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Advanced Imaging Tools in the Evaluation of Epileptogenic Foci in the Pediatric Population

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Editorial

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Introduction

Focal cortical dysplasia (FCD) is a known cause of intractable epilepsy in the pediatric population. It is caused by disorganization of cortical neurons, which results in an epileptogenic focus that may be isolated or associated with other cortical malformations [1,2]. Many patients with FCD have medically intractable epilepsy that significantly affects their quality of life. Surgical excision of these lesions results in marked improvement or complete resolution of the epileptic episodes. FCD is the most frequently identified pathologic substrate in children undergoing epilepsy neurosurgery [2]. In a study performed by Cepeda, FCD (excluding tuberous sclerosis) was identified in 45.5% of operated patients from age 2 months to 19 years [3].

Magnetic resonance imaging, in conjunction with a battery of clinical and electrophysiologic studies, is routinely used in the preoperative evaluation of children with epilepsy [4,5]. Widely accepted MRI features of FCD include abnormal cortical thickness, blurring of the GM-WM junction, WM and GM signal abnormalities, focal enlargement of the subarachnoid spaces adjacent to the dysplastic lesions, abnormal gyral/sulcal patterns, and focal and/or lobar hypoplasia/atrophy [4]. However, advanced imaging MR tools may be helpful in increasing detection of these subtle lesions. Below is a quick summary of current and future advanced imaging techniques that can be used to evaluate these epileptogenic lesions.

Uses of Advanced Imaging Studies

Magnetoencephalography

Wilenius evaluated 34 patients with age range of 2-47 years with FCD with magnetoencephalography [6]. Inter-ictal magnetoencephalography spikes were observed in all patients except one. The agreement between magnetoencephalography localizations and the invasive studies was good in 69% of patients (9/13) with no corresponding anatomical anomaly on MRI.

Arterial Spin Labeling

Wintermark evaluated arterial spin labeling in 12 pediatric patients (7 with FCD and 5 controls) [7]. Of the 7 patients with FCD, only 2 had arterial spin labeling. In these two patients, they found that there was approximately double the perfusion and increased microvessel density in the area of FCD compared to normal adjacent tissue. They hypothesized that the increased perfusion associated in ictal states is not only due to the seizure, but to the increased density of microvasculature associated with the FCD. Blauwblomme, et al. described similar findings in 5 pediatric patients [8].

Magnetization Transfer Imaging

Rugg-Gunn evaluated 15 adult patients with malformations of cortical development (not FCD specifically) with magnetization transfer images maps with voxel by-voxel analysis [9]. They found that in 13 out of 15 patients there were areas of reduced magnetization transfer ratio in areas of FCD seen on MRI, which could be used to increase the identification of occult FCD.

Diffusor Tensor Imaging

Lee et al evaluated 12 patients with a mean age of 14.3 years with FCD using DTI demonstrating that even in cases of normal T2W signal, there were areas of decreased volume of fiber tracts associated with FCD lesions [10].

Voxel-Based Comparisons

Focke evaluated 25 patients with a median age of 38 and age range of 17-59years and compared them to 25 normal patients using Statistical Parametric Mapping ofT2 FLAIR sequences obtained at 3T [11]. Abnormal FLAIR signal detected on Statistical Parametric Mapping software was seen in 22/25 cases.

Positron Emission Tomography- Magnetic Resonance Imaging (PET-MR)

Maldonado evaluated 50 patients with FCD, 23 that had a negative 1.5T MRI scan [12]. He and his colleagues showed that abnormal FDG-PET metabolic changes associated with FCD lesions identified on anatomical MR obtained were present in 98%of patients, mostly hypometabolic (90%) versus hypermetabolic (8%).

Future Advanced Imaging Tools

Computer-Assisted Methods- 3D Cortical Mapping

Although there have been prior articles describing automated cortical mapping detection of FCD none to our knowledge have described a 3D cortical mapping technique using FreeSurfer to identify subtle lesions [13,14]. FreeSurfer is a software suite developed by the Massachusetts General Hospital that processes various forms of MR and fMRI data. 3D cortical mapping with measurements of cortical thickness based on FreeSurfer in pre-surgical patients may be used to improve diagnostic accuracy and post-operative outcome for these patients [15].

In very subtle findings, 3D cortical mapping may be useful, as areas of abnormally increased or decreased cortical thickness will be identified in a color-coded map, similar to computer-aided detection systems used in mammographic studies.

Conclusion

Identifying epileptogenic foci using MRI anatomical imaging alone can be very challenging for radiologist. The use of adjunct advanced imaging techniques, as those mentioned above, could increase the diagnostic accuracy for identifying these subtle lesions.

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