

Epilepsy

James Bowman, Colorado State University, Fort Collins, Colorado, USA

F Edward Dudek, Colorado State University, Fort Collins, Colorado, USA

Mark Spitz, University of Colorado Health Science Center, Denver, Colorado, USA

Epilepsy is a chronic neurological disorder characterized by recurrent epileptic seizures. Brain injury and genetic abnormalities underlie this disorder.

Introduction

Epilepsy is defined as the repeated occurrence of sudden, excessive and/or synchronous discharges in cerebral cortical neurons resulting in disruption of consciousness, disturbance of sensation, movements, impairment of mental function, or some combination of these signs. Because of their sudden nature, seizures are called ictal events, from the Latin *ictus* meaning 'to strike'. The terms epilepsy, seizure and convulsion are not synonymous. A seizure always is a symptom of abnormal function in the central nervous system (CNS) rather than a disease in itself. A seizure discharge may be initiated in an entirely normal cerebral cortex by a variety of acute insults, such as withdrawal from alcohol, low blood sodium, or certain toxins. Seizures are to be distinguished from epilepsy, which is a chronic condition in which seizures occur repeatedly due to an underlying brain abnormality which persists between seizures. A convulsion is a forceful involuntary contraction of skeletal muscles. A convulsion is a physical manifestation of a seizure, but the term is inappropriate as a synonym for epilepsy when epilepsy may consist only of a temporary alteration of consciousness or sensation.

Epilepsy occurs in approximately 0.7% of the population at any one time. More than two-thirds of seizure problems begin in childhood, with a second peak of onset in the elderly. Usually, epilepsy does not significantly alter life expectancy, but quality of life may be seriously compromised when seizures are not satisfactorily managed.

Epilepsy has many causes, but in most patients a cause cannot be identified. Among the pathologies most commonly considered to give rise to epilepsy are cerebrovascular lesions, perinatal or postnatal trauma, infections of the CNS, and tumours or congenital malformations of the brain. This area is referred to as the epileptogenic lesion (Figure 1, A). The epileptogenic zone is where the seizures actually begin, and this area is usually in or near the epileptogenic lesion (Figure 1, C). The function of nerve cells and their circuits in the epileptogenic zone has been fundamentally altered, and some even destroyed, by the pathology. During an epileptic seizure, neurons in the epileptogenic zone begin to discharge hypersynchronous

electrical signals at an excessively high rate and/or in an abnormal pattern. An epileptic seizure can originate only in certain structures of the brain (e.g. the cerebral cortex and amygdala) but the seizure may then spread to other structures of the CNS (e.g. the basal ganglia). Once a patient has developed epilepsy, individual seizures may be precipitated by a number of conditions and circumstances.

Electroencephalography

Electroencephalography (EEG) has been the most important test in the diagnosis of epilepsy. It involves using a set of electrodes (channels) to record the electrical activity of just those neurons nearest each electrode. When electrical abnormalities are present in some channels of the electroencephalogram and not in others, this pattern localizes the site of the problem. EEG usually is able to detect signs of neuronal dysfunction, even between epileptic attacks (the interictal period), although many epileptic patients have normal interictal EEGs. Even ictal EEGs can be normal if the seizure is localized to a small area of cortex distant from the recording electrodes.

The patient usually undergoes several activation procedures in an attempt to bring out EEG abnormalities. This routinely includes hyperventilation (deep, rapid breathing for 3–5 min) and photic stimulation (flashing lights). However, the most useful activation procedure is sleep or sleep deprivation. The activity of cortical neurons during certain stages of sleep becomes more synchronous than during waking, and this may lead to the appearance of specific abnormal electrical activity strongly suggestive of epilepsy.

