TEMPORAL LOBE EPILEPSY: A CLINICAL VIEW POINT

Background: Temporal lobe epilepsy (TLE) was defined in 1985 by the International League Against Epilepsy (ILAE) as a condition characterized by recurrent unprovoked seizures originating from the medial or lateral temporal lobe. The seizures associated with TLE consist of simple partial seizures without loss of awareness (with or without aura) and complex partial seizures (ie, with loss of awareness). The individual loses awareness during a complex partial seizure because the seizure spreads to involve both temporal lobes, which causes impairment of memory.

TLE was first recognized in 1881 by John Hughlings Jackson, who described "uncinate fits" and the "dreamy state." In the 1940s, Gibbs et al introduced the term "psychomotor epilepsy." The international classification of epileptic seizures (1981) replaced the term psychomotor seizures with complex partial seizures. The ILAE classification of the epilepsies uses the term temporal lobe epilepsy and divides the etiologies into cryptogenic (presumed unidentified etiology), idiopathic (genetic), and symptomatic (cause known, eg, tumor).

Pathophysiology: Hippocampal sclerosis is the most common pathologic finding in TLE. Hippocampal sclerosis involves hippocampal cell loss in the CA1 and CA3 regions and the dentate hilus. The CA2 region is relatively spared.

For more information, see Pathophysiology in the article Seizures and Epilepsy: Classification and management.

Frequency:

In the US: Approximately 50% of patients with epilepsy have partial epilepsy. Partial epilepsy is often of temporal lobe origin. However, the true prevalence of TLE is not known, since not all cases of presumed TLE are confirmed by video-EEG and most cases are classified by clinical history and interictal EEG findings alone. The temporal lobe is the most epileptogenic region of the brain. In fact, 90% of patients with temporal interictal epileptiform abnormalities on their EEG have a history of seizures.

History:

Aura

• Auras occur in approximately 80% of temporal lobe seizures. They are a common feature of simple partial seizures and usually precede complex partial seizures of temporal lobe origin.

• Auras may be classified by symptom type; the types comprise somatosensory, special sensory, autonomic, or psychic symptoms.

Somatosensory and special sensory phenomena

• Olfactory and gustatory illusions and hallucinations may occur. Acharya et al found that olfactory auras are associated more commonly with temporal lobe tumors than with other causes of TLE.

• Auditory hallucinations consist of a buzzing sound, a voice or voices, or muffling of ambient sounds. This type of aura is more common with neocortical TLE than with other types of TLE.

• Patients may report distortions of shape, size, and distance of objects.

• These visual illusions are unlike the visual hallucinations associated with occipital lobe seizure in that no formed elementary visual image is noted, such as the visual image of a face that may be seen with seizures arising from the fusiform or the inferior temporal gyrus.

• Things may appear shrunken (micropsia) or larger (macropsia) than usual.

• Tilting of structures has been reported. Vertigo has been described with seizures in the posterior superior temporal gyrus.
Psychic phenomena

- Patients may have a feeling of déjà vu or jamais vu, a sense of familiarity or unfamiliarity, respectively.
- Patients may experience depersonalization (ie, feeling of detachment from oneself) or derealization (ie, surroundings appear unreal).
- Fear or anxiety usually is associated with seizures arising from the amygdala.
- Patients may describe a sense of dissociation or autoscopy, in which they report seeing their own body from outside.

Autonomic phenomena are characterized by changes in heart rate, piloerection, and sweating. Patients may experience an epigastric “rising” sensation or nausea.

