THE ELECTRO-ENCEPHALOGRAM

Among the major categories of neurologic dysfunction that require evaluation by a neurologist are spells, reduced level of consciousness, and impaired thinking. As every neurologist knows, the challenge is to determine if the spells in any given individual are seizures, transient ischemic attacks, syncopal episodes, peripheral nerve disorders, or psychogenic disorders. Reduced levels of consciousness may result from a wide variety of traumatic, epileptic, infectious, and metabolic disorders. Degenerative diseases, metabolic disorders, central nervous system infection, tumors, and psychiatric disorders may all be responsible for impaired thinking. Each of these disorders impair function by producing anatomic or physiologic damage. Neuroimaging depicts the altered anatomy. Measuring electrical signals of the brain, the electroencephalogram (EEG) on the other hand assesses altered physiology of the brain that is often not apparent on imaging studies. The EEG is thus an essential part of the clinical evaluation of patients with seizures, transient symptoms, spells, confusion, cognitive disorders, decreased levels of consciousness, as well as with a host of acute insults to the brain. The EEG thus serves as an adjunct to the neurologic exam by evaluating cerebral function that is not accessible to clinical testing, and complements neuroimaging by providing evidence of physiologic changes that are not shown on imaging studies. The EEG can help determine the type, distribution, and severity of a disturbance of cerebral function.

An EEG records the electrical activity of the cerebral cortex generated primarily by cortical neurons. The EEG activity reflects electrical activity generated by synchronized postsynaptic potentials of the dendrites of cortical neurons. Postsynaptic potentials (PSPs), consisting of excitatory postsynaptic potentials (EPSPs) and inhibitory postsynaptic potentials (IPSPs), are generated at numerous synapses on dendrites in the cortex; the EEG activity results from summated EPSPs or IPSPs. Potassium and sodium are the principle ions generating the membrane potentials of neurons and neurotransmitters such as GABA, and calcium ions are involved in modulating the electrical activity generated by the neurons. The rhythmic EEG activity consists of synchronized oscillations of alternating EPSPs and IPSPs generated by activity in neighboring cortical regions and by thalamic cortical projections. Thalamic relay neurons play a major role in generating and synchronizing rhythmic activity. This reflects the presence of slow calcium, potassium, and sodium currents that result in spontaneous oscillations of the neurons and their membrane potentials. The thalamic reticular nucleus is also thought to be the primary source of sleep spindles; this nucleus is a major source of inhibitory GABA-ergic input to the thalamus and can produce spindles by inducing and synchronizing widespread thalamocortical oscillatory activity.

Thus, rhythmic EEG activity is due to intrinsic membrane properties of various groups of neurons, the synaptic connections of these neurons, and thalamocortical inputs that lead to synchronization of this activity. The activity recorded by the EEG, in turn, consists of continuous rhythmic or arrhythmic oscillating waveforms that vary in appearance, frequency, and amplitude.

There are four basic EEG frequency ranges: alpha, beta, theta, and delta (**figure 1**). *Alpha* frequencies are 8 to 13 Hz (c.p.s., or cycles per second) and are present over the posterior head regions. Alpha activity is reactive to eye opening and represents the background activity of the awake state. *Beta* activity is greater than 13 Hz and consists of low-voltage waves that occur predominantly over the anterior and central head regions. Beta activity is enhanced by drugs such as benzodiazepines and barbiturates. *Theta* activity, 4 to 7 Hz, appears normally in younger children and during drowsiness, but in other circumstances, theta slowing is a result of a mild to moderate disturbance of cerebral function. *Delta* activity, under 4 Hz, is observed in normal infants and during sleep states; in other settings, delta slowing reflects moderate to severe disturbance of cerebral function.

During sleep the EEG exhibits spindles, V-waves, and delta waves. *Sleep spindles* are 10 to 14 Hz, sinusoidal waves present over the frontal and parietal regions. *V (vertex) waves* are high amplitude, sharp waves occurring over the frontal and parietal regions. Both sleep spindles and V-waves are present during light to moderate levels of sleep, while widespread, high amplitude delta waves appear during deep sleep.

The major types of EEG abnormalities are epileptiform discharges, slow waves, asymmetry, and suppression of activity. Epileptiform

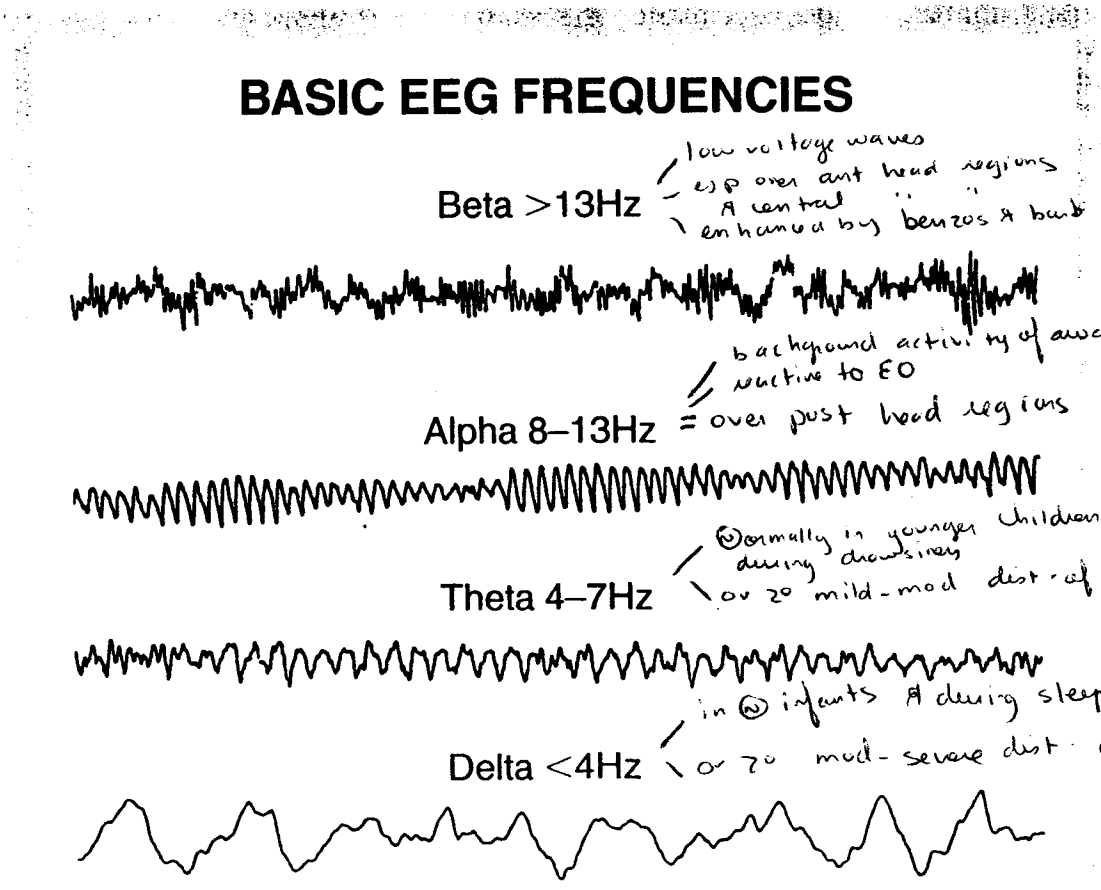

FIGURE 1 The four basic EEG frequencies.

abnormalities (spikes, sharp waves, and spike-and-wave complexes) are interictal (between spells) waveforms associated with an increased likelihood of clinical seizures. Slow activity may be slowing of the background or superimposed slow waves in the theta or delta range. An asymmetry is a decrease or increase in amplitude from one hemisphere as compared to the homologous region on the other hemisphere. Suppression is a significant reduction or attenuation or loss of EEG activity during the recording.

