Simultaneous resting state fMRI and FET-PET

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Abstract

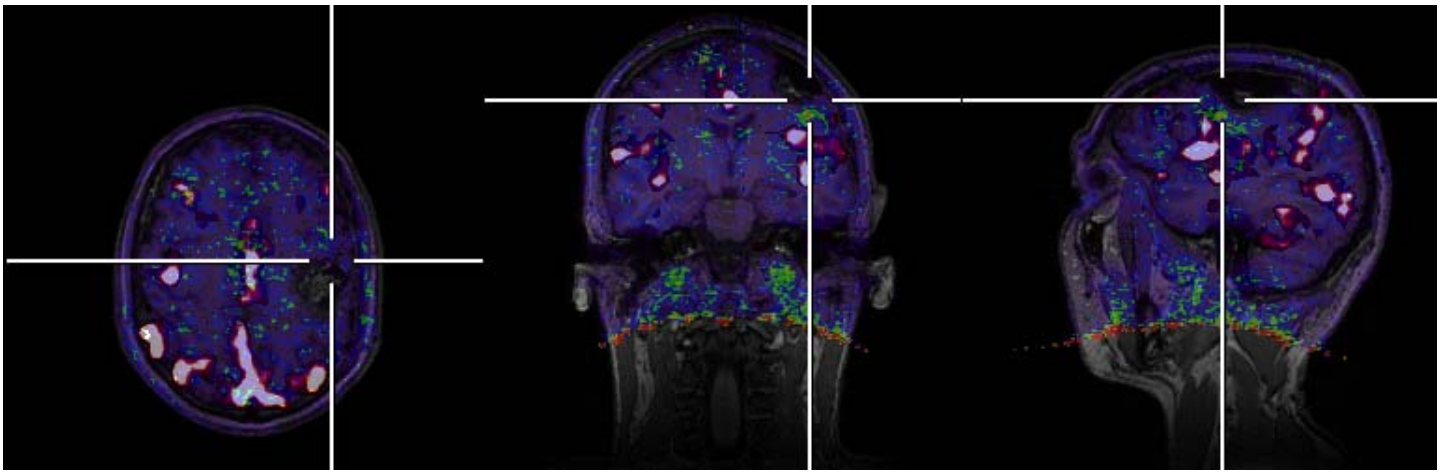
For the planning of surgical intervention in human brain tumour cases, it is important to know if critical brain areas might be affected by the surgical process itself. PET imaging using radiolabelled amino acids is a valuable technique for the diagnosis of cerebral gliomas. O-(2-[^{18}F]Fluorethyl)-L-Tyrosin (FET) is a well established amino acid tracer that delivers information about tumour extent, the optimal biopsy site and detection of tumour recurrences. In this study, FET-PET and BOLD-fMRI data were acquired simultaneously; data from a representative human brain tumour case are presented. In contrast to task-based functional studies, resting state fMRI offers the opportunity to detect a variety of cortical networks in a single experiment.

Introduction

Positron emission tomography (PET) using radiolabelled amino acids is a widely used and established tool for clinical diagnosis of brain tumours. The method complements CT and MR imaging with respect to its metabolic specificity and helps to judge the extent of tumour tissue. In preparation for neurosurgical intervention, following the diagnosis, detailed information about the specific localization of brain functions is needed to estimate individual patient risk to acquire neurological deficits during the surgical process. BOLD-fMRI is the current standard in functional imaging. It is a valuable tool to identify the exact position of functionally important brain structures in relation to the tumour tissue. In an fMRI resting-state study, the activity of a variety of cortical networks can be detected independently from a specific task [1]. This may be advantageous when there is no hint for a specific deficit due to tumour growth. The resting state has been associated with a widespread fronto-parietal network, particularly with superior and medial parietal brain areas. The recently developed new technology of MR-PET hybrid scanners [2,3] offers the advantage of measuring PET and fMRI data simultaneously that are intrinsically co-registered in time and space. Results of a combined PET/fMRI resting-state study in the presence of brain tumours are presented; a representative example - a patient with a superior parietal tumour - is shown below.

Methods

PET was performed using the amino acid O-(2-[^{18}F]Fluorethyl)-L-Tyrosin (FET) [4,5]. After injection of 200 MBq 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 T_1 weighted MP-RAGE sequence. The matrix size was 256x256x192 to achieve a 1mm isotropic resolution within a scan time of 9 min. BOLD fMRI data were acquired with an EPI sequence. The echo time was 30 ms and the repetition time TR 2 sec for recording a single image. Patients were advised to keep eyes closed and think about nothing specific during EPI scanning of 6 min. The fMRI data were processed using FSL. Fused images were produced with VINCI [6]. Data from a representative patient (male, 44yrs), who had an extirpated oligoastrozytoma WHO °III, are shown below. The study was approved by the responsible ethic commission and the patient gave written, informed consent.



Results

Fused transverse, coronal and sagittal slices of PET, MP-RAGE and fMRI images are presented. The MP-RAGE images are coded in grey scale. The PET signal intensity increases from violet to red. The BOLD-fMRI signal is depicted in red to yellow. The presented BOLD-fMRI data are selected from 19 possible detected resting state networks. Criteria for the selection of a resting-state, default-mode network were a low coherence frequency and a well-separated structure of the activated areas including posterior mesial and bilateral parietal areas. The selected network shows a symmetrical localisation of the resting-state network in both hemispheres. In transverse and coronal slice projections, however, it can be recognised that this symmetry is broken by the tumour extirpation. On the contra-lateral side of the tumour, resting-state activity is detected by analysis of fMRI data. On the other hand, PET data show an area of increased counts inferior of the tumour extirpation. This region of possibly carcinomatous tissue is close to functional areas belonging to the selected cortical network.

Conclusions

This study demonstrates the possible gains of combined PET and BOLD-fMRI imaging on a MR-PET hybrid scanner. While this hybrid technology is less burdensome for the patients due to the reduced measurement time, it holds the strong advantage in that it allows fusion of receptor and brain activation information. The use of resting state measurement is of particular interest in patients with fronto-parietal tumours and it can easily be acquired and contributes to the understanding of cerebral organisation particular to the patient. In particular, no difficult-to-understand functional paradigms are necessary for the patients, and information is obtained about functionally-relevant networks apart from the usually examined motor and speech networks. As soon as MR-PET hybrid scanners are clinically available, a routine fMRI resting-state study should be combined with PET investigations.

References

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