Epilepsy is a common disorder, affecting approximately 0.5% to 1.0% of the United States population at any time with an incidence of 30.9 to 56.8 per 100,000. It has been estimated that about 7%–8% of the population experiences at least 1 epileptic seizure during their lifetimes. The basic mechanism of epileptic seizures has not been fully elucidated. The classification of epileptic seizures by the International League Against Epilepsy was last revised in 1989 (Table 1). The classification is important because etiologic diagnosis, appropriate treatment, and accurate prognostication all depend on the correct identification of seizures and epilepsy. There are 2 main seizure types: partial seizures and primary generalized seizures. Partial (formerly referred to as focal) seizures show either clinical or EEG evidence of onset from a localized area within the cerebral hemisphere. The nature of the signs and symptoms in most cases indicate the region of the brain involved by the epileptic process. Partial seizures are designated as simple or complex. Complex partial seizures are associated with loss of consciousness. In simple seizures, the epileptic process is usually confined to neocortical structures, and the limbic system and brain stem are spared. Most simple seizures are less disabling than those associated with loss of consciousness. Partial seizures can spread and develop into secondarily generalized seizures. Primary generalized seizures originate simultaneously from both cerebral hemispheres, and clinical manifestations involve both sides of the body. Primary generalized seizures first occur at an earlier age, and are more likely to be associated with a family history of seizure disorders, but are less likely to be associated with focal cerebral lesions. Some seizures remain unclassified because the underlying mechanism of their origin or propagation is unknown.

Certain types of seizure disorders are likely to be associated with structural brain lesions, including tumors, infection, infarction, traumatic brain injury, vascular malformations, developmental abnormalities, and seizure-associated brain pathology, whereas others are not. Hence, knowledge of seizure types helps to determine whether neuroimaging is clinically indicated and what type of study is appropriate (Table 2).

While the imaging evaluation of epilepsy was greatly advanced by the clinical introduction of CT in the early 1970s because of its superior soft tissue contrast, multiplanar imaging capability, and lack of beam hardening artifacts, virtually all the substrates of epilepsy are visualized with greater sensitivity and accuracy by MR imaging. As a result, MR imaging has become the technique of choice for high-resolution structural imaging in epilepsy. Although routine evaluation techniques of all clinically available scanner field strengths may be sufficient for determining mass lesions, optimized protocols for scans obtained on high-field (>1.5 T) scanners may be necessary for evaluating partial complex epilepsy, requiring scrutiny of the hippocampus and temporal lobe for atrophy and subtle signal intensity alteration, as well as for detecting certain structural abnormalities such as cortical dysplasias, hamartomas, and other developmental abnormalities. Anatomic imaging identifies focal abnormality in up to 51% of patients with partial epilepsy. With the widespread clinical availability of high-performance MR imaging systems, a comprehensive MR imaging examination, with functional techniques providing additional information, adding corroborative information, and improving overall accuracy, may in the future be of even greater value in epilepsy. Although the data provided by MR imaging are essential in the presurgical evaluation of patients with medically refractory epilepsy, structurally detectable abnormalities are absent in many patients. In these patients, functional studies provide useful information on the location of the seizure focus. Functional imaging techniques, including positron emission tomography (PET), single-photon emission CT (SPECT), magnetic source imaging (MSI), and functional MR imaging

Table 1: Outline of the International Classification of Epileptic Seizures

<table>
<thead>
<tr>
<th>I. Partial Seizures (seizures with focal onset)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Simple partial seizures (consciousness not impaired)</td>
</tr>
<tr>
<td>1) With motor signs</td>
</tr>
<tr>
<td>2) With somatosensory or special-sensory symptoms</td>
</tr>
<tr>
<td>3) With autonomic symptoms or signs</td>
</tr>
<tr>
<td>4) With psychic symptoms (disturbance of higher cerebral functions)</td>
</tr>
<tr>
<td>ii) Complex partial seizures (consciousness impaired)</td>
</tr>
<tr>
<td>1) Starting as simple partial seizures</td>
</tr>
<tr>
<td>a) Without automatisms</td>
</tr>
<tr>
<td>b) With automatisms</td>
</tr>
<tr>
<td>c) With impairment of consciousness at onset without automatisms (impairment of consciousness only)</td>
</tr>
<tr>
<td>iii) Partial seizures evolving into secondarily generalized seizures</td>
</tr>
<tr>
<td>II. Generalized Seizures</td>
</tr>
<tr>
<td>i) Absence seizures and atypical absence seizures (may have the following components):</td>
</tr>
<tr>
<td>Mild clonic, atonic, tonic, or autonomic activities, or automatic behavior</td>
</tr>
<tr>
<td>ii) Myoclonic seizures</td>
</tr>
<tr>
<td>iii) Clonic seizures</td>
</tr>
<tr>
<td>iv) Tonic seizures</td>
</tr>
<tr>
<td>v) Tonic-clonic seizures</td>
</tr>
<tr>
<td>vi) Atonic seizures</td>
</tr>
<tr>
<td>III. Unclassified Epileptic Seizures</td>
</tr>
</tbody>
</table>

This article is a summary of the complete version of this topic, which is available on the ACR Website at www.acr.org. Practitioners are encouraged to refer to the complete version.