EEG abnormalities may be focal or generalized. Focal abnormalities indicate a localized disturbance of cerebral function, often from a focal lesion; generalized abnormalities occur with diffuse disturbances of function.

RECORDING THE ELECTROENCEPHALOGRAM

Routine Recordings

The EEG records spontaneous electrical activity of the brain using metal disk electrodes containing conductive jelly, which are attached to the scalp by collodion, paste, or a cap. The recording is made from pairs of electrodes in combinations of electrodes (montages), which record over different areas of the brain. Measurement and placement of the electrodes for EEG and evoked potentials utilize the international 10-20 system, which was first proposed in 1949 by the International Federation of Societies for EEG and Clinical Neurophysiology. The placement of the electrodes is determined by four landmarks: the nasion (at the bridge of the nose), the inion (at the occipital protuberance), and the preauricular areas just anterior to the tragus of the ear. Measurements are made from the nasion to the inion in an anterior posterior direction, between the preauricular points, in a transverse direction, and the circumference of the head at these points. The measurements are in terms of 10 or 20%, hence, the name 10-20 system of electrode placement. The electrodes are designated by an alphabetical numerical system with letters standing for the lobes of the brain: F for frontal, P for parietal, T for temporal, O for occipital, C for central, and Z for midline areas. Odd numbers designate the left side, even numbers the right side. In standard recordings, 21 electrodes are placed over the temporal, frontal, parasagittal, and midline regions. A diagram of the electrode placements is indicated in **figure 2**. Occasionally additional electrodes are used to localize focal epileptiform abnormalities. Since one type of montage may be inadequate to demonstrate the abnormality, a combination of different montages is utilized. Routine EEG recordings utilize 8 to 21 channels of recording. Monitoring studies may use up to 64 channels. Analog EEG instruments, recording the EEG activity on paper, had been the main stay of recording EEG activity in the past and are still being widely used. However, digital EEG instruments provide a number of capabilities not available with analog recordings. These include:

- Ease of obtaining, storing, and retrieving the data
- Signal processing such as reformatting montages, altering recording parameters, and enhancing selected waveforms
- Mathematical analysis of data, such as frequency analysis, quantitative analysis, coherence studies, spectral analysis, auto- and cross-correlation studies, contour and topographic maps, and pattern recognition

Digital recording is particularly useful in prolonged monitoring studies for collecting and analyzing EEG data and applying automated spike and seizure detection programs to facilitate recognition of events.

The EEG itself usually consists of 20 to 30 minutes of recording during

KEY POINT:

- Hyperventilation activates epileptiform discharges in 30 to 50% of patients with absence seizures and in 6 to 10% of patients with focal seizures.

the resting, wake state. Activation by hyperventilation and photic stimulation during the wake recording bring out abnormal activity that may not be present during the resting record. Hyperventilation can elicit both epileptiform abnormalities and seizures. This maneuver activates a 3-Hz generalized spike and wave discharge in 30 to 50% of patients with absence seizures, and focal discharges in 6 to 10% of patients with focal seizures. Focal slow wave abnormalities indicative of a focal disturbance of cerebral function can also be brought out by hyperventilation.

Photic stimulation activates evoked responses over the posterior head regions. An asymmetric driving response can be seen with unilateral occipital lesions. Photic stimulation also identifies the 2 to 3% of patients who have light hypersensitivity, manifested by paroxysmal epileptiform activity and seizures in response to the stimulation.

A sleep recording should be performed as part of the routine recording for evaluation of seizure disorders. Sleep enhances the presence of epileptiform activity and may demonstrate the presence of epileptiform activity that is not present during the wake tracing in 30 to 90% of patients. Sleep disorders such as sleep apnea, narcolepsy, and periodic limb movement can also be detected by routine sleep recordings, but are better evaluated by polysomnography (see chapter on sleep).

The EEG can also document reactivity to afferent or noxious stimuli in patients with depressed levels of consciousness. The EEG technician

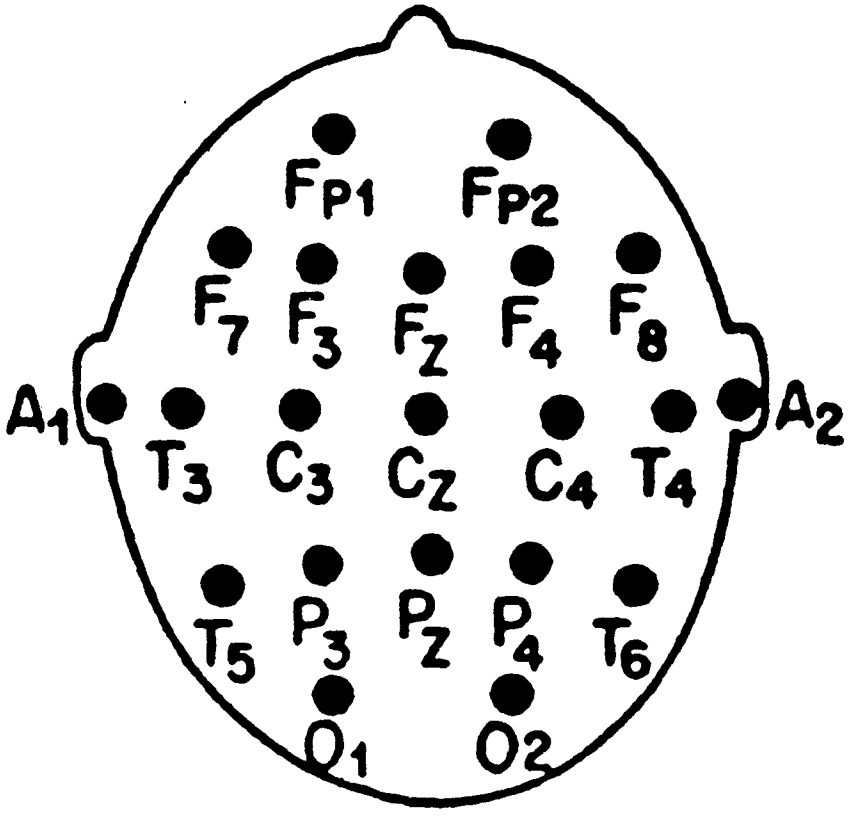

FIGURE 2 10–20 placement of electrodes.

