The scalp electroencephalogram (EEG) is the most valuable and simplest laboratory test available for the evaluation of patients with suspected epilepsy. Although not absolute, there is a strong correlation between interictal discharges in the EEG and a clinical diagnosis of epilepsy. Epilepsy remains, however, a clinical diagnosis with the EEG providing the supporting evidence. The old dictum in epilepsy, "don't treat the EEG" is generally valuable, but sometimes an EEG abnormality is the only objective data one has to treat a patient. A significant number of technical factors increase the yield of this test as follows: duration of recording, use of sleep deprivation, medication reductions, montages and electrodes used.

Definition. The interictal abnormalities refer to findings in the EEG between seizures and these have been traditionally described as transients of faster frequency than the background, specifically spikes and sharp waves with associated slow potentials. Of course, focal slowing without these transients may be persistent over the abnormal area or intermittent and indicate also dysfunctional areas of great importance. Focal slowing (theta, delta) may sometimes be the only abnormality seen in temporal lobe epilepsy (TLE).

Interictal abnormalities in TLE. Interictal abnormalities are a form of epileptiform activity, a generic term used to describe waves associated with epilepsy. However, not all epileptiform abnormalities are interictal, namely small sharp spikes (SSS) variants are epileptiform but are not associated with epilepsy but rather occur in healthy patients and may be mistaken for interictal discharges. In temporal lobe epilepsy, EEG interictal discharges are seen in a large percentage of patients with one series reporting 91% correlation of this with seizures as compared to other areas. (Kellaway 1991)

Spikes. Spike morphology. Like a familiar face a spike is difficult to describe but easy to recognize. It has been defined by the Committee on Terminology of the IFSCEN as "...a transient, clearly distinguished from the..."
background, with pointed peak”. A more specific definition is: a sudden transient of less than 70 milliseconds duration, with multiple phases (bipolar or tripolar) or crossings of the baseline. Spikes tend to have a faster ascending or initial phase than other transients. Spikes are almost always associated with a longer slow wave of different amplitudes and frequencies and their initial component is usually surface negative due to the radial orientation of pyramidal dipoles that is usually perpendicular to the crown of the gyri of the cortex. Some normal transients may look like spikes, for example vertex sleep waves in children which can be very sharp, electromyogram spikes associated with lateral rectus muscle activity and seen in the anterior temporal electrodes (F7 or F8), or electrode “pop” artifacts. Spikes or benign nature are also: 14, 6 positive spikes, phantom spike and wave and others. Computerized software templates to identify spikes are difficult to use, and cannot identify accurately. Human eye recognition is more discriminative, and remains the ideal method of EEG analysis. Utilization of different montages to maximize the localization and identification of transients cannot be stressed enough. Spikes vary in morphology from moment to moment, a phenomenon (Frost 1985) that has been ascribed to the variation in synchrony of different groups of spike foci identified in cortical recordings and that undermine the actual spikes seen in the distant scalp electrodes.

**Spike localization.** In temporal lobe epilepsies, spikes may be detected at a number of scalp or other electrodes utilized in routine EEG recordings. Usually over anterior temporal, or sphenoidal electrodes. The International 10-20 systems of electrode placement or the modified nomenclature of extra electrodes should be used to assist in outlining the focus and in selected cases the iso-potential maps of spikes. The localization of spikes varies between studies to nearby electrodes. The spike foci correlates partially with the site of origin of seizures or epileptogenic zones but sometimes seizures may originate in contiguous areas. This is difficult to determine without using cortical electrodes and it can be said "that interictal spikes represent the tip of the iceberg”

**Use of special electrodes.** Special electrodes introduced nearer the generators may enhance the detection of spikes in temporal lobe epilepsies. These overcome the barrier of bone, which is a significant attenuator of spike amplitude, and take advantage of the presence of foramina near the temporal lobe base, for example as foramen ovale electrodes, and possibly sphenoidal electrodes. There is controversy if sphenoidal are better than T1 or T2 or submaxillary sites (Kanner et al) nasopharyngeal or naso-ethmoidal electrodes are no longer used.