Classification of Seizures and Epilepsy

Classification is critical to the optimal care of a patient. It provides information on aetiology, treatment and prognosis. Modern classification of the epilepsies is based on how the seizures begin. Two broad categories are recognized depending upon whether the entire brain

Introductory article

Article Contents

- Introduction
- Electroencephalography
- Classification of Seizures and Epilepsy
- The Brain Abnormality in Epilepsy
- Precipitants of the Epileptic Attack
- Treatment
- Summary

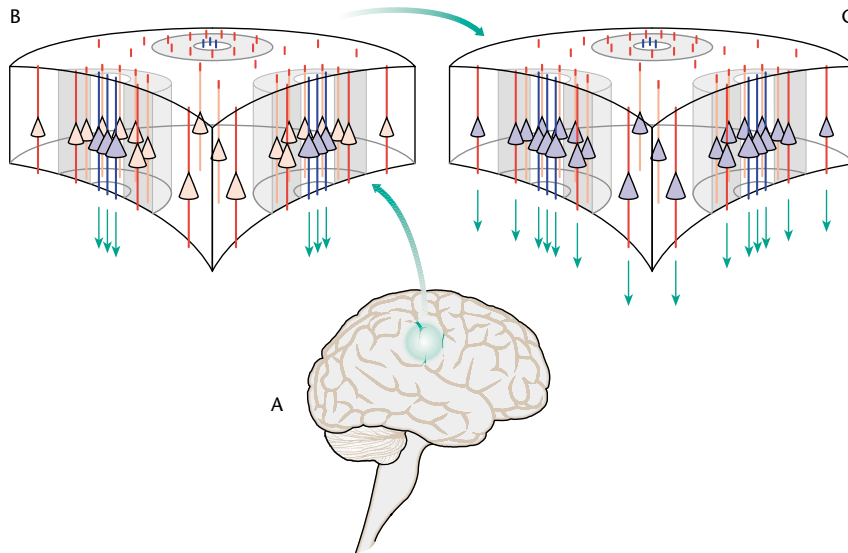


Figure 1 The three cortical areas contributing to seizure onset. (A) The epileptogenic lesion, a structural abnormality that leads to the development of epileptic foci (B). Each focus consists of a group of excessively discharging neurons (blue) surrounded by a zone of inhibited neurons (shaded area) which keeps each focus from spreading to neighbouring neurons (pink). (C) The epileptogenic zone, a large group of excessively discharging neurons (blue) created by the breakdown of the foci and responsible for seizure onset.

(generalized seizure) or only a restricted part of the brain (partial seizure) is involved in the discharge at its onset. Each category is further subdivided, depending on the symptoms displayed by the patient during the seizure. Many patients have more than one seizure type, but it is rare to have both partial onset and primary generalized seizures.

Partial seizures

Partial seizures begin in a discrete cortical area. They are categorized as simple when consciousness is preserved and complex when consciousness is altered. Simple partial seizures may evolve into complex partial seizures or secondarily generalized tonic–clonic seizures as a result of the spread of abnormal electrical activity.

Simple partial seizures

Simple partial seizures are the primary complaint in 10% of patients with epilepsy. They can occur frequently and may result in little disability. Simple motor seizures result from a discharging lesion in the precentral gyrus of the frontal lobe of the cerebral hemisphere opposite the muscle contractions. Some are sustained (tonic) and others intermittent (clonic), and they may involve any body part depending on the location of the abnormal brain discharge. Simple sensory seizures indicate discharging nerve cells in the appropriate primary sensory cortex of the hemisphere. Simple somatosensory seizures usually result from an epileptogenic zone in or near the postcentral gyrus of the

opposite cerebral hemisphere. Somatosensory seizures are usually described by the patient as the sensation of ‘pins-and-needles’. A simple seizure may remain restricted or ‘march’ to other parts of the body in a sequence determined by the somatotopic organization of the cortex, or it may spread through other axonal pathways. Visual seizures indicate an epileptogenic zone in or near the primary visual cortex of the occipital lobe. Spots or patterns are experienced in the visual field opposite the side of the seizure focus. Seizures eliciting auditory, vestibular, olfactory or visceral sensations can also occur.

Complex partial seizures

Complex partial seizures are the predominant seizure type in about 20% of patients with epilepsy. The terms psychomotor, temporal lobe and limbic system seizure are older terms, somewhat synonymous with the term complex partial seizure, all designating a form of partial seizure in which consciousness is altered but not necessarily lost. During these seizures there is a period of altered behaviour for which the patient is later amnesic. The amnesia for ictal events is a key factor for the diagnosis of a complex partial seizure.