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should also document any change in the state of the patient, and any movements, tremor, seizure activity, apnea, or other clinical accompaniments to the EEG activity.

Ambulatory Monitoring

Ambulatory monitoring is used to evaluate seizures, loss of consciousness, transient spells, or other reflective events. If a patient's spells are not recorded on an initial routine EEG, and if the events occur frequently enough (at least once a day), ambulatory monitoring may document the episode. Ambulatory EEG monitoring (A/EEG) allows recording of the EEG in a patient outside the laboratory for up to 72 hours.

From the technical points of view, 8 to 16 channels of EEG are recorded on a magnetic tape cassette from scalp electrodes. The recording instrument, attached to a belt or shoulder strap, allows normal, daily activities. The activity recorded on the cassette is played through a computer that translates the recording into EEG data that can be reviewed on a video screen and/or printed out in hard copy.

Prolonged Monitoring

Prolonged monitoring records EEG activity in a laboratory or hospital setting over a day or more, usually in association with video monitoring to allow a correlation of EEG abnormalities with clinical events. Prolonged monitoring is used after a routine recording to determine if spells are seizures, to document the type and frequency of seizures, and for evaluation of candidates for surgery for control of intractable seizures. Anticonvulsant drugs may be reduced to increase the chance of recording a seizure during the monitoring period.

DISORDERS ASSOCIATED WITH TRANSIENT SYMPTOMS

The major indication for an EEG study is the evaluation of patients with paroxysmal symptoms, or spells. Specific EEG patterns when the patient is asymptomatic may provide a clue as to the mechanism of the recurrent spells. The EEG in these patients is used to identify potentially epileptiform changes that may suggest an increased seizure tendency and support the diagnosis of epilepsy. Unfortunately, a direct electroclinical correlation is seldom obtainable during the routine EEG of patients with spells, reflecting the infrequency of spells in most patients. The diagnostic yield of the routine EEG in patients with seizures depends on many factors, including the seizure type, the frequency of seizures, and the location of the epileptic brain tissue.

Seizures

The EEG is the most frequently performed diagnostic study in the patient with recurrent, unprovoked spells. EEG studies typically are obtained between spells and record interictal changes. Most patients do not have spells during the relatively brief EEG recordings; nonetheless, the interictal EEG may be useful in recognizing epilepsy and distinguishing it from other episodic disorders. It can also serve to classify seizure type and localize the epileptogenic zone, i.e., the site of seizure onset and initial seizure propagation. The diagnostic yield of the EEG in epilepsy depends on several factors, including age of the patient, type of seizure disorder, frequency of seizure activity, and presence of antiepileptic drug medication. Importantly, persistently normal EEG recordings may occur in an individual with epilepsy. Conversely, epileptogenic alterations may be present, albeit rarely, in individuals without a history of seizure activity. In the final analysis, epilepsy is a clinical diagnosis, and the EEG findings must be carefully correlated with the patient's clinical presentation.

Interictal electroencephalogram patterns. The spike, sharp

KEY POINTS:

- Ambulatory EEG monitoring is valuable in the evaluation of frequent seizures, transient events, or spells.
- Prolonged EEG monitoring can document the type of transient events or seizures, and determine the frequency of seizures in candidates for surgery.
- EEG study in suspected epilepsy confirms the diagnosis, classifies the seizure type, and localizes the site of onset.
- Diagnostic yield of EEG in patients with epilepsy depends on patient age, seizure type, seizure frequency, and antiepileptic drug medication.

KEY POINTS:

- A normal EEG study does not exclude the diagnosis of epilepsy.
- Specific interictal epileptiform discharges are rare in nonepileptic patients.
- Interictal EEG alterations are spike, sharp wave, or spike-and-wave complex.

Case 1

A 44-year-old woman is referred for partial seizures with altered mentation. She has a history of a prolonged febrile seizure during childhood. The patient and her husband describe only one type of seizure: an abdominal aura followed by lip smacking and behavioral arrest. Her EEG is shown in **figure 3**.

Comment. The EEG shows unilateral, right anterior temporal lobe, interictal focal spike and sharp wave discharges. During drowsiness, right temporal, intermittent, rhythmic delta activity emerged without clinical alteration. The patient's abdominal aura was associated with attenuation over the entire right cerebral hemisphere, maximal in the temporal lobe region. Subsequently there was a progressive right temporal lobe, low-voltage, high-frequency discharge that gradually slowed in frequency and increased in amplitude. The postictal EEG had right hemisphere slowing, maximal in the right temporal lobe. The patient has right temporal lobe epilepsy, complex partial seizures. The aura suggests seizure onset in the amygdalo-hippocampal complex.

