By Steven Karceski, MD

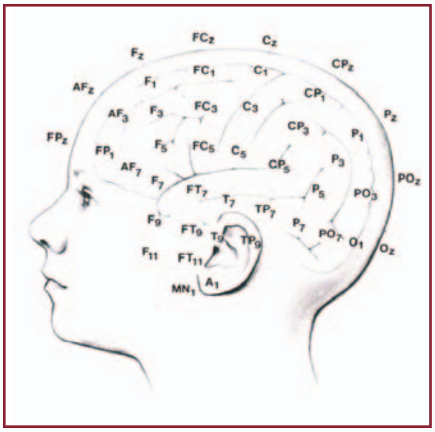
How to Get More Out of Your EEGs

Electrodiagnostic testing helps to localize seizure activity and improve clinical management. Here's advice on administration and interpretation of the test.

Although much of the focus in clinical epilepsy (in this column and elsewhere) tends to be on the medical management challenges, electrodiagnostic tools play an important role and deserve greater attention. Electroencephalography (EEG) is commonly performed to either narrow a differential diagnosis or to confirm or support a clinician's suspicion. Video-EEG combines video capture with EEG, and by recording the events directly, can be essential identifying the cause of episodes of transient neurological dysfunction. In addition, video-EEG is important in identifying the region of seizure onset in people with refractory seizures: the results of this test may be used to plan for a non-medical treatment such as epilepsy surgery. Whether used as a routine outpatient test or in the form of a detailed inpatient evaluation, every neurologist should be familiar with the utility and limitations of this test.

EEG: An Overview

During an evaluation of episodic neurological dysfunction, it is customary to combine tests such as neuroimaging and electrophysiology in the form of EEG. The neuroimaging documents structural lesions while the EEG identifies abnormalities in brain wave patterns: more specifically, EEG measures the summated electrical potentials generated by the cerebral cortex. EEG may be helpful in one of two ways. First, the clinician may record the events directly (events are also called *ictus*, and a recording of these events is also called an *ictal EEG*). Second, EEG may be recorded between events (also called an *interictal EEG*). Interictal EEG may identify specific abnormal patterns called epileptiform discharges: these are specific summated



potentials that occur more often in persons with epilepsy. Focal epileptiform discharges occur in partial (localization related) epilepsies while generalized epileptiform discharges indicate a generalized epilepsy syndrome.[1] Of the two, interictal EEG is the more commonly performed test, accounting for nearly all outpatient EEGs.

As with almost any test, the quality of the EEG directly impacts the usefulness of the test. Most laboratories have adopted the international 10-20 system of electrode placement (see the figure above), a standardized method for EEG recording. The 10-20 system is flexible, and easily accommodates additional electrodes. Special electrodes such as anterior temporal electrodes should be included in persons with suspected partial epilepsy, since the temporal lobe is the most common region where epileptiform discharges are identified. Montages that use transverse chains of electrode pairs that extend from one ear to the other further enhance the ability to detect temporal lobe abnormalities (since the temporal lobes are so close to the ears).[2] Nasopharyngeal electrodes are generally no longer used: they are uncomfortable, and are prone to artifact.

Careful attention must be paid to electrode placement *and* to the way the EEG is recorded. For instance, during interictal EEG recording, the ability to record an interictal epileptiform discharge will depend on whether or not the person was able to fall asleep during the EEG itself. Adachi showed that an EEG that records sleep increases the chance of identifying an epileptiform discharge. In this series of 83 patients with temporal lobe epilepsy, 51.8 percent had a lateralized epileptiform discharge while awake, and 78.3 percent showed a lateralized epileptiform abnormality when the EEG included sleep.[3]

During the EEG recording, hyperventilation and photic stimulation are often performed. The reason for this is that these maneuvers increase the likelihood of identifying an epileptiform abnormality. For instance, hyperventilation may induce an absence seizure, and can activate generalized 3 Hz spike and wave in up to 80 percent of persons with idiopathic generalized epilepsy. In a person with partial epilepsy, hyperventilation only increases the likelihood of identifying an epileptiform discharge in six to nine percent. In a similar way, photic stimulation is better at activating generalized rather than focal epileptiform discharges.