A typical complex partial seizure consists of several phases. About 70% begin with an ‘aura’, a sometimes complex psychic experience that may be manifest in one or more of a wide variety of vivid forms: as an illusion, hallucination, dyscognitive state or emotional (affective) experience. This usually lasts a few seconds. Such psychic experiences may comprise the entire seizure, which is then a

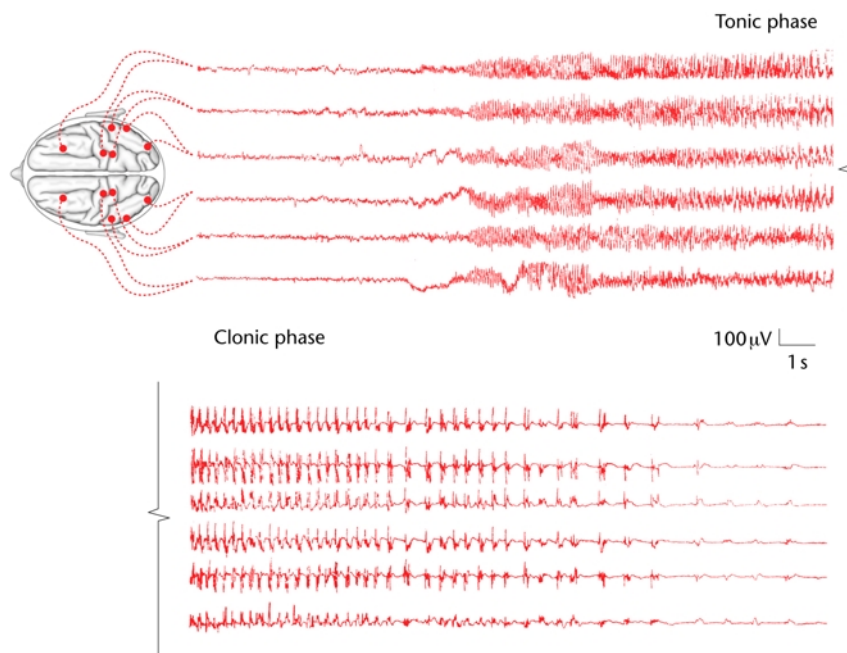


Figure 2 Simulated electroencephalogram (EEG) of a generalized seizure characterized by a tonic-clonic convulsion. Each line tracing (channel) is from electrodes positioned on the scalp as shown in the inset EEG montage. (Adapted from Gastaut H and Broughton R (1972) *Epileptic Seizures*. Springfield, Illinois: Charles C. Thomas.)

simple partial seizure. However, when the seizure progresses into a second phase with alteration of consciousness, it is defined as a complex partial seizure. Dystonic (twisted, stiff) posturing of the arm or leg on the side opposite to where the seizure occurs is often observed. Primitive movements occur frequently. These are referred to as spontaneous automatisms, and may include aimless fumbling with clothing or walking in a daze, and chewing or swallowing. However, reactive automatisms also may occur and these are not stereotyped because they are determined by environmental stimuli. Such automatisms are why the old term psychomotor seizures was coined.

Primary generalized seizures

Primary generalized seizures (also called generalized seizures) involve widespread areas of the cerebral cortex from the onset. These terms must not be confused with the term secondary generalized seizure, which refers to a partial onset seizure that spreads to wide areas of cortex. The abnormal electrical activity is the same in both the left and right hemispheres (bilaterally symmetrical). Generalized seizures are further subdivided into convulsive and nonconvulsive types. Convulsive seizures are characterized by sometimes violent and sustained contractions of muscles. Nonconvulsive seizures lack prominent motor activity. Generalized tonic-clonic, clonic, and some tonic seizures are referred to as convulsive generalized seizures. The most common nonconvulsive generalized seizure is the

absence seizure, but the category also includes atonic, brief tonic, and myoclonic seizures.

Convulsive seizures

Tonic-clonic convulsions often begin with a piercing cry or choking as the entire body musculature is seized in a strong contraction and air is forced out through partially closed vocal cords. Patients fall to the ground in an unconscious state. Initial motor signs include brief flexion of the trunk, an opening of the mouth and eyelids, upward deviation of the eyes, and elevation of the arms. These are followed by a rigid extension phase, involving the back, neck, arms and legs, which lasts for 15–20 s. Involvement of the respiratory muscles in the spasm results in a suspension of breathing, and in a few seconds the skin and mucous membranes become cyanotic. The patient often loses bowel and bladder control during this phase. This tonic phase of the convulsive seizure is followed by the clonic phase, which consists of rhythmic muscle contractions lasting for 20–30 s. Autonomic signs are conspicuous: the pupils are dilated, blood pressure is raised, the pulse is rapid, and salivation and sweating occur.

