

## ILAE Commission Report

# Guidelines for Neuroimaging Evaluation of Patients with Uncontrolled Epilepsy Considered for Surgery

\*Commission on Neuroimaging of the International League Against Epilepsy

### 1. PREAMBLE

These guidelines apply to patients whose seizures have not been controlled by antiepileptic drugs and who are being evaluated for possible surgery. They are supplemental to the general "Recommendations for Neuroimaging of Patients with Epilepsy."

### 2. GOALS

In individual patients undergoing presurgical evaluation, neuroimaging should provide data on

- Delineation of structural and functional abnormalities in the putative epileptogenic region
- Prediction of the nature of structural pathology in the putative epileptogenic region
- Detection of abnormalities distant from the putative epileptogenic region
- Emerging goals include identification of brain regions important for normal function including primary sensorimotor function, language and memory, and the relation of these regions to the epileptogenic region.

### 3. TECHNIQUES

#### 3.1 General Considerations

To interpret neuroimaging data, it is important first to make correct seizure and epilepsy syndrome diagnoses.

When imaging is used as part of presurgical evaluation, strict standards for technique and interpretation must be used. Imaging results must be placed in the context of other clinical and laboratory data including clinical history, neurologic examination, video recordings of typical seizures, ictal and interictal EEG, and neuropsychological evaluation. Images should be re-

viewed by physicians experienced in the evaluation of patients with epilepsy.

Many neuroimaging tests are now available. They provide data of a differing and complementary nature. Minimal requirements for the number and types of tests have not yet been established.

#### 3.2 X-Ray CT Scanning

X-ray CT scanning can detect certain structural lesions, but will miss many small mass lesions including tumors and vascular malformations and most instances of hippocampal sclerosis and developmental cortical malformations. A negative CT scan conveys little information. For this reason, CT should not be relied on and usually does not need to be performed when magnetic resonance imaging (MRI) is available. Exceptions would include suspicion of small calcified lesions (e.g., cysticercosis).

#### 3.3 MRI

MRI is essential for presurgical evaluation. Even when a CT scan reveals an epileptogenic lesion, MRI often adds new and important data. Epilepsy surgery should never be contemplated without an MRI examination, apart from exceptional circumstances, such as a specific contraindication (e.g., cardiac pacemaker).

Both T<sub>1</sub>-weighted and T<sub>2</sub>-weighted images should be obtained, with slices as thin as possible. 3-D volume acquisition is preferable, but coronal as well as axial slices should be obtained in all cases. In rare cases gadolinium contrast enhancement may give useful additional information. Other sequences such as FLAIR (fluid-attenuated inversion recovery) may have a role in selected cases (e.g., if standard imaging is normal, or to clarify the significance of a possible focal abnormality).

In addition to careful qualitative evaluation of the hippocampus, quantitative assessment can be useful. Hippocampal volumetry requires side-to-side ratios as well as absolute volumes corrected for intracranial volume, which must be compared with appropriate controls from the same laboratory. T<sub>2</sub> relaxometry also quantitates hippocampal abnormalities and may show evidence of bilateral disease.

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### 3.4 Functional Magnetic Resonance Imaging (fMRI)

fMRI has been used in research settings to identify regions involved in sensorimotor function and language. Attempts are being made to identify seizure foci by showing altered signal during ictal episodes. fMRI is rapidly evolving as a clinical tool but requires a high degree of experience and technical expertise.

### 3.5 Magnetic Resonance Spectroscopy (MRS)

MRS has been used to detect chemical changes that may be associated with epileptogenic regions. At present MRS remains a research technique and is not applicable for routine clinical work.

### 3.6 Single Photon Emission Computed Tomography (SPECT)

Several compounds for cerebral SPECT are available and most in widespread clinical use have  $^{99}\text{Tc}$  as the radiotracer. Interictal scans alone, using cerebral blood-flow agents, are unreliable for identification of epileptogenic regions. In patients with complex partial seizures, ictal SPECT can be used to identify epileptogenic regions, but it is very important to inject the tracer as soon as the beginning of the seizure is detected. This calls for a high degree of organization and timing. Video-EEG is essential to establish the exact relation of isotope injection to EEG and clinical events. Even though  $^{99}\text{Tc}$  has a half-life of 6 h, it is better to perform the actual scan as soon as possible after injection, because dissociation of the tracer from the carrier may degrade the images if the delay is prolonged. Ictal scans should be compared with interictal baseline examination to detect subtle changes. Coregistration of ictal SPECT images with MRI can provide more precise information regarding localization of blood-flow changes.

Multiheaded cameras provide higher resolution than conventional single-headed instruments.

### 3.7 Positron-Emission Tomography (PET)

PET can measure a wide range of functions including cerebral neurotransmitter systems. To date, only interictal scans with fluorodeoxyglucose (FDG) to measure regional glucose metabolic rates and possibly central benzodiazepine receptor scans using [ $^{11}\text{C}$ ]flumazenil have been shown to be clinically useful markers of focal epileptogenic regions.

Although FDG-PET can provide absolute values for glucose metabolic rates if arterial blood measurements are made, it is more important to measure relative glucose utilization in regions suspected of being epileptogenic and comparing them with contralateral regions. It is helpful to monitor the EEG during PET studies, as unrecognized ictal activity could lead to otherwise unexplained increases in regional metabolism.

Other tracers are appropriate for research purposes. [ $^{15}\text{O}$ ]labeled water has been used to map cognitive functions including speech. These studies are clinically promising, but presently remain in the research domain.

## 4. APPROACHES IN SPECIFIC CLINICAL SYNDROMES

### 4.1 Localization-Related (Partial, Focal) Epilepsies

In patients with the clinical syndrome of refractory mesial temporal lobe epilepsy, properly performed MRI will provide supporting evidence for localization of the epileptogenic region in a high proportion of cases. Ictal SPECT and interictal FDG-PET also appear to be sensitive in this clinical setting, and at least one of these should be considered if MRI is nonlocalizing.

In patients with suspected neocortical temporal lobe epilepsy and in extratemporal epilepsies, subtle structural lesions can be missed unless MRI is performed with optimal technical quality and is expertly interpreted. FDG-PET and ictal SPECT also can be valuable in this clinical setting, although fewer data are available regarding their sensitivity, specificity, and relation to favorable surgical outcome, compared with mesial temporal lobe epilepsy.

Correlation of structural and functional imaging data is essential. Coregistration of images from different modalities by using postprocessing software is extremely useful, particularly when putative abnormalities are subtle.

### 4.2 Symptomatic Generalized Epilepsies

Some children with infantile spasms have focal epileptogenic regions, typically in the posterior quadrants, composed of malformations of cortical development, that may be treatable by focal cortical resection. These lesions may be identified on MRI studies or suspected on interictal PET and SPECT examinations when the EEG appears to be nonlocalizing.

Patients with other symptomatic generalized epilepsies such as Lennox-Gastaut syndrome should have an MRI to help determine the etiology. Focal cortical resection is rarely appropriate in such cases, but MRI is useful to plan potential corpus callosotomy. PET and SPECT have not shown consistent patterns of clinically useful information in these epilepsies.

### 4.3 Postoperative Imaging

Postoperative MRI is useful to document the extent of surgical resection or tract division. It should be done a minimum of 3 months after surgery and is particularly useful when investigating cases of surgical failure or complications.