

## NONINVASIVE IMAGING TECHNIQUE DEMONSTRATES SOURCE OF INTERICTAL EPILEPTIFORM DISCHARGES

### *f*MRI Activation in Continuous and Spike-triggered EEG–*f*MRI Studies of Epileptic Spikes

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**PURPOSE:** To evaluate functional magnetic resonance imaging (*f*MRI) with simultaneous EEG for finding metabolic sources of epileptic spikes. To find the localizing value of activated regions and factors influencing *f*MRI responses.

**METHODS:** Patients with focal epilepsy and frequent spikes were subjected to spike-triggered or continuous *f*MRI with simultaneous EEG. Results were analyzed in terms of *f*MRI activation, concordance with the location of EEG spiking and anatomic MRI abnormalities, and other EEG and clinical variables. In four patients, results also were compared with those of intracerebral EEG.

**RESULTS:** Forty-eight studies were performed on 38 patients. Seventeen studies were not analyzed, primarily because no spikes occurred during scanning. Activation was obtained in 39% of 31 studies, with an activation volume of  $2.55 \pm 4.84$  cc. Activated regions were concordant with EEG localization in almost all studies and confirmed by intracerebral EEG in four patients. Forty percent of patients without an MRI lesion showed activation; 37.5% of patients with a lesion had an activation; the activation was near or inside the lesion. Bursts of spikes were more likely to generate an *f*MRI response than were isolated spikes (76% vs. 11%;  $P < 0.05$ ).

**CONCLUSIONS:** Combining EEG and *f*MRI in focal epilepsy yields regions of activation that are presumably the source of spiking activity. These regions are highly linked with epileptic foci and epileptogenic lesions in a significant number of patients. Activation also is found in patients with no visible MRI lesion. Intracerebral recordings largely confirm that these activation regions represent epileptogenic areas. It is still unclear why many patients show no activation.

### COMMENTARY

Localization of the epileptogenic zone, that is, the site of seizure onset and initial seizure propagation, is pivotal in the evaluation and treatment of patients with intractable partial epilepsy. The use of noninvasive diagnostic techniques may assist selection of patients for surgery and help to plan operative strategies for placement of intracranial EEG electrodes and for focal cortical resection. The limitations of the scalp-recorded EEG to localize the anatomic source of interictal epileptiform discharges in patients with intractable partial epilepsy have been recognized. The sensitivity and specificity of interictal epileptic spikes to localize the epileptic brain tissue is significantly less favorable in patients with extrahippocampal, neocortical seizures. The absence of a structural magnetic resonance imaging (MRI)-identified lesional pathology in these individuals hinders selection of patients for surgical management of a pharmacoresistant seizure disorder.

Functional MRI (*f*MRI) has been shown to permit accurate cortical localization of the sources of sensory, movement, and language stimulation. The blood oxygenation level-dependent response is analyzed to indicate the location of neuronal activity during the *f*MRI studies. Previous attempts at *f*MRI during ictal epileptiform activity have revealed appropriate focal activation at the site of seizure onset. Ictal imaging is technically difficult because of movement artifacts and the random occurrence of partial seizures.

The present study by Al-Asmi et al. at the Montreal Neurological Institute investigates the diagnostic yield of *f*MRI to localize the source of interictal epileptiform discharges in 38 patients with partial seizure disorders. All the patients had “frequent focal or multifocal” interictal epileptiform discharges during long-term EEG monitoring. Forty-eight studies using spike-triggered *f*MRI ( $n = 16$ ) or continuous *f*MRI ( $n = 32$ ) were evaluated. *f*MRI activation occurred in 39% of the 31 studies that showed interictal epileptic spikes. The localization of the neuroimaging focal abnormality was highly concordant with the extracranial or intracranial, or both, EEG patterns. The diagnostic yield of continuous *f*MRI studies with off-line EEG processing was superior to spike-triggered activation. The pattern of the epileptiform discharges was a significant predictor of *f*MRI activation, that is, “bursts” were superior to single spikes.

Structural MRI findings did not appear to be a significant determinant of *f*MRI activation. Finally, four of eight patients who underwent intracranial EEG monitoring had a localized *f*MRI alteration. The focal activation appeared concordant with the ictal-onset zone in these patients.

The investigators provide additional evidence that continuous *f*MRI with off-line postprocessing of the EEG is possible and that this noninvasive neuroimaging technique may indicate the anatomic source of interictal epileptic spikes (1,2). Continuous EEG-*f*MRI studies may assist surgical planning by identifying the epileptogenic zone. The *f*MRI focal activation should be considered in patients undergoing implantation of intracranial EEG electrodes. The limitation associated with this technique is the number of patients with focal and multifocal spikes who do not show *f*MRI activation (>60% in the present study). The predictive value of *f*MRI activation in patients undergoing epilepsy surgery will require further study.

Ultimately, the clinical application of continuous EEG-*f*MRI studies will depend on establishing the relation between the ictal-onset zone, as determined by prolonged intracranial EEG monitoring, and focal *f*MRI activation in a larger patient cohort, as well as demonstrating a favorable effect on operative outcome.

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## References

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