The onset of a grand mal seizure is characterized electroencephalographically by the simultaneous appearance of abnormal activity over large areas of the cerebral cortex in both hemispheres (**Figure 2**). The EEG shows a fast rhythmic discharge (> 10 Hz), which decreases in frequency and increases in amplitude during the tonic phase. The cortical discharge then changes from continuous to

intermittent bursts of activity, which signals the beginning of the clonic phase of the seizure. These intermittent bursts of activity are referred to as grouped polyspikes and are separated by quiet intervals. The bursts gradually decrease in frequency, which correlates behaviourally with the decrease in the frequency of the repetitive clonic muscular jerks.

When the seizure is over, the patient does not immediately return to normal. This postictal state, which lasts for minutes to hours (rarely days), is first characterized by the patient lying still and limp, and breathing quietly. The patient slowly regains consciousness, usually over the next several minutes, but is obviously confused. The patient may remain sleepy for several hours; if left undisturbed, the patient may fall into a deep sleep for hours and awaken with a postictal headache and fatigue. Once recovered, the patient may have no memory for any part of the seizure. However, the patient is aware that something troublesome has happened because of a bitten tongue, injury from the fall, concern expressed by others, regaining consciousness in different surroundings, and aching muscles from the violent contractions. A small proportion (5–8%) of these patients in the future will experience a prolonged series of tonic–clonic seizures without fully regaining consciousness between them. This condition is termed status epilepticus; it is life threatening and demands urgent medical treatment.

Absence seizures

Absence (petit mal) seizures occur without warning and consist of a sudden interruption of consciousness. The hallmarks of absence seizures are their brevity, general lack of motor activity, frequency, and lack of a postictal period.

The seizures usually last from 2 to 10 s, occasionally longer. Patients are often unaware of them. An observer may interpret an absence as a moment of daydreaming. The person stops talking briefly in midsentence, stares, or stops responding. As many as several hundred such seizures may occur in 1 day. Absence seizures almost always begin in childhood or adolescence. They often disappear before adulthood, presumably because of the biochemical or structural changes associated with brain maturation. When they occur with high frequency in school, they often lead to poor performance.

During short absences the patient may be completely motionless. With longer absences, subtle automatisms are often observed such as blinking. When used correctly, the older term *petit mal* is synonymous with absence seizures. However, the term is often applied incorrectly, as when a patient with complex partial seizures is said to have *petit mal* staring spells.

The EEG signature of a typical absence seizure is an abrupt onset and sudden cessation of a bilaterally synchronous and regular discharge recorded over widespread areas of the scalp (**Figure 3**). The discharge consists of spike- or multiple spike-and-slow wave complexes at a frequency of about 3 Hz.

Atonic seizures

Atonic seizures (drop attacks) manifest themselves as a sudden loss of tone in postural muscles. In a mild variant, only the head drops. However, in the severe form, all of the postural muscles lose tone, and the patient suddenly collapses to the ground. Frequent falls may result in injury, especially to the head, so protective headgear may be needed. The duration of the attack is usually only a few