Another factor to consider is the effect that medication use may have on the EEG: a detailed EEG report should include this information. For instance, some AEDs like benzodiazepines and barbiturates decrease the likelihood of recording an interictal epileptiform discharge.[4] Conversely, the abrupt withdrawal of barbiturates may cause activate generalized epileptiform discharges. Valproate dramatically reduces interictal generalized discharges; it has a less dramatic effect on the occurrence of focal interictal epileptiform discharges.[5]

Not every EEG in a person with epilepsy is abnormal: even when a technically good study is performed on a person with known epilepsy, the EEG may not record an epileptiform discharge. Using serial EEGs in people with known epilepsy, Ajmone-Marsan and Zivin (1970) looked at the presence or absence of epileptiform discharges.[6] One recording showed epileptiform discharges in 56 percent. Repeated EEGs captured characteristic abnormalities in an additional 26 percent. Salinsky et. al (1987) found that four EEGs brought the yield for epileptiform abnormalities to 90 percent.[7] In short, when seizures are suspected, and the first EEG is "negative," additional EEGs may help to confirm the diagnosis by increasing the likelihood of identifying an epileptiform discharge.

Interictal EEG

Localized epileptiform discharges and focal slowing are characteristic of partial epilepsy. Epileptiform discharges can occur as either spikes or sharps: by definition, spikes are waveforms of more than 20 msec but less than 70 msec duration while sharps are more than 70 msec but less than 200 msec. Sharps and spikes may be distinguished from background activity with a pointed peak (hence the name), according to the Committee on Terminology of IFSECN. They are generally surface-negative.

Interictal spike may be confused with normal transients. Central vertex waves, mu rhythms, benign epileptiform transients of sleep (also called *small sharp spikes*), rhythmic mid-temporal theta of drowsiness with spikes (wicket spike), positive occipital sharp transients (POSTs), and even EMG and electrode artifact may appear to be epileptiform. By evaluating the state in which the discharges occur, some of the "confusion" can be eliminated: for instance, midtemporal theta and POSTS occur in sleep.

However, even with careful testing, distinguishing what is epileptiform and what is normal can be challenging. In general, epileptiform discharges often appear in all states of arousal, while normal variants are state dependent. This does not mean epileptiform discharges occur with equal frequency in all states. In fact, they tend to occur more often in sleep. The electroencephalographer must consider all potential normal variants before declaring a sharp transient to be epileptiform. In addition, special care must be taken when interpreting EEG from the region of a skull defect. When a skull defect is present, brain wave patterns will appear "sharper," and can be mistaken for epileptiform discharges.

Ictal EEG

Generalized epilepsy syndromes cause seizures that are generalized in onset. Just as the interictal discharge is generalized (often maximal bifrontally), so too is the ictal pattern. For instance, a typical absence seizure is characterized by 3 Hz spike-and-wave. A myoclonic seizure may appear as a generalized polyspike-and-wave discharge.

Partial seizures vary considerably depending on the region of cortex from which they arise. Although rhythmic discharges in the gamma, beta, alpha or theta frequency range may occur, other patterns have been described. Holmes et. al described 69 partial seizures: 74 percent showed initial beta activity, 22 percent initial theta, and only four percent began with spikes.[8] A sudden flattening or attenuation in background activity (desynchronization or suppression) may occur in up to 10 percent of partial seizures.[9] Finally, the ictus may begin with a *disappearance* of interictal spikes.

Sperling and Clancy offer advice to the electroencephalographer when interpreting ictal EEG (often in the form of video-EEG, as many of these recordings are performed on an inpatient basis):[10]

1. During some seizures, electrical activity may be completely obscured by muscle and movement. A diagnosis of seizures may still be offered if the pattern of muscular contractions is stereotyped or if it is followed by postictal slowing of EEG frequencies.

2. The scalp EEG usually does not show ictal discharges during simple partial seizures because of their restricted potential fields. This is especially true of simple partial seizures arising from the medial, basal and interhemispheric cortices.

3. The scalp EEG may not detect ictal discharges during complex seizures of frontal lobe origin.

Conclusions

EEG can be invaluable in the diagnosis of a seizure disorder. However, a "negative" EEG does not rule out this diagnosis. When seizures are highly suspect, repeat EEG may be needed in order to identify epileptiform discharges. If one EEG does not record sleep, a second may be needed that does so (and is therefore more likely to pick up the abnormality). When the interictal EEG fails to capture abnormalities (and seizures are suspected), ictal EEG may then be needed. If the test results are confusing or do not seem to support the clinical diagnosis, a consult with an epilepsy center may be needed. **PN**

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