as well as physiological measures of disease states. Additionally, perfusion MRI provides a precise method to map the hemodynamic status of brain tissue. In this study, we present the feasibility of simultaneous, multimodal imaging combining anatomical (MP-RAGE), hemodynamic (CBV), and metabolic (PET) information for the investigation of reorganization in human brain tumour.

Materials and Methods

PET was performed using the amino acid radiotracer O-(2-[^{18}F]Fluorethyl)- L-Tyrosin (FET)[1] [3,4]. After injection of 200 MBq of FET, a combined MR-PET scan was performed on a Siemens 3 Tesla MAGNETOM Tim-Trio system equipped with a BrainPET insert. The BrainPET scan time was 35 min and MRI was performed simultaneously. Anatomical images were acquired with a T1-weighted MP-RAGE sequence. The matrix size was 256 x 256 x 192 to achieve a 1mm isotropic resolution within a scan time of 9 min. Perfusion measurements were performed using (DCE) MRI with an FID-EPI sequence. Before, during and after the bolus injection of 0.1mmol/kg Gd^+ contrast agent, 100 measurements of 21 slices were obtained. The sequence parameters were as follows: TE = 31 ms, TR = 2 s for the acquisition of 21 images, FOV = 256 x 256, matrix size = 128 x 128, and TA = 3.3 min. Before the calculation of CBV, the AIF (arterial input function) $C_a(t)$ was determined from the parameters of concentration-time curves $C(t)$ such as the maximum, the moment of maximum, the full width at half maximum. CBV was calculated as: $\int C(t)dt / \int C_a(t)dt$, the integration of concentration curve over integration of AIF [5]. Data from a representative patient (male, 57 yrs) with an astrocytoma WHO grade III are shown below. The study was approved by the responsible ethic commission and the patient gave written, informed consent.



Results

The transverse slice of MP-RAGE (left), CBV (centre) , and FET-PET(right) are shown above. Low intensity in the MP-RAGE indicates a brain tumour. The measured mean grey matter-to-white matter ratio for CBV is 2.5, which is in good agreement with the value from literature [6,7]. An increase in CBV is noted within the tumour area with a lesion-to-white matter ratio of 9.7 whereas the FET uptake is not significant. This indicates a discrepancy between amino acid uptake and vascularity.

Conclusion

This study demonstrates the feasibility of simultaneous FET-PET and perfusion imaging on a MR-PET hybrid scanner to investigate vascularity and amino acid uptake in a human brain tumour. Multimodal imaging may offer complementary and therefore more reliable information for biopsy and treatment planning and the assessment of brain tumour progression. Additionally, a hybrid system for the investigation of brain function / dysfunction also reduces the total measurement time, the registration time, and improves the spatial resolution.

References : [1] Schlemmer, HP. et al. Radiology 2008;248:1028-35, [2] Herzog, H. et al. Neuroimage. 2010 Feb 1;49(3):2072-82, [3] Wester et al. J Nucl Med, 1999;40:205-212, [4] Langen et al., Nucl Med Biol, 2003. 30(5):501-508, [5] Ostergaard, L. et al. Magn Reson Med. 1996 Nov; 36(5): 726-36, [6] Claus, S. et al. JMRI. 1999;92(29):342-7, [7] Nighoghossian, N. et al. J Neurol Sci. 1997 Aug;149(2):171-6.