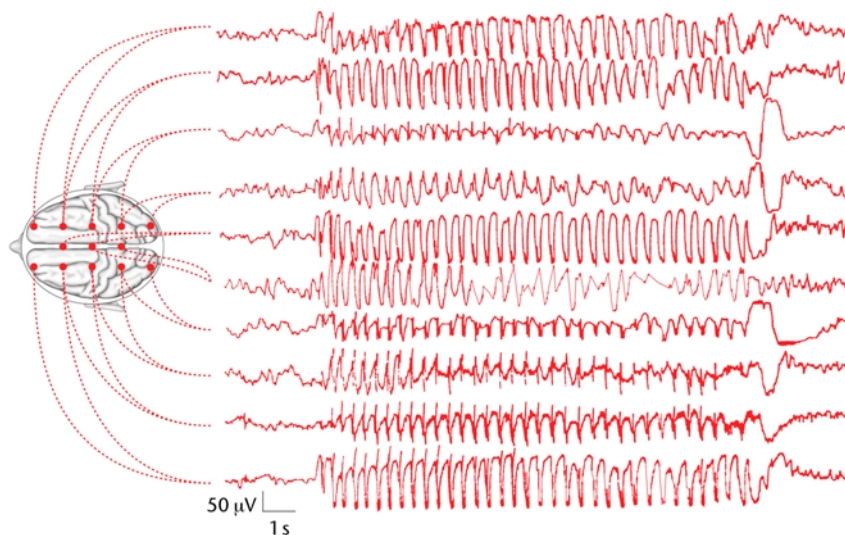


Figure 3 Simulated electroencephalogram of generalized 3-Hz spike-and-wave complexes during an absence seizure. Note the abrupt onset and sudden cessation of the bilaterally synchronous activity. (Adapted from Lothman EW and Collins RC (1990) In: Pearlman AL and Collins RC (eds) *Neurobiology of Disease*. New York: Oxford University Press.)

seconds, but the seizure may be more prolonged. When the attack is brief, no notable postictal symptoms occur.

Myoclonic seizures

Myoclonus is a nonspecific term applied to a class of motor signs characterized by fast involuntary muscle jerks. Many forms of myoclonus are nonepileptic, but the myoclonic seizure is considered to be a type of primary generalized epilepsy. It is the predominant seizure type in approximately 4% of patients with epilepsy. Myoclonic seizures consist of bilaterally synchronous involuntary muscle jerks that occur singly or in a brief salvo of repeated jerks. Some myoclonic jerks can be restricted to only one muscle, while others involve large muscle masses including both arms and legs or even the entire body. Repetitive massive myoclonic jerks can occur without any alteration in consciousness, indicating that the mechanism and anatomy underlying myoclonic seizures is different from that in other types of generalized epilepsy.

The Brain Abnormality in Epilepsy

Genetic disorders versus structural pathology

The brain abnormality responsible for epilepsy can result from a genetic disturbance (i.e. primary, idiopathic or essential epilepsy) or from a structural pathology (i.e. secondary, symptomatic or acquired epilepsy). Structural pathology may be inherited or acquired (e.g. secondary to head injury). That diseases as different as infection, tumour and stroke can each give rise to epilepsy suggests that the cause of the lesion itself is not the reason epilepsy develops. We know that normal interrelationships between cortical neurons have been disrupted in epilepsy, but it is not fully understood just why a genetic disturbance or structural pathology causes neurons to discharge abnormally in the different types of epilepsy.

Animal models of seizures and epilepsy

Most of what is known or hypothesized about the molecular and cellular mechanisms of seizures and epileptogenesis, which is the creation of a chronic predisposition for seizures, has been derived from the study of animal models. A distinction must be drawn between studies seeking to understand (1) how seizures are initiated and propagated, which can be the response of normal brain tissue to acute injury or experimental treatments, versus (2) how the increased seizure susceptibility of chronic epileptogenesis occurs, which can result from persistent abnormalities due to genetic or structural factors. The mechanisms of seizure generation, synchronization and propagation have been studied in intact animals, in *in vitro* isolated brain slice preparations, and in

computer models. Neuroscientists have been successful in producing experimental models of epilepsy using a variety of techniques, primarily based upon inducing seizures in intact animals by repeated electrical stimulation of discrete brain sites (i.e. kindling) or by treatment with excitotoxic chemicals (e.g. kainic acid and pilocarpine). Each model has advantages and disadvantages. For example, 'kindling' is an experimental condition in an animal model where an increased seizure susceptibility arises after daily seizures from focal stimulation of specific brain areas (e.g. the amygdala); however, 'kindled' animals generally do not have spontaneous seizures. Kainic acid and pilocarpine treatment induces status epilepticus, which is later followed by a chronic epileptic state (i.e. spontaneous recurrent seizures); however, these drugs presumably act at many sites to induce seizures, and one must consider the primary effect of the drug versus the secondary effects of the seizures associated with the status epilepticus. Several genetic models have been discovered for absence epilepsy. Although this type of epilepsy is generally thought to have a genetic component, and these animal models provide a basis for exploring the molecular mechanisms of absence epilepsy, it is not clear that every mutation that leads to absence epilepsy in an animal is relevant to the human condition. Collectively, these models have provided fundamental information about the molecular and cellular events transpiring in cortical neurons and their circuits during interictal discharges and during the transition from the interictal discharge to a fully developed seizure.