Physical Signs:

- Following the aura, a temporal lobe complex partial seizure begins with a wide-eyed, motionless stare, dilated pupils, and behavioral arrest. Oral alimentary automatisms such as lip smacking, chewing, and swallowing may be noted. Manual automatisms or unilateral dystonic posturing of a limb also may be observed.
- Patients may continue their ongoing motor activity or react to their surroundings in a semipurposeful manner (ie, reactive automatisms). They can have repetitive stereotyped manual automatisms.
- A complex partial seizure may evolve to a secondarily generalized tonic-clonic seizure.
- Patients usually experience a postictal period of confusion, which distinguishes TLE from absence seizures, which are not associated with postictal confusion. In addition, absence seizures are not associated with complex automatisms. Postictal aphasia suggests onset in the language-dominant temporal lobe.
- Most auras and automatisms last a very short period—seconds or 1-2 minutes. The postictal phase may last for a longer period (several minutes). By definition, amnesia occurs during a complex partial seizure because of bilateral hemispheric involvement.

Causes:

Approximately two thirds of patients with TLE treated surgically have hippocampal sclerosis as the pathologic substrate.

- The etiologies of TLE include the following:
  - Past infections, eg, herpes encephalitis or bacterial meningitis
  - Trauma producing contusion or hemorrhage that results in encephalomalacia or cortical scarring
  - Hamartomas
  - Gliomas
  - Vascular malformations (ie, arteriovenous malformation, cavernous angioma)
  - Cryptogenic: A cause is presumed but has not been identified.
  - Idiopathic (genetic): This is rare. Familial TLE was described by Berkovic and colleagues, and partial epilepsy with auditory features was described by Scheffer and colleagues.

Hippocampal sclerosis produces a clinical syndrome called mesial temporal lobe epilepsy (MTLE). MTLE begins in late childhood, then remits, but reappears in adolescence or early adulthood in a refractory form.

Febrile seizures: The association of simple febrile seizure with TLE has been controversial. However, a subset of children with complex febrile convulsions appear to be at risk of developing TLE in later life. Complex febrile seizures are febrile seizures that last longer than 15 minutes, have focal features, or recur within 24 hours.
Diagnostic work-up

Imaging Studies:

- **MRI is the neuroimaging modality of choice for patients with TLE.**
  - Thin coronal oblique slices of 1.5-2 mm with no gap using spoiled gradient recall images (SPGR) are recommended.
  - All patients with newly diagnosed TLE should have a high-resolution MRI.
  - High-resolution MRI shows hippocampal atrophy in 87% of patients with TLE by visual analysis alone. Hippocampal atrophy is bilateral in 10-15% of cases. An increase in the T2-weighted signal intensity in the hippocampus may be seen on fluid-attenuated recovery (FLAIR) MRI; this finding is also consistent with hippocampal sclerosis.
  - **Positron emission tomography with 18-fluorodeoxyglucose (PET-FDG) is a useful tool for interictal seizure localization in surgical candidates when the MRI result is normal.**
    - It usually is performed as an adjunctive measure to delineate the epileptogenic zone.
    - Interictal deficits include reduced glucose metabolism in the medial and lateral temporal lobe.
    - Ictal PET recordings are rare.
  - **Single-photon emission computed tomography (SPECT) is also an adjunctive imaging modality useful only for surgical candidates; the accuracy of seizure localization is about 80-90%.**
    - Ictal SPECT done with hexamethylpropyleneamine oxime (HMPAO) shows hyperperfusion in the region of seizure onset. The characteristic pattern is hyperperfusion of the medial and lateral temporal lobe. This requires ictal injection within 30 seconds of seizure onset.
    - Interictal SPECT testing is less sensitive than FDG-PET and ictal SPECT and is not used routinely for localization of the epileptogenic zone.
    - Investigational techniques such as MR spectroscopy may become clinically useful in the future in selected surgical candidates with normal MRI.

Other Tests:

Interictal EEG should be performed in all patients with suspected TLE.

- Interictal abnormalities, consisting of spike/sharp and slow complexes, usually are located in the anterior temporal region (F7/F8 and T3/T4 electrodes) or basal temporal electrodes (T9/T10 and F9/F10).
Anterior temporal spikes (or sharp waves) are the EEG cornerstone for the diagnosis of temporal lobe epilepsy (commonly recorded at F7, F8 electrodes). Anterior temporal or frontal midline theta activity is occasionally the EEG correlate of temporal lobe epilepsy. Marked unilateral temporal polymorphic delta activity is very suggestive of a rapidly growing temporal lobe tumor.