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terictal perfusion imaging alone. Injection of the blood flow guided surgery datasets is proving to be more useful than in-

jection imaging with coregistration on MR imaging and image-

abnormality is limited. The use of ictal/interictal subtrac-

perfusion assessment in patients without anatomic imaging

on ictal examinations. The utility of isolated interictal cerebral

examinations and will be seen as a focus of increased activity

typically manifest as a focus of hypoperfusion on interictal

blood flow rather than brain metabolism. A seizure focus will

99mTc-HMPAO or 99mTc-Neurolite, as well as bolus MR

55% and 78%. SPECT utilizing perfusion agents such as

strengths and techniques yielded a sensitivity and specificity of

sensitive and 95% specific to extratemporal epilepsy. By compar-

ison, structural imaging by using a variety of MR field

strengths and techniques yielded a sensitivity and specificity of

55% and 78%. SPECT utilizing perfusion agents such as

99mTc-HMPAO or 99mTc-Neurolite, as well as bolus MR

imaging perfusion provide an assessment of regional cerebral

blood flow rather than brain metabolism. A seizure focus will

typically manifest as a focus of hypoperfusion on interictal

examinations and will be seen as a focus of increased activity

on ictal examinations. The utility of isolated interictal cerebral

perfusion assessment in patients without anatomic imaging

abnormality is limited. The use of ictal/interictal subtraction

imaging with coregistration on MR imaging and image-

guided surgery datasets is proving to be more useful than in-

terictal perfusion imaging alone. Injection of the blood flow

agent within 90 seconds of seizure onset does, however, appear
to be required to demonstrate the expected localized increase

in cerebral perfusion. The use of perfusion techniques in

epilepsy is therefore limited because of the technological chal-

lenge of injecting EEG-monitored patients within 90 seconds of

seizure onset.

fMRI techniques include phosphorus and proton spectroscopy
(MR spectroscopy), perfusion, and blood oxygen level
dependent (BOLD) activation. The widespread application of
most of these techniques in clinical practice depends on the
widely available of high-performance MR imagers ca-

pable of performing fast echo-planar pulse sequences (EPIs),
as well as substantial data postprocessing capabilities.

MR spectroscopy is a set of noninvasive techniques for in-
vivo chemical analysis of the brain, some of which can be per-
formed on standard-performance clinical MR units. Although
MR spectroscopy has been used extensively for the past 30
years in molecular physics and chemistry, its application to the
study of epilepsy is relatively recent. Widely available proton
and phosphorus single-voxel techniques have consistently
demonstrated metabolite changes in the epileptogenic region

of the brain. MR spectroscopy or chemical shift imaging (CSI)
allows simultaneous acquisition of spectra from all brain re-

gions. The pictorial display of MR spectroscopy information
facilitates comparison of the epileptogenic zone with the re-

mainder of the brain and provides localizing information. CSI

is not yet widely available in clinical practice. Initial studies
suggest that both proton and phosphorus MR spectroscopy
may be useful adjunctive presurgical tests for localizing seizure
foci in patients with partial epilepsy, particularly in difficult
cases, potentially reducing the need for intracranial-depth

electrode EEG recordings and those with extratemporal sei-

zure foci.

Only magnetoencephalography (MEG) and EEG are capa-

ble of measuring epileptic brain activity directly and with high
temporal resolution. The temporal resolution of PET, SPECT,
and fMRI is poor by comparison (sec-min). Recent improve-

ments in MEG technology now allow whole brain coverage
and overlay of source information on MR or CT images (MSI).
Available data indicate that interictal MEG can be an effective
tool for localization of seizure foci, in patients with medically
refractory partial epilepsy. Significant shortcomings include
limited availability, high cost, and assessment limited to rela-
tively superficial and tangential sources. Nonetheless, MSI
does provide unique, accurate, and useful information about
epileptogenic regions in the brain, and where available, has a
potential role in the diagnostic workup of most patients with
epilepsy.

Review Information
This guideline was originally developed in 1996. The last re-

view and update was completed in 2006.

Appendix
Expert Panel on Neurologic Imaging: John P. Karis, Principal
Author, SW Neuro-Imaging, Phoenix, AZ; David J. Seidenwurm,
MD, Panel Chair; Patricia C. Davis, MD; James A. Brunberg, MD;
Roberto Luis De La Paz, MD; Pr. Didier Dormont; David B.
Hackney, MD; John E. Jordan, MD; Suresh Kumar Mukherji,
MD; Patrick A. Turski, MD; Franz J. Wippold II, MD; Robert D.
Zimmerman, MD; Michael W. McDermott, MD, American As-
sociation of Neurological Surgeons; Michael A. Sloan, MD, MS,
American Academy of Neurology.

References
1. Hauser WA, Hesdorffer DC. Epilepsy: frequency, causes and consequences. New

York: Demos; 1990:1–51

Table 2: Clinical condition: epilepsy

<table>
<thead>
<tr>
<th>Clinical condition: epilepsy</th>
<th>MRI head without contrast</th>
<th>MRI head without and with contrast</th>
<th>CT head without and with contrast</th>
<th>CT head without contrast</th>
<th>FDG-PET head</th>
<th>SPECT head</th>
<th>fMRI head</th>
<th>MSI</th>
<th>MRA head</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic epilepsy, poor therapeutic response. Surgery candidate.</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>New onset seizure. ETOH. and/or drug related.</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>New onset seizure. Aged 18–40 years.</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>New onset seizure. Older than age 40.</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>New onset seizure. Focal neurological deficit.</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Rating Scale: 1, least appropriate; 9, most appropriate.

May be helpful in pre-op planning.

Data probably equivalent to BOLD and SPECT.

May be helpful in pre-op planning.
22. Wiesmann UC. Clinical application of neuroimaging in epilepsy. J Neurol Neurosurg Psychiatry 2003;74:466–70