Initiation and spread of seizures

A number of terms are widely used in describing the results of epilepsy research and so should be defined. The epileptogenic focus is a cortical area containing abnormally functioning neurons which is determined electroencephalographically during the interictal period; thus, it is an electrophysiological concept (**Figure 1, B**). The epileptogenic zone is the area of brain tissue where an epileptogenic seizure actually begins, but its location can rarely be pinpointed accurately in patients, so it is largely a theoretical concept. An epileptogenic lesion is a structural concept denoting, for example, a tumour or scar which gives rise to chronic epileptic seizures. Neither clinical human nor animal research has yet provided well-understood relationships between these three brain areas, but, importantly, they do not always correspond to one another anatomically.

In order for any abnormal electrical activity to be recorded in the EEG during the interictal period, there must be an epileptic focus in which many cortical neurons synchronously fire brief bursts of electrical activity (< 1 s). Neurons within the focus usually possess properties resulting in a cessation of the synchronized discharge shortly after it begins and they are organized to prevent the

discharge from spreading further to adjacent neurons. That is, an 'inhibitory surround' appears to exist (Figure 1, B), which is controlled by inhibitory neurons that use the transmitter γ -aminobutyric acid (GABA). As the abnormal discharge remains confined to the focus, it is incapable of producing any behavioural symptoms.

The transition from interictal to ictal activity is hypothesized to involve a breakdown in the inhibition that temporally and spatially restricts the discharge to the focus. This breakdown allows the epileptic focus to become or create elsewhere in the brain an epileptogenic zone, the site of seizure origin (Figure 1, C). During the actual seizure, neurons then generate continuous high-frequency discharges over many seconds and recruit the surrounding neurons (ultimately adjacent cortical areas) into the seizure discharge. The continuous high-frequency discharge of many neurons creates a marked increase in the concentration of potassium ions and a decrease in the concentration of calcium ions within the extracellular fluid, which further increase neuronal excitability and promote seizure spread.

The spread of the seizure discharge through the brain gives rise to the symptoms of an epileptic attack. Once a full-blown seizure begins, excitation may spread rapidly to adjacent cortex, to cortex in the opposite hemisphere, and to subcortical structures (Figure 4). The spread of the seizure reflects in part the strength of the connections of the

epileptogenic zone to other brain sites. This spread of the discharge allows the focal seizure to generalize secondarily. When the discharge spreads from the motor cortex through the descending motor pathways, muscles are activated.

Complex partial seizures usually arise from an epileptogenic zone in the hippocampus, parahippocampal area or amygdala, which are deeply positioned structures of the temporal lobe. As a focal seizure spreads to the opposite temporal lobe, the patient loses consciousness. The patient usually has no memory of the seizure. This amnesia is attributed to the disruptive effect of the seizure on neurons of the hippocampi.

Hypothetical cellular mechanisms

Numerous mechanisms have been hypothesized to account for the various types of seizures and epilepsy. Because pharmacological blockade of GABA-mediated inhibition can trigger interictal discharges that may lead to ictal events, a long-standing yet controversial hypothesis is that epileptic seizures are the result of decreased synaptic inhibition. Another hypothesis is that augmentation of the *N*-methyl-D-aspartate (NMDA) type of excitatory glutamate receptor contributes to epileptogenesis. Because secondary or symptomatic epilepsy usually appears to develop following a latent period of months or even years after an injury, many researchers have proposed that axonal sprouting and formation of new excitatory synaptic circuits (i.e. synaptic reorganization) contributes to or is responsible for some forms of epilepsy. Other researchers have shown *in vitro* that robust seizure activity can occur without active chemical synapses. Controversy surrounds all of these hypotheses, and it is likely that future research will delineate their relative contributions to the different types of seizures and epilepsy.

Precipitants of the Epileptic Attack

Just what causes cortical neurons to begin seizure discharge at a particular time is uncertain. Neurons in an epileptic focus are prone to abnormal burst activity, which would make them more susceptible to activation by increased body temperature (hyperthermia), decreased oxygen to the brain (hypoxia), decreased blood sugar (hypoglycaemia), decreased calcium in the blood (hypocalcaemia), decreased sodium ions in the blood (hyponatraemia) and various behavioural states. For example, some rare epileptic patients are abnormally sensitive to stimulation by light and will have a seizure when exposed to flashing light. Other patients experience seizures only during sleep. Still others may have seizures from a lack of normal sleep. The hormonal changes that occur in women during menstruation may influence seizure susceptibility.