The spike (sharp wave) discharge is bilateral in about 25 to 35% of the cases. Patients with bilateral anterior temporal spikes (sharp waves) are more likely to have both psychomotor and grand mal seizures. Sleep has an important role in the facilitation of temporal spikes.

Brain tumor is rarely discovered in patients with bilateral independent temporal spikes. Patients with unilateral spikes often prove to have mesial temporal sclerosis.

Above age 50-60 yr, the anterior temporal spike or sharp wave is, in most cases, a simple exaggeration of temporal minor sharp activity, which is extremely common in elderly patients with mild or moderate degrees of cerebrovascular disorder and no seizure disorder whatsoever.

Children and young adolescents with temporal lobe epilepsy and unequivocal complex partial seizures often have inconclusive EEG findings. Spikes or sharp waves may be over midtemporal or central regions (thus falsely suggestive of benign Rolandic epilepsy) or diffuse. Even generalized spike wave discharges may occur and slow spike wave complexes may overshadow all other abnormalities when one deals with a case of Lennox-Gastaut syndrome giving rise to psychomotor seizures.

Temporal lobe epilepsy (as an electroclinical syndrome) is usually found in older adolescents and in young and middle-aged adults; childhood and senium tend to dilute the clinical and EEG semiology. In particular the anterior temporal spikes or sharp wave focus is not well developed in young children as it takes a while to develop. In older age the anterior temporal spike or sharp wave is, in most cases, a simple exaggeration of temporal minor sharp activity, which is extremely common in elderly patients with mild or moderate degrees of cerebrovascular disorder and no seizure disorder whatsoever.

**Table 1** Electroclinical characteristic of temporal lobe epilepsy.

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- The spike (sharp wave) discharge is bilateral in about 25 to 35% of the cases. Patients with bilateral anterior temporal spikes (sharp waves) are more likely to have both psychomotor and grand mal seizures. Sleep has an important role in the facilitation of temporal spikes.
- Brain tumor is rarely discovered in patients with bilateral independent temporal spikes. Patients with unilateral spikes often prove to have mesial temporal sclerosis.
- Above age 50-60 yr, the anterior temporal spike or sharp wave is, in most cases, a simple exaggeration of temporal minor sharp activity, which is extremely common in elderly patients with mild or moderate degrees of cerebrovascular disorder and no seizure disorder whatsoever.
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**Medical Care:**

- About 47-60% of new-onset partial seizures are controlled effectively by the first drug. Studies in 1985 and 1992 by the Department of Veterans Affairs (VA) have shown that the 4 major antiepileptic drugs (AEDs), phenytoin, phenobarbital, carbamazepine, and valproate, are equally effective in controlling partial seizures; however, phenobarbital and valproate have more severe adverse effects.
- The newer AEDs, such topiramate, lamotrigine, levetiracetam, oxcarbazepine, and zonisamide have similar if not better efficacy than the older AEDs. In patients with newly diagnosed epilepsy, lamotrigine appears to be significantly better than carbamazepine in terms of tolerability and health-related quality of life issues.
- Four other drugs were approved in the year 2000 by the US Food and Drug Administration (FDA) for treatment of partial seizures. These include zonisamide, oxcarbazepine, and levetiracetam.
- About 40% of patients continue to have seizures in spite of trials with 3 AEDs. Semah and colleagues showed that seizures are more likely to be refractory to AEDs in patients with hippocampal sclerosis.
Mesial temporal sclerosis consists of cell loss and astrogliosis in the mesial temporal cortex, the hippocampal formation, amygdala, parahippocampal gyrus, and entorhinal cortex. These changes have been best described in the hippocampus, partly due to its severe involvement and the lamellar pattern of hippocampal organization that lends itself to histopathologic study. Two forms of hippocampal cell loss have been identified in mesial temporal sclerosis. Classic sclerosis, also known as Ammon’s horn sclerosis, is the more frequent form. This consists of marked loss of the pyramidal cells in CA1, CA3, and the dentate hilus, with sparing of pyramidal cells in the CA2 sector. The second form is denoted as end folium sclerosis, which consists primarily of cell loss and astroglial proliferation in the end folium with relative sparing of the other sectors. Autopsy studies have demonstrated that mesial temporal sclerosis is present bilaterally, in up to 80% of cases. However, it is usually asymmetric in that one side is more severely involved than the other; the more severely involved of the two hippocampi typically denotes the site of origin of a patient’s seizures.