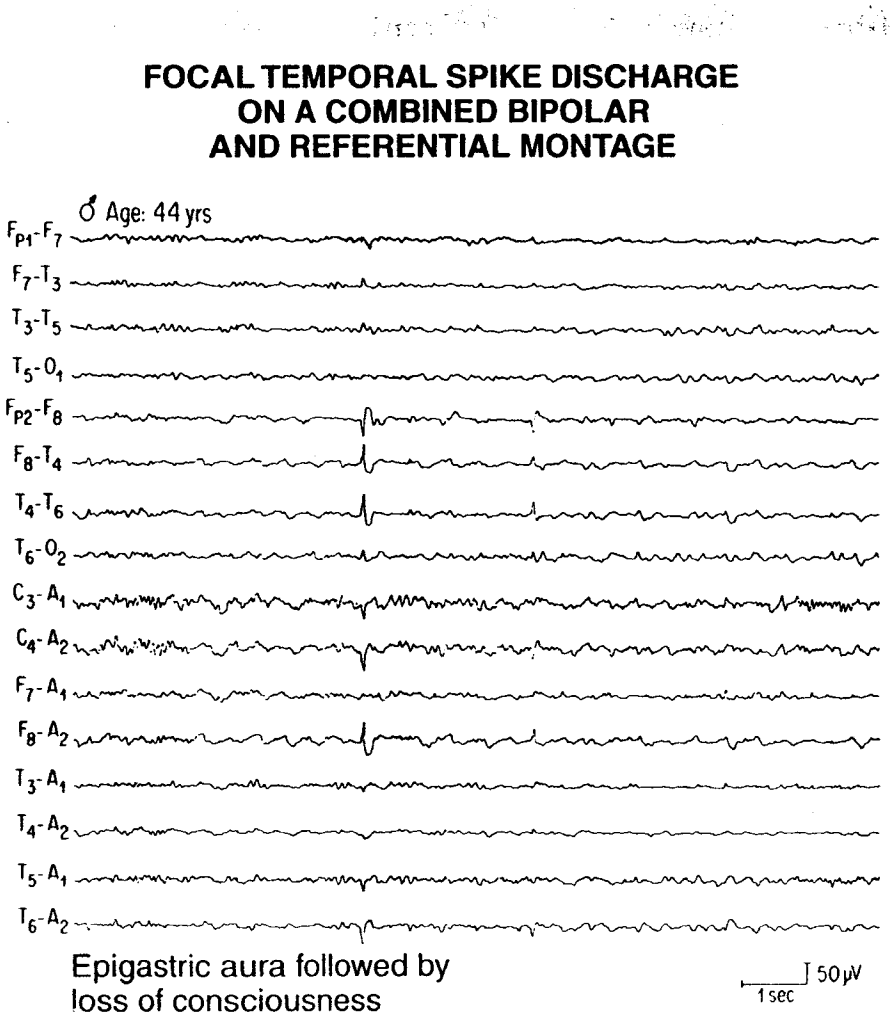

FIGURE 3 Right anterior temporal lobe spike in a patient with complex partial seizures (**case 1**).

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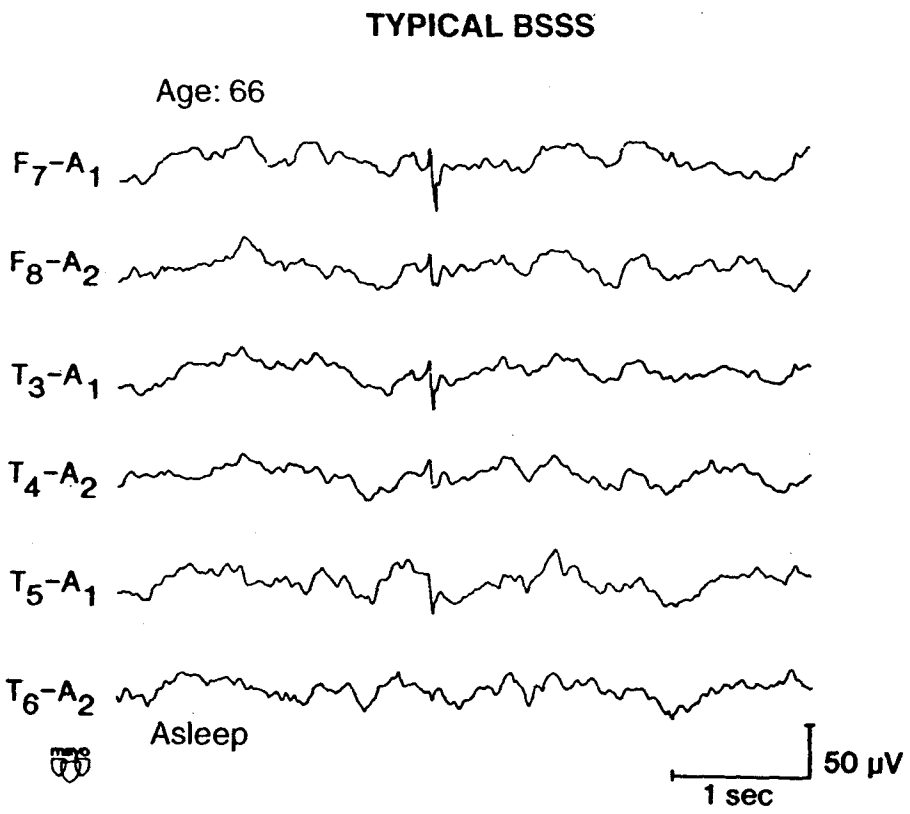

FIGURE 4 Small sharp spike in a 66-year-old patient.

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KEY POINTS:

- Medial temporal lobe epilepsy is the most common partial seizure disorder.
- The surgically remediable epileptic syndromes are medial temporal lobe epilepsy and lesional epilepsy.

wave, and spike-and-wave complexes are the interictal EEG alterations associated with an increased epileptogenic potential. Spike discharges are predominantly surface-negative transients with steep ascending and descending limbs and a duration of 20 to 70 milliseconds (**figure 3**), while sharp wave discharges are broader potentials with a duration of 70 to 200 milliseconds. These electrical abnormalities have a potential field and involve more than one electrode. Spike-and-wave complexes consist of a spike followed by a slow wave in an isolated or repetitive fashion. The frequency of spike discharges is a good predictor of the frequency of seizure activity; it does not correlate with antiepileptic drug levels.

Certain paroxysmal EEG patterns such as small sharp spikes or benign epileptiform transients of sleep (**figure 4**), 14 and 6 positive spike bursts (**figure 5**), 6-Hz spike-and-wave, so-called wicket waves (**figure 6**), and rhythmic temporal theta activity of drowsiness may resemble epileptiform activity but are not associated with an increased epileptogenic potential.

Electroencephalogram in partial epilepsy. Partial or localization-related epilepsy is the most common type of seizure disorder. Over 90% of the incident cases of epilepsy in adults have partial seizures. The most epileptogenic area in the patient with partial epilepsy is the mesiobasal limbic region or medial temporal lobe, including the amygdalo-hippocampal

KEY POINTS:

- Focal spikes or sharp waves are the most common interictal EEG pattern in partial epilepsy.
- A sleep recording increases the diagnostic yield of the interictal EEG in partial epilepsy.
- Sphenoidal electrodes may increase the diagnostic yield in medial temporal lobe epilepsy.
- Nasopharyngeal electrodes are not useful.
- Auras or simple partial seizures may occur without an EEG alteration.

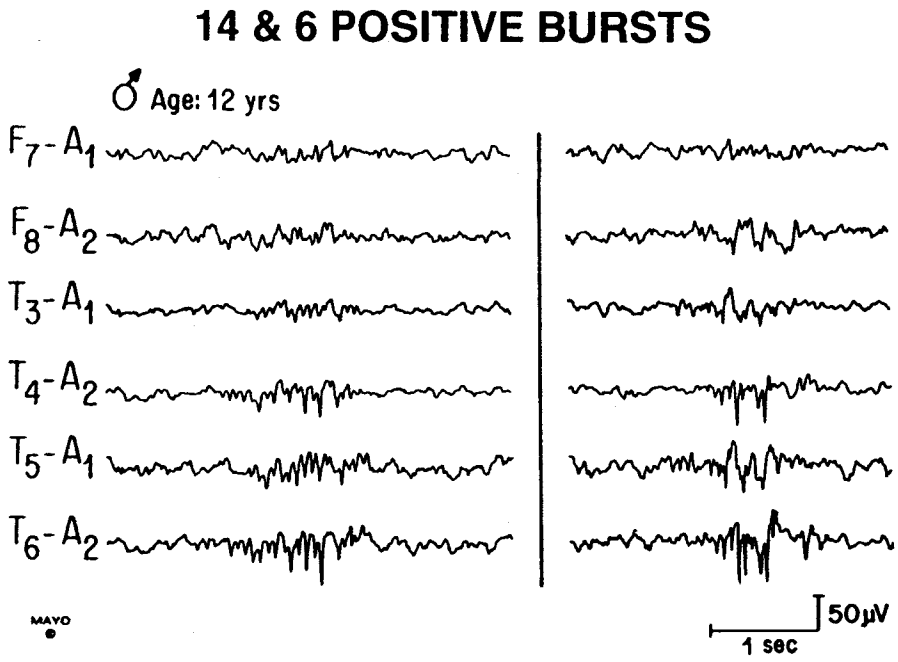

FIGURE 5 14 and 6 positive spike bursts in a 12-year-old patient.