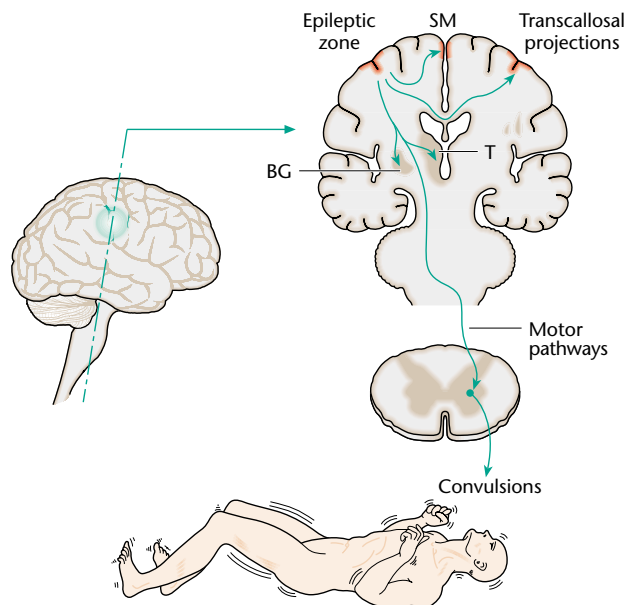


Figure 4 Coronal section, at the level shown in the inset, illustrating the spread of the seizure discharge. The discharge spreads from the epileptogenic zone in one cerebral hemisphere to the supplementary motor cortex (SM), into the same areas of the opposite hemisphere across the corpus callosum, and subcortically into the basal ganglia (BG) and thalamus (T). Spread into descending motor pathways activates muscles resulting in a convulsion.

Treatment

Antiepileptic drug therapy

Most epileptic patients benefit from antiepileptic drugs (AEDs). The objective of the therapeutic management of seizures with medication is to control the seizures with minimal adverse side effects. The proper diagnosis of seizure type is essential to the selection of an appropriate AED. If used for the wrong seizure type, some AEDs actually increase seizure activity.

The AEDs are different in terms of the type of epilepsy against which they work, and this provides clues as to the underlying mechanisms involved in the origin and spread of epileptic discharges. The AEDs carbamazepine and phenytoin are effective against both partial and generalized convulsive seizures but can exacerbate absence seizures, while ethosuximide is effective against absence seizures and is not helpful for other seizure types. This suggests that generalized convulsive and most partial seizures share a common set of underlying neuronal mechanisms that are different from those giving rise to absence seizures. Valproate and the benzodiazepines (e.g. diazepam, lorazepam) have a broader range of action and can be useful in both partial onset and primary generalized epilepsies.

Approximately 12 different AEDs are currently used. All affect, directly or indirectly, the cellular or molecular mechanisms by which nerve cells communicate with one another. Phenytoin and carbamazepine act by reducing the repetitive firing of action potentials through a use-dependent blockade of sodium channels. These medications allow nerve cells to fire at normal rates, but inhibit the abnormally fast rates of discharge that occur during partial and generalized convulsive seizures. They thus limit the spread of seizure activity in the cerebral cortex and also increase seizure threshold in the brain.

Absence seizures are thought to originate from pacemaker cells in the thalamus, which have projections to wide areas of the cerebral cortex. Ethosuximide, a medication that specifically inhibits absence seizures, acts on voltage-gated calcium channels and reduces the flow of calcium ions into thalamic neurons. This action reduces the pacemaker activity of thalamic neurons that influence the cerebral cortex to produce the 3-per-second spike-and-wave activity that characterizes absence seizures.

GABA is the major inhibitory neurotransmitter in the brain. Several of the antiseizure medicines work through the GABA system. The benzodiazepines mimic GABA; they bind to the GABA receptors and augment the inhibitory effect of GABA. Tiagabine also enhances the GABA system, but through a different mechanism. After a neuron has released GABA and it has acted on post-synaptic receptors, an active transport system takes it back up into the cell from which it originated. Tiagabine inhibits this reuptake process. Gabapentin is a newer antiseizure drug that probably acts through multiple mechanisms,

which are not well understood. However, gabapentin has been shown to increase brain GABA above control levels. Thus, AEDs can act on different parts of the GABA system.