The MR image counterparts to these two pathologic abnormalities are atrophy and signal change. Hippocampal atrophy is best identified on T1-weighted images obtained coronally or, ideally, perpendicular to the principal axis of the hippocampal formation, which is variably canted downward from posterior to anterior. The identification of atrophy by MR imaging corresponds to cell loss identified in histologic specimens.

The other principal finding is a signal intensity change consistent with increased tissue-free water resulting in decreased signal intensity on T1-weighted images and an increased signal intensity on T2-weighted images. It is logical to assume that the abnormality in signal intensity is a function of astrogliosis proliferation. Several other findings on MR images have been helpful in identifying the temporal lobe predominantly involved in mesial temporal sclerosis; these include (1) loss of normal internal architecture of the involved hippocampus; (2) unilateral atrophy of the mammillary body; (3) unilateral atrophy of the columns of the fornix; (4) unilateral atrophy of the amygdala; and (5) unilateral atrophy of white matter bundle in the parahippocampal gyrus.

**Surgical Care:**

**Vagus nerve stimulation**

- Vagus nerve stimulation (VNS) was approved by the FDA in 1997 for treatment of intractable partial epilepsy for patients aged 12 years and older. VNS with a high-frequency stimulation rate resulted in a mean reduction in seizure frequency of 25-28%. The exact mechanism by which it exerts its antiepileptic effect is not known. A battery-operated stimulator device is implanted in the left vagus nerve subcutaneously in the neck.

- Adverse effects include hoarseness of voice, cough, local pain, paresthesias, dysphagia, and dyspnea. VNS does not have the adverse effects associated with AEDs.

**Anterior temporal lobectomy**

- Temporal lobectomy is the definitive treatment for medically intractable TLE (see article Identification of Potential Epilepsy Surgery Candidates). When seizures are not controlled by 2 different AED trials, the patient should be considered for a presurgical evaluation. These patients are not likely to achieve seizure control with medications alone (5-10% chance of becoming seizure free).

- The presence of unilateral hippocampal sclerosis and concordant EEG findings predict seizure-free outcome in patients considered for surgery. Foldvary and colleagues showed that a higher monthly preoperative seizure frequency is associated with a less favorable surgical outcome (see article Outcome of Epilepsy Surgery).

- An extensive presurgical assessment for the feasibility of surgery is essential. This includes MRI, interictal and ictal EEG, neuropsychological testing, and the intracarotid amobarbital test.

- Seizure-free state at 2 years postoperatively is predictive of long-term seizure-free outcome. In well-selected cases, 70-80% of patients with refractory TLE become seizure free after surgery (see article Outcome of Epilepsy Surgery).