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complex. Approximately 80% of partial seizures emanate from the temporal lobe, and nearly 90% of temporal lobe seizures are of medial temporal lobe onset. The remaining 20% of partial seizures are mainly of frontal lobe onset. The relatively poor response of partial seizures to antiepileptic drug medication has been well documented. Only about 55% of patients will achieve a seizure remission with medication alone. Epilepsy surgery has been shown to be highly effective and well tolerated in selected patients with medically intractable partial seizures. Surgically remediable epileptic syndromes include medial temporal lobe epilepsy and lesional epilepsy. Nonlesional, neocortical partial seizures are less likely to experience a significant reduction in seizure frequency following surgical treatment.

Temporal lobe seizures. Temporal lobe seizures are classified by the site of the epileptogenic zone, i.e., medial temporal versus neocortical. The most common interictal EEG pattern in patients with temporal lobe epilepsy is the anterior temporal lobe spike or sharp wave discharge (see **figure 3**). This spike discharge has a maximum amplitude over the anterior temporal lobe region and may involve the ear, sphenoidal, or inferior temporal leads. Recording the EEG during sleep may be needed to record the epileptiform alterations. Approximately 90% of patients with medial temporal lobe epilepsy have spike or sharp wave discharges during the sleep recording. Neocortical spikes are more likely to appear as bitemporal, independent discharges or bisynchronous alterations.

Sphenoidal or inferolateral temporal scalp (T1, T2, F9, F10) electrodes, as well as closely spaced scalp electrodes, may delineate the topography of the interictal activity. Sphenoidal electrodes record epileptiform activity emanating from the mesiobasal

limbic region. Nasopharyngeal electrodes are not useful because of associated artifact, limited efficacy, and poor patient tolerance.

Ictal EEG alterations in patients with partial seizures of temporal lobe origin depend on the type of seizure and the localization of the epileptic brain tissue. Most seizures are progressive, with a change in the electrographic pattern from interictal to ictal to postictal. Prior to the seizure, there may be an increase in interictal unilateral or bilateral temporal lobe spiking. There may be little background alteration during simple partial seizures or auras, other than an attenuation of interictal epileptiform activity during the clinical seizure. Importantly, an aura or simple partial seizure of temporal lobe origin may occur in the absence of electrographic change.

A subtle electrographic seizure that may occur during these spells is a low-voltage, high-frequency discharge that gradually increases in amplitude and slows in frequency.

Temporal lobe complex partial seizures almost invariably are associated with an ictal EEG alteration. The seizure discharge may be *focal, lobar, regional, or bihemispheric*. A focal electrographic change is maximal at one or more electrode positions within a lobe, e.g., F9 and F7 lateral frontal or anterior temporal electrodes over the anterior temporal lobe.

A focal discharge has of course the highest localizing value but is relatively uncommon during extracranial EEG recordings. A lobar discharge is lateralized and localized to one lobe; lobar onset of a seizure is the most common scalp-recorded alteration in complex partial seizures of tempo-

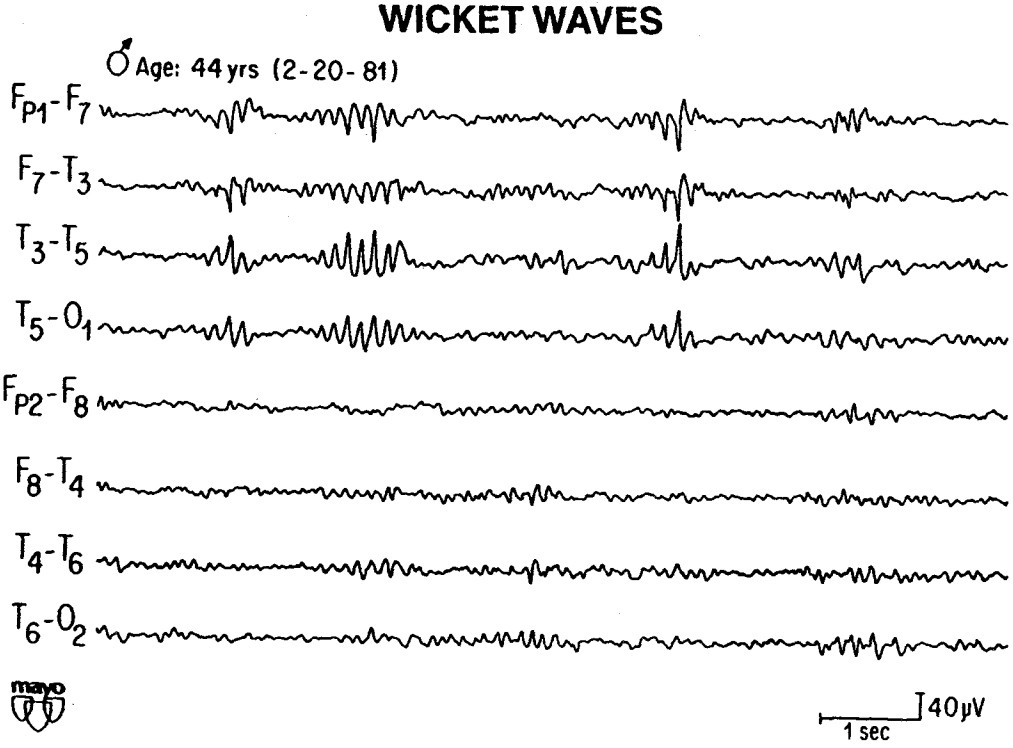

FIGURE 6 Wicket waves in a 44-year-old patient.

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Case 2

A 28-year-old woman has had recurrent spells with memory loss for 1 year. The five to six spells in the last year occurred during sleep, were associated with stiffening of the upper extremities, and a "growling" noise and lasted for about 1 minute. The patient could not be aroused during or immediately after the episodes. She slept 4 to 6 hours after a spell and awakened in a confused state. An earlier EEG when the patient was unresponsive showed normal sleep activity without epileptiform alterations. Her EEG is shown in **figure 7**.