Valproate has multiple mechanisms of action, and may be used in the treatment of both convulsive and absence seizures. Like carbamazepine and phenytoin, valproate prolongs the inactivation of sodium channels, thus reducing the ability of nerve cells to fire at high frequencies. Similar to some other AEDs (barbiturates and benzodiazepines), the drug increases the effectiveness of GABA-mediated inhibition. And, like ethosuximide, valproate reduces the flow of calcium ions through specific calcium channels in thalamic neurons.

An understanding of AED mechanisms is important because this knowledge can potentially lead to the development of newer and better medications. Also, when combinations of AEDs are administered to patients, it is best to use agents with different mechanisms of action with the hope that they will have synergistic actions in controlling seizures.

Surgical treatment of epilepsy

One type of surgical treatment consists of the removal (resection) of an abnormal brain area that has been identified as likely to be responsible for the seizure onset. It is a procedure applied only to a select population of people with epilepsy, namely those who have not responded to aggressive medical therapy with AEDs. These patients are referred to as being medically intractable. About 80% of all such surgical procedures in adults involve resections of the temporal lobe, although multilobar resections and even hemispherectomies are sometimes undertaken for catastrophic epilepsy in children.

Accurate localization of the abnormal area(s) is critical. Magnetic resonance imaging is the most useful of the modern brain imaging techniques in localizing the site of a lesion. Accurate localization also requires careful and intensive EEG analysis, typically combined with video monitoring. The patient is usually hospitalized, and continuous EEG and video data are recorded during typical seizures. Both types of data provide information on lesion localization; the EEG provides electrical localization, and the video behavioural localization. Sometimes EEG recording from electrodes placed directly in deep structures of the brain or on the surface of the brain may be necessary.

About 80% of patients with complex partial seizures become seizure free or experience a significant improvement (at least a 75% reduction in seizures) after removal of the anterior portion of the temporal lobe. Patients often still require medication with AEDs after operation. Other surgical procedures are performed, including section of the corpus callosum for the treatment of atonic seizures (a

callosotomy). This is a palliative procedure which does not necessarily stop seizures but inhibits rapid electrical spread with resultant less severe seizures.

Summary

Epilepsy is a common neurological condition characterized by the repeated occurrence of seizures due to a persistent brain abnormality. It affects both children and adults. Its diagnosis is based primarily on the description of the seizures by the patient and other observers. The EEG is often very helpful in diagnosis, although many people with epilepsy have normal interictal EEGs. Two major categories of epilepsy are recognized (partial and generalized), each having various subtypes. Epilepsy has many different causes but the exact molecular and cellular characteristics of the neuronal abnormality in the cerebral cortex that causes epileptic seizures is not fully known. Animal experimentation has suggested that abnormalities exist in the ion channels in neuronal membranes and/or in the synaptic relationships between neurons. Epilepsy usually is

not a life-threatening condition, but the quality of life may be impaired significantly when the patient's epilepsy is not treated successfully. Many patients can be treated with one or more of several medications, and those who do not respond to aggressive medical management may be treated neurosurgically.

Further Reading

- Engel J Jr (1989) *Seizures and Epilepsy*. Philadelphia: FA Davis.
- Engel J Jr (ed.) (1993) *Surgical Treatment of the Epilepsies*. New York: Raven Press.
- Hauser WA and Hesdorffer DC (1990) *Epilepsy: Frequency, Causes, and Consequences*. New York: Demos.
- Levy RH, Mattson RH and Meldrum BS (eds) (1995) *Antiepileptic Drugs*, 4th edn. New York: Raven Press.
- Lothman EW and Collins RC (1990) Seizures and Epilepsy. In: Pearlman AL and Collins RC (eds) *Neurobiology of Disease*. New York: Oxford University Press.
- Schwartzkroin PA (ed.) (1993) *Epilepsy: Models, Mechanisms, and Concepts*. New York: Cambridge University Press.
- Wyllie E (ed.) (1997) *The Treatment of Epilepsy: Principles and Practice*, 2nd edn. Baltimore: Williams and Wilkins.