**MESIAL TEMPORAL SCLEROSIS**

Mesial temporal sclerosis consists of cell loss and astrogliosis in the mesial temporal cortex, the hippocampal formation, amygdala, parahippocampal gyrus, and entorhinal cortex. These changes have been best described in the hippocampus, partly due to its severe involvement and the lamellar pattern of hippocampal organization that lends itself to histopathologic study. Two forms of hippocampal cell loss have been identified in mesial temporal sclerosis. Classic sclerosis, also known as Ammon’s horn sclerosis, is the more frequent form. This consists of marked loss of the pyramidal cells in CA1, CA3, and the dentate hilus, with sparing of pyramidal cells in the CA2 sector. The second form is denoted as end folium sclerosis, which consists primarily of cell loss and astroglial proliferation in the end folium with relative sparing of the other sectors. Autopsy studies have demonstrated that mesial temporal sclerosis is present bilaterally, in up to 80% of cases. However, it is usually asymmetric in that one side is more severely involved than the other; the more severely involved of the two hippocampi typically denotes the site of origin of a patient’s seizures.

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Although all of these findings may occur in cases of mesial temporal sclerosis, the author believes that the small, bright hippocampus is the most reliable. Both of these findings are usually present in an individual patient. In some patients with mesial temporal sclerosis, however, the hippocampus may appear to be normal-sized but of increased signal, or atrophic without an obvious signal abnormality. Studies of the accuracy of visual perception have demonstrated that predominantly unilateral mesial temporal sclerosis can be identified with an accuracy of about 90% by knowledgeable readers. Although the unilateral dilatation of the temporal horn has been suggested as a useful marker of mesial temporal sclerosis, the author regards this finding as unreliable. Whereas this exists in cases of severe hippocampal atrophy because of mesial temporal sclerosis, it is not a reliable indicator of mesial temporal sclerosis because it also occurs as a common normal variant.

As mentioned, mesial temporal sclerosis is found bilaterally in approximately 80% of autopsy cases. However, the goal of imaging and the assumption underlying treatment by temporal lobectomy would indicate that in most cases of mesial temporal sclerosis, only one of the temporal lobes actually produces seizures. This apparent discrepancy is best explained by regarding the entire spectrum of mesial temporal sclerosis in four categories: (1) category I, one hippocampus is entirely normal and the other is abnormal; (2) category II, one hippocampus is slightly abnormal and the other severely abnormal; (3) category III, both hippocampi are abnormal to an equal degree; and (4) category IV, both hippocampi are normal. Clinical experience to date indicates that in category II patients, the more severely involved hippocampus typically represents the site of seizure onset. It is the distinction between categories I/II and III/IV that appears to be the most critical, both in terms of surgical outcome and imaging identification of the substrate of epilepsy.

Patients in categories I and II both respond well following removal of the abnormal temporal lobe. Furthermore, visual identification of the more abnormal hippocampus is fairly straightforward when there is a significant side-to-side discrepancy in volume and signal intensity. On the basis of imaging criteria, however, it is impossible to identify the more involved hippocampus in categories III and IV because, by definition, the two hippocampi are either symmetrically abnormal or symmetrically normal. These two categories appear to have a similarly mediocre response to temporal lobectomy: fewer than 50% of patients are seizure free postoperatively.
Epilepsy is defined as "paroxysmal transient disturbances of brain function that may be manifested as episodic impairment or loss of consciousness, abnormal motor phenomena, psychic or sensory disturbances, or perturbation of the autonomic nervous system. A seizure, or ictus epilepticus, is an epileptic attack or recurrence. The classification of epilepsies used by International League Against Epilepsy (ILAE) includes two major categories: partial epilepsies and generalized epilepsies. A partial seizure disorder is considered to have a focal region of onset in the brain, and awareness may be either preserved (simple partial seizure) or lost (complex partial seizure). A generalized seizure disorder is considered to involve most, if not all, of the brain at onset. The generalized seizure types may involve cessation of activity with loss of awareness (absence seizure) or generalized tonic-clonic activity (generalized tonic-clonic seizure). Both partial and generalized seizure disorders are further subdivided into idiopathic and symptomatic types, previously called primary and secondary, respectively. Idiopathic epilepsies are thought to be genetically heritable, are associated with normal intelligence, and occur during specific age periods. The symptomatic epilepsies are likely the result of a CNS injury, which in a symptomatic partial epilepsy consists of a focal lesion and in a symptomatic generalized epilepsy consists of diffuse cerebral abnormality. Symptomatic epilepsies are typically lifelong conditions.

