EEG-correlated diffusion-weighted fMRI in epilepsy

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Introduction

Diffusion-weighted imaging (DWI) has been shown to be sensitive to the cellular changes occurring following stroke. DWI detects diffusion changes in the animal brain in epileptic events (1), but there are many difficulties in humans. These are mainly associated with the extreme motion-sensitivity of the diffusion sequence which effectively precludes study of any ictal events in which there is movement. Cardiac gating is normally used to mitigate these effects, however epileptic seizures are associated with cardiac arrhythmia and the resulting variable TR renders this approach ineffective for snap-shot EPI-based DWI. We have detected diffusion changes in diffusion in both the grey and white matter in a patient in simple partial status (2), but a more robust approach is needed to study less severe ictal events. We have developed a method of recording EEG safely in the scanner (3) and used EEG-correlated fMRI to reproducibly localise areas of epileptic activity (4). Here we report our preliminary results of EEG-triggered DWI where we correlated changes in diffusion with EEG activity.

Methods

The subject was a 47-year old woman with a 7-year history of complex partial seizures. EEG-correlated fMRI was performed as described previously (4) (matrix 128x128 FOV 24cm, TE 40 ms, TR 30 s, 10 5mm slices in 4s), with a typical delay of 2s between the EEG event (spike or rest) and the start of gradient-echo EPI acquisition. In a separate study, EEG-correlated DWI was performed with similar timings and parameters except as noted (matrix 64x64, FOV 24cm, TE 78ms, TR 30 s, delta 28ms, DELTA 35ms, b 700s/mm², 10 5mm slices in 2.5s). The data was transferred to an off-line workstation for processing. 3D-registration with through-plane spin-history correction was used to motion-correct and detrend the data (5). A t-test was used (6) to detect areas of significant change between those epochs identified as having EEG spikes and those having no spikes. In-plane clustering was applied to remove small activations that were unlikely to be of biological significance.

Results

Activation maps for the gradient-echo and DWI exams are shown in figure 1 at a confidence level of 95%. The slice shown for both studies contains an area of activation in the left temporal region that was identified from the fMRI study as being strongly correlated with the area localised by the EEG. In spite of the larger variation in the DWI data, similar areas are activated in the left temporal region, though the area is less extensive.

Discussion

While the delay associated with the Haemodynamic Response Function facilitates concurrent acquisition of EEG and MRI data for an EEG-correlated fMRI experiment, it is likely that the diffusion changes associated with epileptiform events follow a different time-scale. Simultaneous EEG and MRI acquisition would be needed to observe more rapid changes. Using the approach to data acquisition and processing developed for fMRI, EEG-correlated DWI offers the possibility of detecting changes in diffusion reflecting shrinkage of extracellular cell space or neuronal swelling, and this information, particularly taken in combination with other functional data, may lead to new insights about the mechanisms of seizures in epilepsy.

References


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