Simultaneous fMRI/EEG in idiopathic generalized epilepsy (IGE)

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Introduction: IGE consists of a group of epilepsy syndromes, characterised by their age of onset and combination of seizure types. The common subtypes are: childhood absence epilepsy (CAE); juvenile absence epilepsy (JAE); and juvenile myoclonic epilepsy (JME). Some patients with IGE have GTCS alone, here they are referred to as IGE-GTCS. The EEG in IGE is characterized by generalized, rhythmic discharges.

Subcortical, particularly thalamic generation of these discharges has been suggested based on experimental work. Three recent studies (1,2,3) assessed the pattern of cortical and subcortical activation at the time of these discharges using EEG recording during functional MRI (fMRI/EEG). However, these studies have included adults with drug-refractory IGE, thus somewhat atypical IGE cases. Here, we present a series of children and young adults with recently diagnosed IGE, investigated with simultaneous fMRI/EEG.

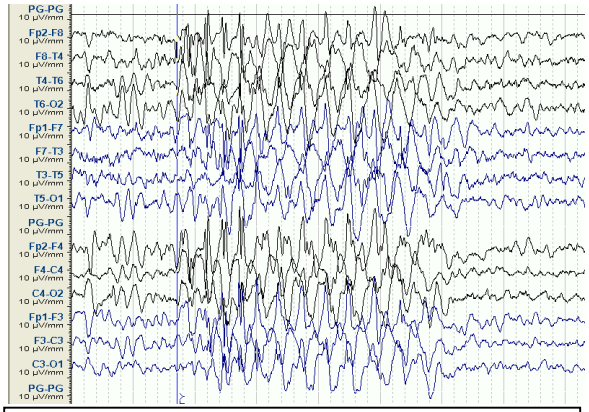

Figure 1: EEG recording at the time of a burst of rhythmic activity in study 1. The EEG is displayed as seen during scanning without post-processing, and clearly allows diagnosis of the epileptiform activity during scanning.

Methods: Seventeen subjects were recruited through the First Seizure Clinic or the EEG lab at Austin Health, Melbourne, Australia. All subjects showed frequent, stereotypical generalized discharges. Mean age at examination was 16±7 years. All patients were either not on antiepileptic drugs, or had just started to take one antiepileptic drug, and were still on a very low dose treatment. fMRI/EEG was performed at 3T using 18 non-metallic electrodes, placed on the 10/20 system. Figure 1 shows the EEG recording inside the scanner. One subject showed no discharges during recording, and in two the study failed due to technical reasons. Event-related analysis was performed using SPM software (www.fil.ion.bpmf.ac.uk/spm/) in combination with some pre-processing in iBrain™ (www.brain.org.au/iBrain).

Results: Typical discharges were present during fMRI/EEG in 14 patients. Seven of these patients showed bursts of rhythmic discharges, and seven patients had isolated generalized discharges. Two patients with bursts (study 1 and 2) had absences during scanning, in the other 12 subjects clinical absences were not observed. In three subjects signal was present at a threshold of of $P<0.05$, corrected for multiple comparisons (study 1, 2 and 13), in the other subjects, areas of activation and deactivation were only visible at a threshold of 0.001, uncorrected.

The activation and deactivation pattern was quite different between individuals. Signal change was found in subcortical and cortical areas. Cortical signal change was present in all subjects, 55% of the patients showed deactivation in the posterior cingulate. Subcortical signal change was predominantly found in patients with bursts during scanning. Thalamic signal change was only found in two patients (1 and 2), both showed marked activation, and had electro-clinical absences during scanning. The other subcortical nuclei showed predominantly deactivation. Figure 2 shows the activation and deactivation pattern in four of the 14 subjects.

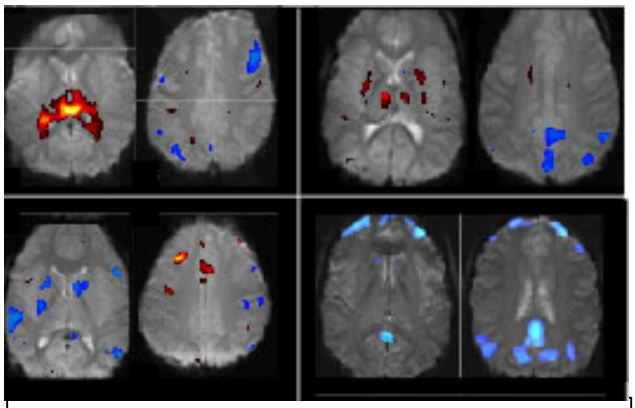

Figure 2:
fMRI/EEG data of study 1 (top left), study 2 (top right), study 5 (bottom left) and 13 (bottom right). Data analysed with SPM99, areas of activation shown in warm colours, areas of deactivation in cold colours. Threshold $p<0.05$, corr (study 1,2 and 13), $p<0.001$, uncorr, (study 5). Note the interindividual differences of the activation and deactivation pattern: Thalamic activation was noted in study 1 and 2, signal change in other subcortical nuclei in study 2 ,5 and 12, signal change in the posterior cingulate in study 2, 5 and 13, and various areas of cortical activation or deactivation in all studies.

Discussion: Our study confirms that fMRI/EEG in IGE shows a mixed pattern of areas of activation and deactivation (1). This may be, at least partly, explained by the clinical heterogeneity of IGE. Similar to one of the previous studies (2), deactivation in the posterior cingulate was frequent. It may indicate areas of altered cortical excitability. .Another previous study presented a single case with atypical, prolonged absences, during which bilateral thalamic activation was present (3). In our study, thalamic activation was only found in two patients, both had clinical absences during scanning. This may support that the thalamus is particularly activated in the ictal state. Signal change in other subcortical nuclei was mainly found in patients in which rhythmic bursts were not associated with clinical absences, and may reflect inhibition of these discharges.

References:

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