Comment. The initial portions of her EEG showed generalized background activity without epileptiform alterations. During the EEG, the patient had a spell with lip smacking, starring with the eyes open, and posturing in the left upper extremity. There was a vocalization during the seizure that resembled the description by her husband. The ictal EEG shown in **figure 7** revealed a right temporal lobe, scalp-recorded seizure that demonstrates partial epilepsy of right temporal lobe origin. The history of nocturnal spells during sleep suggests a true seizure disorder rather than psychogenic manifestations.

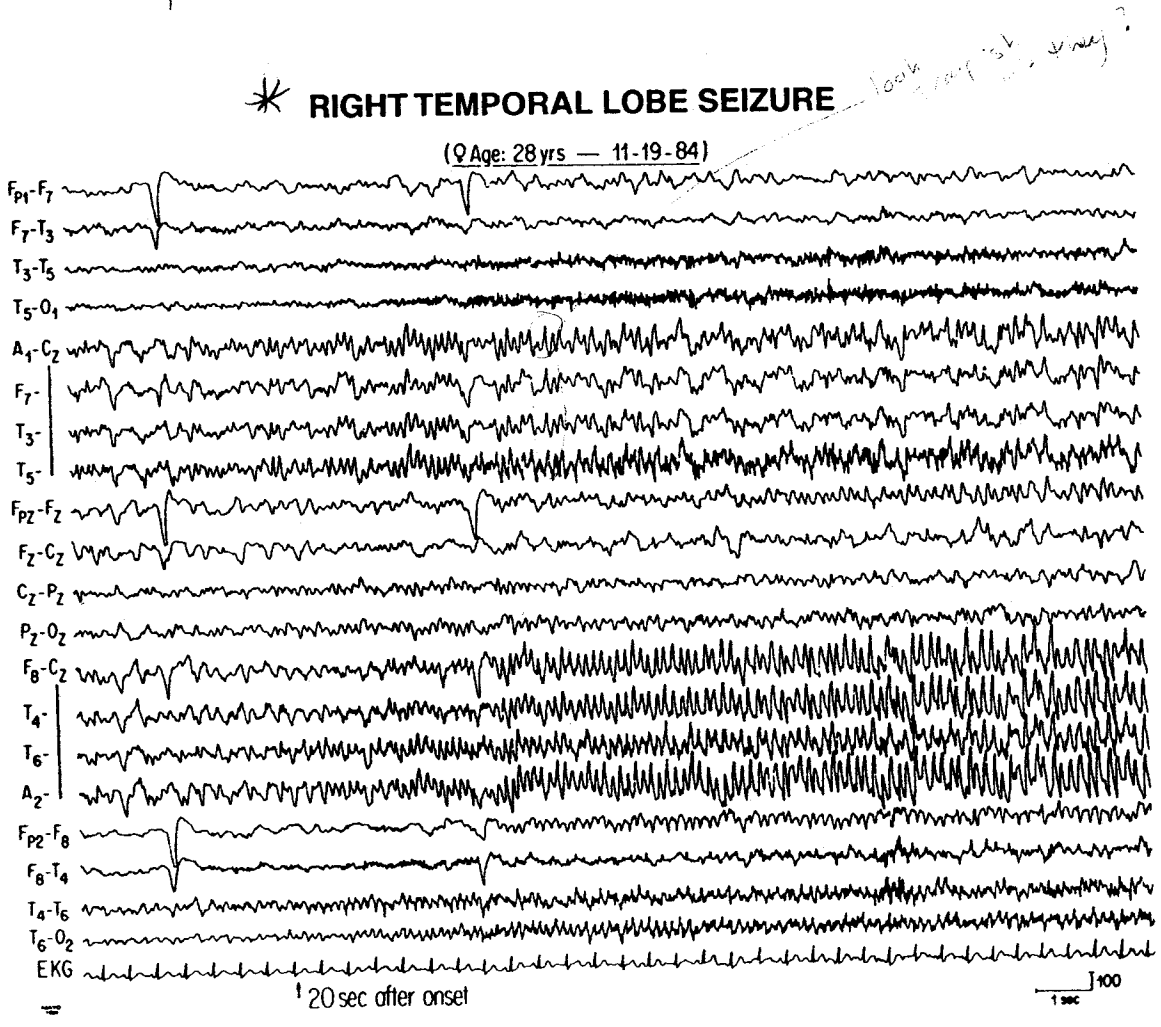

FIGURE 7 Right temporal lobe seizure discharge in a patient with partial epilepsy (**case 2**).

ral lobe origin. A lateralized, moderate to high amplitude, rhythmic paroxysm of theta activity is most prominent in the lateral temporal scalp electrodes and may progress to generalized, rhythmical slowing on the side of the seizure. The regional change is lateralized, but not well localized, e.g., a fronto-temporo-parietal seizure. Finally, a bisynchronous alteration, e.g., bitemporal rhythmical slowing, may occur at seizure onset, which confirms the diagnosis of epilepsy but does not allow appropriate localization of the site of seizure onset.

The postictal state in partial epilepsy is associated with widely distributed slow wave activity that may be maximal over the cerebral hemisphere of seizure origin. A prominent increase in interictal spiking may occur at the conclusion of the postictal period.

Extratemporal seizures. Neocortical, extratemporal seizures are most commonly of frontal lobe origin. Curiously, the interictal and ictal extracranial EEGs are less sensitive and specific in patients with extratemporal seizures than in partial seizures of temporal lobe origin. Unfortunately, the ictal behavior in this group of patients is sufficiently ill-defined and variable to suggest to the clinician a nonepileptic disorder. Multiple *interictal* EEG studies may be unremarkable in these patients, especially troublesome in those with medically refractory extratemporal seizures. When present, interictal alterations are more likely to be generalized and bisynchronous than in patients with temporal lobe epilepsy. Less than 20% of patients with frontal lobe seizures have unilateral and localized interictal changes. The most common interictal pattern in patients with extratemporal seizures is a lateralized, but not well-localized spike discharge, e.g., fronto-temporo-parietal spikes.

The most prominent *ictal* pattern in patients with extratemporal seizures is the "*beta buzz*," which represents a high-frequency, low-voltage discharge that may correspond to the site of seizure onset. Focal and lobar electrographic changes are much less common in patients with extratemporal seizures than in those with temporal lobe seizures (**figure 8**). The most common extracranial ictal pattern is a regional or generalized alteration that may appear relatively late during the clinical seizure. The seizure discharge frequently is widely distributed or involves midline or paramesial regions, which does not allow determination of the site of the epileptogenic zone. Of particular importance is the fact that a complex partial seizure of frontal lobe origin may be present without electrographic change. The subtle, brief electrographic pattern may be missed if the seizure is relatively brief in duration and there is muscle or eye movement artifact.