It cannot be overemphasized that the diagnosis of epilepsy is based primarily on the clinical history. As noted above, a clinical seizure rarely occurs during an EEG, and thus the EEG is rarely diagnostic of a seizure disorder or epilepsy. In a large, population-based EEG study by Zivin and Ajmone-Marsan [2] involving subjects without a history of seizures, approximately 2 percent of the subjects had EEGs with epileptiform discharges. Of the individuals in this subgroup, only 15 percent subsequently developed a seizure disorder. Therefore, epileptiform discharges seen on an EEG should not be referred to as interictal discharges unless it is known that the patient has a clinically defined seizure disorder. Focal or generalized epileptiform discharges should be noted as consistent with the interictal expression of either a partial or a generalized epilepsy, respectively. When applied in the appropriate clinical setting, the EEG is useful in classifying the seizure type, predicting the long-term outcome, and choosing the appropriate antiepileptic medication.

Overall, symptomatic partial seizure disorders are the most common type of epilepsy. The clinical semiology of the partial seizure generally depends on the site of onset. In children, focal epileptiform discharges arising from the temporal region have the greatest incidence of clinical seizures, ranging from 85 to 95 percent. The next highest incidence (70 to 75 percent) is associated with frontal discharges. The central, parietal, and occipital regions have the lowest incidence of seizures related to epileptiform discharges, estimated at 40 to 70 percent. In addition to the characteristics of recorded epileptiform activity, the age of the patient and the presence or absence of neurological deficits on examination are important factors that are helpful in determining the clinical significance of epileptiform discharges and in classifying the partial seizure disorder as either symptomatic or idiopathic. The occurrence of a clinical seizure with a focal electrographic correlate is diagnostic of a partial epilepsy. Blume and colleagues [3] presented several types of scalp EEG correlates for partial seizures, most of which began with rhythmic sinusoidal activity or repetitive sharp wave activity that subsequently evolved in frequency. Most patients with complex partial seizures were noted to have a scalp correlate on the EEG. Patients with simple partial seizures were less likely to have a scalp correlate.

The best-defined idiopathic partial epilepsy is benign rolandic epilepsy. The classic EEG finding in this childhood seizure disorder is a characteristic monomorphic centrotemporal sharp wave. The sharp waves are often seen independently in the centrotemporal and adjacent regions, and they are accentuated by light sleep. The waking background rhythm is generally normal.

Of the idiopathic generalized epilepsies, the absence seizure is the most common type. The interictal EEG feature of this type of seizure disorder consists of generalized, high-amplitude, anteriorly predominant 3-Hz spike and wave discharges, called typical 3-Hz spike and wave. When the spike and wave discharges occur repetitively, they are called bursts. Although these discharges are called "3-Hz," the initial frequency of the burst is 3 to 4 Hz, and the frequency may slow to 2.5 Hz during more prolonged bursts. The discharges are reactive to alerting maneuvers and may become fragmented in deeper stages of sleep. Juvenile myoclonic epilepsy (JME) is another type of idiopathic generalized epilepsy. The spike and wave discharges of this seizure disorder are also generalized and anteriorly predominant, but they have an initial frequency of 4 to 6 Hz and may begin with a polyspike discharge. The EEG of a patient with an idiopathic generalized epilepsy who is maximally alerted is generally normal. During photic stimulation, there may be a photoparoxysmal response in both absence epilepsy and JME, which may be helpful in classifying recognized epileptiform discharges as consistent with an idiopathic generalized epilepsy rather than a symptomatic partial or generalized epilepsy.

