Positive default-mode activation in epilepsy using 2dTCA

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Introduction

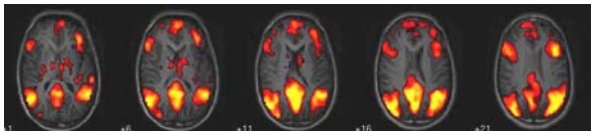
The default-mode network of the brain first described by Raichle et al [1], which includes the posterior cingulate cortex (PCC), the ventral anterior cingulate cortex (ACC), and the bilateral inferior parietal cortex (IPC), is postulated to support the baseline attention state of the brain at rest. In healthy subjects these regions are negatively activated using a task-rest paradigm. Similarly, these regions have demonstrated primarily negative fMRI activation resulting from epileptic spiking in studies with simultaneous EEG/fMRI in generalized epilepsy [2-7]. Kobayashi et al. [8] also found negative activation due to EEG spiking in default-mode regions in approximately 12% of focal epilepsy patients. The objective of this study was to determine whether generalized and focal epilepsy patients experienced significant transient BOLD spiking in the default-mode regions independent of EEG spiking.

Methods

Two separate fMRI data sets on different groups of epilepsy patients were acquired. One set was performed in collaboration with the University of Cincinnati, Cincinnati, OH. This group included seven patients with frequent generalized spike and wave discharges SWD on interictal EEG. Two to three series of fMRI data (20 minutes each) were collected per patient at 4T. The second group included 17 temporal lobe epilepsy patients with focal spiking on EEG who were imaged on a 3T MRI scanner (Philips Medical Systems, Cleveland, OH). Two to three sets of fMRI data (6.5 minutes each) were acquired per subject with eyes closed at rest.

Each fMRI dataset was preprocessed including slice timing correction, motion correction and spatial smoothing. Next, the 2dTCA algorithm [9] was used to determine reference time courses indicating when significantly large clusters of voxels had significantly large transient signal increases. The reference time courses resulting from the 2dTCA clustering analysis were incorporated into the general linear model with the motion regressors to determine activation maps. Each subject's activation map(s) were qualitatively compared to the default-mode regions. The datasets were analyzed for positive and negative BOLD spiking separately.

Results



Of the seven generalized epilepsy patients with SWD on EEG, five had positive activation maps consisting of primarily PCC and IPC regions strongly correlating with the default-mode regions. The two remaining subjects had positive activation maps with primarily PCC activation without IPC. Activation in the ACC across subjects was variable.

The negative activation maps much more loosely resembled the default-mode regions in all subjects. Of the 17 temporal lobe epilepsy patients, 11 showed clear positive default-mode activation (see Figure) and 5 showed clear negative activation in the PCC and IPC with some subjects showing involvement of the ACC.

Discussion

The 2dTCA algorithm detected significant *positive* transient BOLD signal changes much more frequently than *negative* ones in the default-mode network in the epileptic subjects studied. In studies using simultaneous EEG/fMRI, only *negative* BOLD signal changes were detected following EEG spikes. The *positive* spikes detected by 2dTCA were large enough to be detected from the background noise, but in many cases the *negative* spikes were not. This indicates that the *negative* activation reported in the literature was detected primarily due to its loose timing relationship to the EEG discharges, and less likely due to large amplitude. Many have postulated than the *negative* activation of the default-mode network following an EEG spike is manifested as a state of altered consciousness resulting from EEG discharges. These results suggest that the frequent *positive* spiking activation of the default-mode network independent of scalp EEG discharges may play an equal role in the understanding and characterization of these patients and that additional research is required.

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