KEY POINTS:

- Complex partial seizures of temporal lobe origin have electrographic seizure patterns that may be localized, lateralized, or widespread.
- A lobar discharge is most common during a temporal lobe seizure.
- Extracranial EEG may reveal a bisynchronous seizure discharge during a partial seizure.
- The EEG has a lower diagnostic yield in patients with extratemporal partial seizures.
- Localized seizure discharges are uncommon in patients with frontal lobe seizures.

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Case 3

A 20-year old man is evaluated for stereotyped nocturnal episodes that had occurred only during sleep. During a typical spell, he awakens and stiffens his left arm and leg. Repetitive clonic movements are noted in the left lower face progressing to the left arm and leg. The patient is very agitated and cannot be consoled during these spells that last 30 to 45 seconds. A mild left hemiparesis is present in the immediate postictal period (**figure 8**).

Comment. The routine EEG showed rare right fronto-central interictal epileptiform discharges most prominent during sleep. Ictal EEG revealed repetitive spike activity in the right fronto-central region (**figure 8**). This patient has partial epilepsy of extratemporal origin. The ictal semiology and EEG pattern suggest localization of the epileptic brain tissue in the right perirolandic region with a "Jacksonian" seizure.

KEY POINTS:

- A "beta buzz" may be a reliable indicator of the site of seizure onset.
- The EEG may be normal during a complex partial seizure of frontal lobe origin.
- Generalized spike-and-wave is the primary interictal and ictal pattern with generalized epilepsy.
- A 3-Hz generalized spike-and-wave discharge occurs during an absence seizure.

Electroencephalogram in generalized epilepsy. The generalized epilepsies are classified as idiopathic (primary) or symptomatic (secondary), depending on etiology, seizure type, and EEG alterations. Generalized seizure types include absence, tonic-clonic, tonic, atonic, atypical absence, and myoclonic seizures.

Idiopathic generalized epilepsy is thought to have a genetic basis. Patients with idiopathic generalized epilepsy typically have a medically responsive disorder and may experience a reduction in seizure tendency with maturation. In contrast, patients with symptomatic generalized epilepsy may exhibit significant cognitive decline and may have "catastrophic" seizures that are resistant to medications and physically disabling. Many patients with symptomatic generalized epilepsy develop the Lennox-Gastaut syndrome with developmental delay, multiple seizure types, and generalized slow spike-and-wave.

The specific interictal EEG patterns in patients with generalized epilepsy include 3-Hz generalized spike-and-wave, slow generalized spike-and-wave, atypical generalized spike-and-wave, and paroxysmal fast generalized activity.

Absence seizures. Patients with absence seizures are ordinarily considered to have idiopathic generalized epilepsy. The interictal and ictal alterations in these patients are similar, with a characteristic pattern of 3-Hz generalized spike-and-wave. The duration of the discharge is a primary determinant of alteration in behavior, i.e., an absence seizure. The electrographic alteration comprises generalized, often anterior predominant, repetitive, bisynchronous, symmetric, spike and slow wave discharges occurring at 3 Hz. The discharge frequency may be 4 Hz at onset, gradually slowing to 2.5 Hz at termination. Hyperventilation, drowsiness, sleep deprivation, hypoglycemia, and eye closure may activate the typical pattern (**figure 10**).

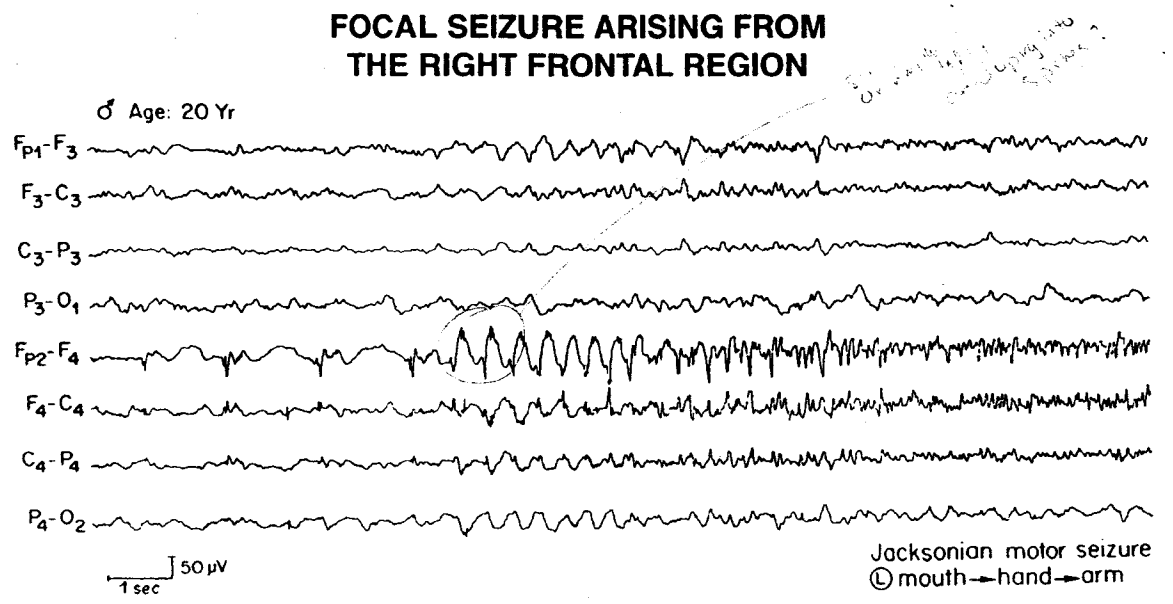

FIGURE 8 Right fronto-central seizure discharge in a patient with extratemporal seizures involving the peri-Rolandic region (**case 3**).

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Case 4

A 19-year-old man has had a global, static encephalopathy since childhood with multiple seizure types. There is a history of cryptogenic infantile spasms. The patient has several nonconvulsive seizures per day associated with staring, head drop, and fumbling movements of the fingers in both hands. These spells last 1 to 2 minutes. The patient also has three to four generalized tonic-clonic seizures per week that are not associated with an aura. Several times per day he experiences drop attacks, falling to the ground without warning. The latter spells have resulted in significant physical injury (**figure 9**).

Comment. The awake EEG revealed generalized, slow spike-and-wave at a frequency of 1.5 to 2.5 Hz with a generalized background slowing. During sleep, there were multiple bursts of generalized paroxysmal fast activity associated with tonic stiffening of the upper extremities. A prolonged nonconvulsive seizure was associated with a generalized electrographic seizure discharge.