Epileptiform patterns in symptomatic generalized epilepsies are of three types. A slow spike and wave pattern at approximately 2 Hz is seen in patients with mental retardation having multiple seizure types (atypical absence, tonic, atonic, or tonic-clonic seizures), which is known as the Lennox-Gastaut syndrome. A second type of interictal or ictal EEG pattern seen in patients with symptomatic generalized epilepsy is generalized paroxysmal fast activity (GPFA), which consists of bursts of rhythmic, generalized beta activity. When the bursts are seen during wakefulness, they are commonly accompanied by a tonic seizure. During sleep, bursts of GPFA not accompanied by clinical changes are considered an interictal pattern. The third pattern of epileptiform activity in secondary generalized epilepsy is an atypical generalized spike and wave pattern, consisting of generalized 3 to 6-Hz spike or polyspike and wave activity. The waking background in patients with secondary generalized epilepsies is abnormally slow, including slowing of the posterior background rhythm and generalized slowing.

In patients suspected of having a seizure disorder, a normal routine, awake EEG should be followed with either a natural or medication-induced sleep EEG or a sleep-deprived EEG. Before the advent of long-term video-EEG monitoring for the diagnosis of possible seizures, three or more EEGs were often obtained to confidently conclude normality and absence of epileptiform activity. Because antiepileptic medications have been shown not to affect the frequency of focal interictal epileptiform discharges, the decision to treat a patient for a...
suspected partial seizure disorder should not be based solely on the initial EEG findings. Conversely, the EEG has not proven to be a reliable tool in predicting whether a patient's antiepileptic medication can be discontinued. In patients with an idiopathic generalized epilepsy, treatment with appropriate antiepileptic medication may eliminate all interictal epileptiform activity on the EEG. Therefore, the decision to discontinue an antiepileptic medication in a patient with a seizure disorder should be based on the type, etiology and response to medications of the seizures and not on interictal EEG findings.

**Table 2. Electroclinical criteria of spike/ sharp wave discharge**

- A spike is a transient, clearly distinguished from the background activity, with pointed peak at conventional paper speeds and a duration from 20 to under 70 msec; the main component is generally negative. Amplitude is variable. Spikes represent the basic element of paroxysmal activity in the EEG.

- A sharp wave is a transient, clearly distinguished from background activity, with pointed peak at conventional paper speeds and duration of 70 to 200 msec. The main component is generally negative relative to other areas.

- Both spikes and sharp waves have multiphasic characters, being composed of a sequence of a minor positive, a major negative, and a second minor positive component is typical in most instances. The long duration of a sharp wave permits better insight into the multiphasic character of this potential.

- The spike/sharp wave potentials are reliable indicators of a potential seizure focus because they result from the characteristic neurophysiological event "the paroxysmal depolarization shift" (PDS). This phenomenon consists of thousands of neurons simultaneously undergoing large depolarization with superimposed action potentials. Both synaptic events and intrinsic cellular currents have been implicated in this process. EEG spikes/sharp waves are due to the slow depolarization currents in the PDS. Neurons surrounding the focus are inhibited during the paroxysmal depolarization shift, and within the focus the paroxysmal depolarization shift is followed by a hyperpolarization potential. Both an increase in depolarizing events and a loss of inhibitory mechanisms can lead to persistence and propagation of the discharge as a seizure.

- Spikes and sharp waves are neurophysiologically closely related phenomena; both of them are typical paroxysmal discharges and highly suggestive of an epileptic seizure disorder, although both phenomena may occur in patients without a history of seizure disorder.

- The largest and most pronounced spikes are not necessarily associated with more serious epileptic seizure disorders. On the contrary, Rolandic spikes in a child age 4 to 10 yr are very prominent; however, the seizure disorder is usually quite benign or there may be no clinical seizures at all. Low voltage spiking in the frontal or anterior temporal regions is highly epileptogenic even though its amplitude can be so low to the point that these spikes might be completely drowned within the background waves and subsequently can not be easily detected.

![Figure 6. Examples of sharp waves (left) and spike (right)](image)
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References