**Location of interictal activity in the scalp.** Temporal lobe epilepsy may produce interictal EEG abnormalities at multiple scalp electrodes or not at all, as in mesio-temporal epilepsy, where they may be so localized and not reach the scalp or other electrodes. The topography of spikes seems to vary more in children. We must remember that for an EEG signal to be registered in a scalp electrode it is necessary that 6cm² of cortex beat in synchrony!!

**Sharp waves morphology.** Spikes are occasionally easier to define and identify than sharp waves. The more classical sharp waves are those seen in the benign rolandic epilepsies over the centro temporal area - usually T4 or T5 or mid-temporal area. Sharp waves can be defined as: abrupt changes in the voltage of the EEG by faster potentials, usually with a following slow wave, with the transient lasting more than 70 msec but less than 200 msec. One can say that "sharp waves you can sit on but not spikes”. Sharp waves can be the EEG nightmare being occasionally difficult to identify. It is believed that SW are farther from the seizure generator area than spikes. In most cases, SW alternate with spikes in temporal lobe epilepsies, also a reflection of this variation in foci synchrony we alluded to above. Repetitive sharp waves well defined and clearly standing out of the background can be easily identified as epileptic associated rhythm.

**Ictal EEG in TLE. Long-term monitoring units.** Recording of a seizure is the best way to prove a seizure disorder exists. This can, in cases, be very important, as interictal EEG abnormalities may co-exist with psychogenic or non-epileptic seizures. However, it is difficult to record seizures in most laboratories unless Long-Term Monitoring (LTM) Video-EEG facilities, fully staffed by experienced EEG technologists, are available - as in tertiary referral centers. Regular EEG laboratories may maximize recording results by the following techniques:

**Ambulatory EEG.** Ambulatory digital EEG recording, when available, may be of some diagnostic utility when attempting to classify symptoms and spells, but is not adequate for surgical evaluations and for accurate identification of seizure foci. These 24-48 hour recordings are technically challenging and fraught with artifacts, and lack good clinical observation by trained staff to correlate with the EEG.

**Ictal patterns in TLE.** Ictal EEG patterns are interestingly different from interictal ones. This is especially true in TLE, but not in absence seizures, where the same pattern (3/sec spike/wave) repeats itself. The reason for this is not known, but it is speculated that absence patterns arise out of cortico-thalamic interaction, and not out of focal cortical discharges - as in TLE and other partial seizures. Paroxysmal depolarization shifts and other neurophysiological discharges are the basis for the spikes seen in surface recordings (Figure 1). A number of different EEG patterns may be seen during TLE seizures as follows: rhythmic variably sinusoidal lateralized discharges in theta frequency range (4-6 Hz) (Figure 2) followed by higher amplitude slower
frequency pattern and then variable lateralized spikes. This is the pattern seen in 2/3 of cases (Blume et al 1984). Initial focal flattening over the temporal electrodes may be seen in approximately 10% of cases. A delayed focal ictal pattern, namely, after an initial generalized slowing, shows good localization if it occurs after the first 10 seconds. If the seizure becomes secondarily generalized, the EEG will show further transition to repetitive generalized continuous spikes (tonic) and then intermittent cluster of spikes (clonic).

Neurophysiological basis. The transition of the interictal to the ictal patterns that occur in the partial epilepsies are the subject of interesting studies. The suggestion that interictal spikes are actually a manifestation of an active inhibitory system are bolstered by the findings of several investigators (Rodin 1974, Gottman 1989) that spike counts actually increase after a seizure.

The ictal EEG patterns witnessed on scalp recordings are initially different that those seen during depth electrode recordings and there is a significant variable lag between surface and depth onset as well as different patterns not to be reviewed at this time but of great interest to the Neurophysiologist.

Focal rhythmic delta over temporal lobe electrodes of several seconds duration has been associated with the seizure focus and is considered an ictal EEG equivalent.

Further Reading