Simultaneous Diffusion, Perfusion MRI and FET-PET

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Abstract

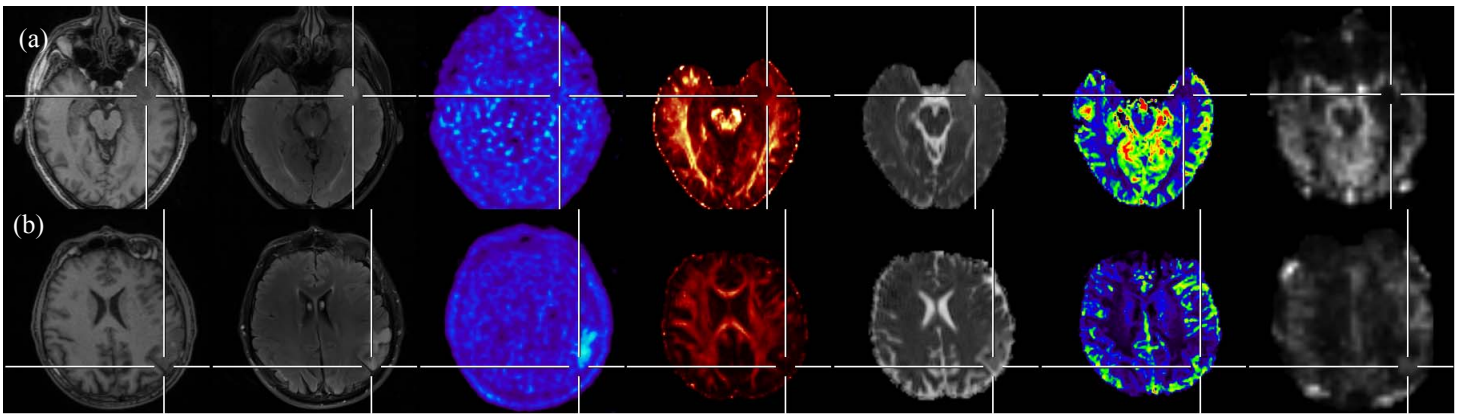
PET using radiolabeled amino acids is helpful to determine the tumor extent of cerebral gliomas. Diffusion tensor imaging (DTI) could add important information on displacement and compression of fiber tracts in the brain. Perfusion MRI, which measures microcirculatory parameters such as cerebral blood flow (CBF) and cerebral blood volume (CBV), could add information on vascularity and angiogenesis in the tumour. In this study, diffusion, perfusion MRI and FET-PET were **simultaneously** acquired using a hybrid 3T MR-PET scanner. The hybrid system has advantage of reduction of measurement time and improvement of PET spatial resolution. Using the hybrid approach, data from two representative human brain tumour cases are presented. In combination with T_1 and T_2 weighted images, this technique offers important additional information for optimized treatment planning of cerebral gliomas.

Introduction

Positron emission tomography (PET) has been widely used for metabolic imaging of brain tumours. MRI is capable of providing anatomical, physiological, and functional information in various pathologies of the human brain. The new 3TMR-BrainPET hybrid scanner with its APD-based PET technology offers the opportunity of comprehensively studying the human brain using both modalities in a fast way [1,2]. In this work, we demonstrate the feasibility and advantages of simultaneous, multimodal imaging combining anatomical (MP-RAGE, FLAIR), structural (DTI), hemodynamic (DSC, ASL), and metabolic (PET) information for the investigation of human brain tumours.

Materials and Methods

The study was performed on a Siemens 3 Tesla MAGNETOM Tim-Trio system equipped with a BrainPET insert (Siemens, Erlangen, Germany). Two patients with brain tumours were scanned under approval by the responsible ethic commission with written and informed consent. For all measurements, an outer bird cage coil was used for transmit and receive and an inner 8 channel coil for additional receive, both positioned inside the PET detector. PET was performed using 200 MBq of the amino acid radiotracer O-(2-[^{18}F]Fluorethyl)- L-tyrosine (FET) [3]. The BrainPET scan time was 50 min and the following MR protocols were performed simultaneously: anatomical images with T_1-weighted MP-RAGE T_2-weighted FLAIR; DTI by double spin-echo diffusion weighted EPI with 30 diffusion gradient directions and b-value of 1000 [4]; non-contrast agent based perfusion measurements with a dynamic PASL implemented with GRASE readout [5]; contrast agent based DSC perfusion with an FID-EPI sequence [6]. The contrast agent was injected using an MRI-compatible power injector (Spectris, Medrad) at a rate of 5mL/s followed by a saline flush of 20mL. Data analyses were performed using in-house Matlab scripts for ASL and DSC, FSL scripts for DTI. The derived results from the two patients are shown below.



Results

The transverse slices (left to right) of MP-RAGE, FLAIR, FET-PET, FA, MD, DSC-CBF, ASL-CBF are shown above. Low intensity in T_1 and high intensity in T_2 indicate an increase of T_1 and T_2 in the abnormal regions. FET uptake is weak in the first case (Fig. a), but stronger in the second (Fig. b). DTI with changed FA and increased MD present the bias of fibre orientation and increased extracellular bulk water induced by tumour. Hypo-perfusion is observed in the abnormal region in Fig. a; hyper- perfusion surrounds the FET activity can be interestingly found in Fig. b. These differences in T_1, T_2, metabolism, diffusion and perfusion reflect different pathophysiologic properties of the two brain tumours.

Conclusion

This study demonstrates the feasibility of simultaneous diffusion, perfusion MRI and FET-PET on a hybrid scanner to investigate involvement of cerebral fiber tracts, vascularity and amino acid uptake in human brain tumours. Multimodal imaging is helpful to provide comprehensive diagnostic information in brain tumors in a fast, precise and comfortable way.

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