This patient has a symptomatic generalized seizure disorder with probable atypical absence, atonic, generalized tonic-clonic, and tonic seizures. The patient has the clinical triad that is seen in individuals with the Lennox-Gastaut syndrome, i.e., developmental delay, slow spike-and-wave, and multiple generalized seizure types. Note that gestural automatisms, i.e., fumbling movements with the fingers, may occur in patients with generalized epilepsy. Prognosis for a seizure remission with antiepileptic drug medication is poor.

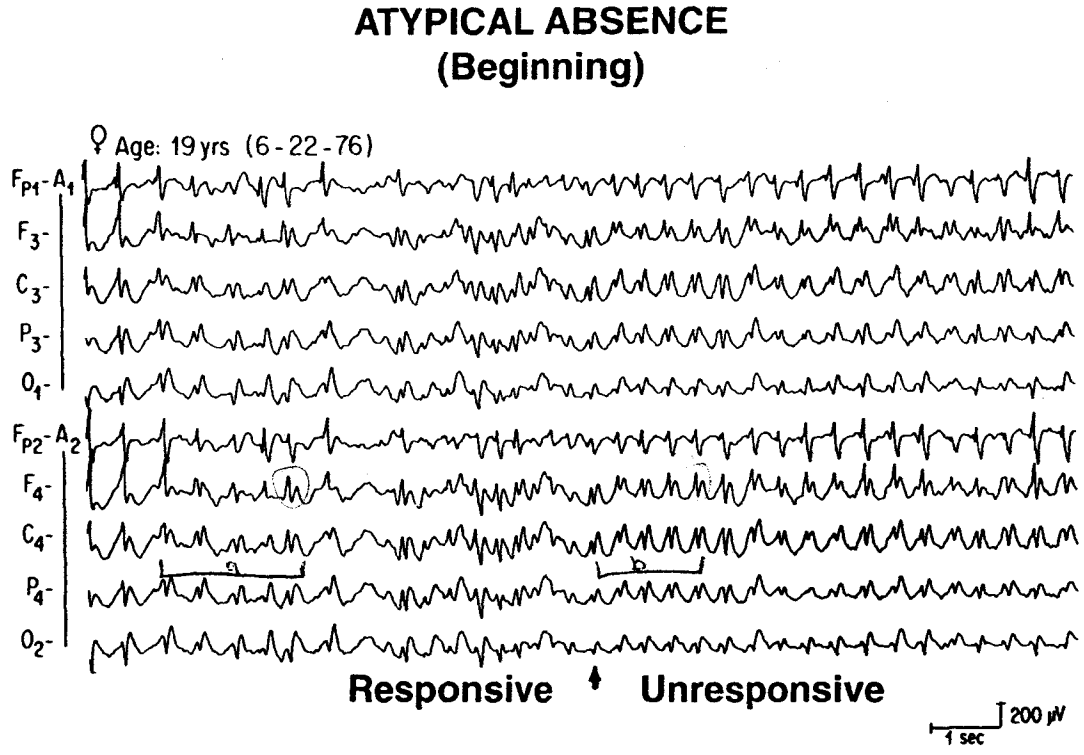

FIGURE 9 Ictal EEG during an atypical absence seizure in a patient with symptomatic generalized epilepsy (**case 4**).

The morphology of the pattern may change during slow wave sleep with the emergence of fragments of asymmetric spike-and-wave.

The EEG background is usually normal. The interictal EEG in patients with absence seizures correlates closely with the patient's current

KEY POINT:

- Tonic seizures are associated with generalized paroxysmal fast activity.

Case 5

A 33-year-old man has had multiple spells per day associated with repetitive movements in the upper and lower extremities and loss of consciousness. There is a history of alcohol abuse, sexual abuse as a child, and depression. The patient has been unable to drive or work because of the spells.

Comment. The routine EEG revealed a mild increase in generalized background slowing that was presumed to be related to antiepileptic drug effect. Long-term EEG monitoring recorded multiple clinical episodes that lasted from 3 to 5 minutes and were associated with arrhythmic jerking in the arms and legs with a "start and stop" quality. Despite the fact that the patient appeared unresponsive, the EEG revealed normal posterior alpha activity. Subsequent psychiatric examination suggested the diagnosis of a somatoform disorder. Antiepileptic drug therapy was discontinued. The electroclinical correlation supports the diagnosis of psychogenic seizures.

level of seizure activity. Individuals experiencing absence seizures usually have an abnormal routine EEG if standard activating procedures are performed.

Tonic-clonic seizures. Generalized tonic-clonic seizures may be associated with either idiopathic or symptomatic generalized epilepsy. The latter group of patients may be expected to have intermixed, generalized background slowing. Patients with partial epilepsy may also experience secondarily generalized tonic-clonic seizures; in these patients, the interictal pattern would be focal or localized spike or sharp wave discharges.

The interictal EEG pattern in patients with generalized, tonic-clonic

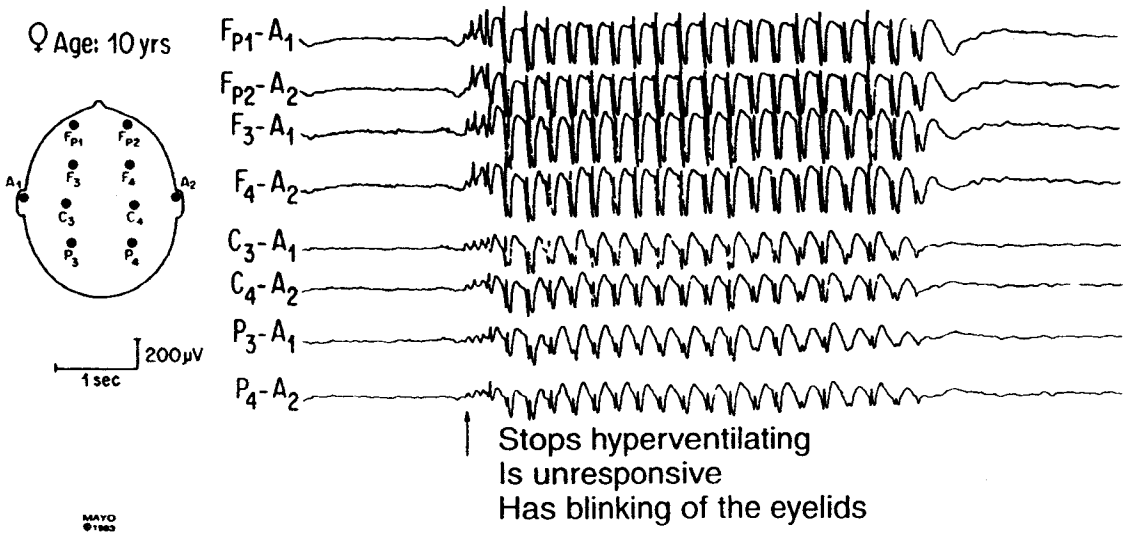

FIGURE 10 Generalized spike-and-wave discharge during an absence seizure provoked by hyperventilation.

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