Comparison between 2dTCA and EEG/fMRI to localize interictal activity in Temporal Lobe Epilepsy

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Introduction

Functional MRI (fMRI) has the potential for non-invasively localizing interictal epileptic activity more accurately than other clinical methods. While currently the gold standard for detecting the timing of interictal activity during the fMRI scan is simultaneous electroencephalography (EEG) [1], there are several practical obstacles to using this method [2,3]. Therefore, data-driven methods may offer alternative or complementary information. The objective of this work is to compare a data-driven method, 2dTCA [4-5], to EEG/fMRI in temporal lobe epilepsy. The results presented here are the first step in this comparison, specifically focusing on the qualitative comparison of the activation maps.

Methods

Patients with either unilateral or bilateral temporal lobe epilepsy determined by standard clinical evaluation were recruited for this study. Functional MRI imaging was performed with a 3T MRI scanner (Philips Healthcare, Inc., Best, Netherlands) using T2* weighted, gradient-echo, echo planar BOLD fMRI scans with subject instructed to hold still with eyes closed (64 x 64, 3.75 mm x 3.75 mm, FOV = 240 mm, 4.5 mm thick/0.5 mm gap, TE=35 ms, TR = 2 sec, 200 volumes per series, 2 series per subject). Simultaneous EEG was acquired using a Neuroscan EEG system (Neuroscan Compumedics, Charlotte, NC) with either a 64 channel cap or 25 individual gold leads (Ives EEG Solutions, Manotick, Ontario, CA). Images were analyzed using SPM5 software and the 2dTCA algorithm [4-5]. The EEG data were analyzed using the Neuroscan Scan software including gradient artifact removal and ballistocardiogram artifact removal.

Results

A total of 13 patients were successfully imaged with fMRI and simultaneous scalp EEG. Six of these had no spikes detected on EEG. The remaining seven patients had scalp EEG spikes detected and the EEG data were compared to the 2dTCA maps. In these seven, the 2dTCA yielded an average of 3 maps containing focal areas of activity per subject. The seven EEG and 2dTCA activation datasets were compared qualitatively paying particular attention to the correspondence of activation in mesial temporal lobes/hippocampus, lateral temporal lobes and thalamus which may be expected to be engaged in these patients. In 6/7 patients there was agreement (5 with overlap) in activated regions
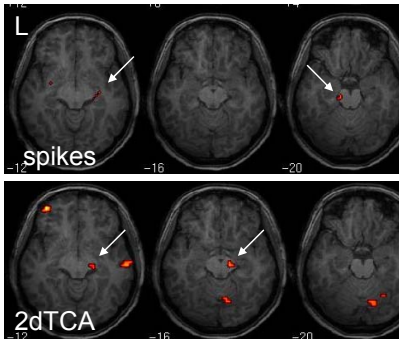
between the spike map and at least one 2dTCA map. In 4/7 the 2dTCA included mesial temporal/hippocampal activation (usually bilateral) not included in the spike map. In six patients, thalamic activation was present in at least one 2dTCA map that was not found in the spike map. Overall, there was good qualitative agreement between the two methods with the 2dTCA maps showing more mesial temporal activation concurring with the presumed epileptogenic region in these patients.
Example 1: The figure shows the EEG spike and one of three 2dTCA maps of a patient with right ictal and bilateral interictal mesial temporal discharges detected in the Epilepsy Monitoring Unit (EMU) with video EEG. The spike map (T>2 cluster 5) shows bilateral mesial temporal activation while the 2dTCA map (T>3 cluster 5) shows only right mesial temporal activation overlapping with the spike map.
Example 2: In one patient with independent right and left ictal discharges detected in the EMU, the spike map showed bilateral lateral temporal activation. The 2dTCA analysis yielded 6 maps (more than any other patient with expected unilateral TLE) with one showing bilateral lateral temporal (similar to the spike map) and bilateral mesial temporal activation. Another 2dTCA map showed bilateral insula activation. One map contained only left mesial temporal, lateral temporal and thalamic activation, while one contained only right mesial temporal, lateral temporal and thalamic activation. This suggests that 2dTCA can accurately detect the independent left and right discharges.

Discussion and Conclusion

This qualitative comparison of the activation maps is only the first step in a thorough assessment of the relationship between these two methods. Further analysis on more patients including comparisons of EEG timing to 2dTCA timing are currently being performed. However, these results show that the 2dTCA is a promising technique which may be able to detect interictal activity at least as well as simultaneous EEG methods without the need for the additional hardware, software, analyses and scalp EEG spikes required for that method.

This work was supported by NIH EB00461 and NIH NS055822. [1] Gotman J. *Epilepsia* 2008;49(Suppl.3):42-51. [2] Di Boneventura C, et al. *Epilepsia* 2006;47(Suppl.5):52-58. [3] Flanagan D, et al. *Clin Neurophysiol*. 2009;120:1637-1647. [4] Morgan VL, et al. *HBM* 2008;29:57-69 [5] Morgan, et al *HBM* 2009;30:3393-3405.