oligodendrocytic tumors of the cerebral hemispheres (11,12). Electroencephalogram findings are generally related to location of the tumor and rapidity of growth. Most, but not all, studies associate rapidly growing tumors with very slow delta range activity and more slowly growing tumors with arrhythmic theta range activity with occasionally intermixed epileptiform spikes and sharp waves. It should be noted that up to one-third of patients with brain tumors have an epileptogenic focus remote from the tumor site, which may give rise to some confusion in localization. Meningiomas and other slow-growing or midline tumors may be difficult to localize, although HV may reveal the focus of slowing not seen otherwise (2,3,12–14). Focal theta range activity can occur with any type of tumor, and one series noted it in 75% of patients with hemispheric tumors. In that study, focal delta range activity was most common in patients with glioblastoma multiforme, although it also occurred with meningeal tumors (15). Activity in the delta range was less frequent with astrocytomas and focal sharp waves were more common. Focal epileptiform activity appears to be correlated generally with clinical seizures in patients with astrocytomas. Clinical seizures were not as common among patients with meningeal tumors, even though they also had a fair amount of focal epileptiform activity on the EEG. Patients with multiple metastases may also have a good deal of epileptiform activity in their EEG; over 90% of patients with metastatic disease have abnormal EEGs, including epileptiform activity, delta range activity, and dysrhythmias (16).

Focal delta and theta range activity correlates with WM involvement of tumors. This includes tumors involving both gray and white matter, as well as those involving WM only. Rhythmic delta activity may indicate involvement of the thalamus, although involvement of deep frontal WM may produce similar findings.

In a seminal series, Gastaut and colleagues studied 127 cases of brain tumor using both CT and EEG. These included both malignant and benign tumors. Intermittent or continuous focal delta activity occurred in 62% of the EEGs. The presence of surrounding edema, even when extensive, did not affect the EEG findings. Other investigators have found that cerebral edema does not contribute significantly to EEG findings (17–19).
**Large Hemispheric Brain Tumors**

Although the EEG may be normal in up to 40% of brain tumors, normal EEGs actually occur in only about 5% of large hemispheric tumors, which account for the majority of brain tumors in adults. In contrast, EEGs are normal in at least 25% of deep midline, basal, and infratentorial tumors. This figure is higher in the absence of obstructive hydrocephalus and increased intracranial pressure. When abnormalities are detected, there are a number of common findings on EEGs in patients with hemispheric tumors. PLEDs (10,12) are frequently reported, with up to 18% of patients demonstrating this finding. FIRDA is often seen with frontal tumors, whereas parietal and occipital tumors may affect the posterior basic rhythm. Nevertheless, tumor location does not always correlate with EEG localization. Posterior tumors can show abnormalities in more anterior regions and unilateral temporal tumors can produce bitemporal abnormalities, possibly leading to false localization.

**Infratentorial Brain Tumors**

Most tumors in children over one year of age are infratentorial. Although most of these patients have had an imaging study, the presenting symptoms can be so nonspecific, such as altered mental status that an EEG might be obtained for other reasons in the course of a patient’s treatment. Therefore, it is important to understand EEG findings in this context so that an appropriate interpretation of the pattern can be made. Electroencephalograms are abnormal in only 30% of patients with brainstem tumors. However, specific infratentorial locations may influence whether an EEG abnormality is found. For example, over 80% of EEGs were abnormal in a series with cerebellar or fourth ventricular tumors (20). Abnormalities included 27% with posterior rhythmic delta waves, 32% had generalized bilateral bursts of rhythmic slowing, 51% had posterior arrhythmic delta waves, and 11% had rhythmic theta or delta waves on vertex or anterior quadrants (21).

![Figure 8.8: PLEDs. The EEG shows an unusual case of occipital PLEDs in a 32-year-old man with an occipital infarction.](image)
Figure 8.9: BIPLEDs. The EEG displays BIPLEDs in a patient with a paraneoplastic encephalitis.

Figure 8.10: PLEDs plus. The EEG shows an example of parasagittal PLEDs plus. This patient had eyelid twitching with a correlation of the central PLEDs plus pattern. Note the extra waveforms occurring after the main spike wave.
Attenuation of background activity is seen in patients with high-grade gliomas that have thalamic involvement, but may also be seen in regions with extensive peritumoral edema, although this is a nonspecific finding.

Electroencephalogram abnormalities in tumors of the sellar region include temporal lobe abnormalities, unilateral delta range activity, and bitemporal dysrhythmia. It is important to remember this in the differential diagnosis of temporal lobe abnormalities. In tumors that compress the third ventricle, generalized slowing was noted and the degree of compression was the only factor that correlated with abnormalities in the EEG. In most case series, EEG abnormalities do not predict tumor type.

Hypothalamic hamartoma is a developmental malformation that frequently presents with seizures including infantile spasms. The EEG in this condition may be normal, similar to other deep-seated masses, although over time, it may evolve through the appearance of focal and then generalized seizures consistent with the clinical semiology. There may be associated autonomic features. Focal slowing or epileptiform activity over frontal and/or temporal head regions may be the initial appearance on the EEG, although this evolves into bilateral spike wave over time if treated (9,22). Eventually, a pattern consistent of generalized slow spike wave, paroxysmal fast, and electrodecremental patterns can occur reminiscent of the EEG in Lennox Gastaut Syndrome. There is a possibility that the hamartoma in some way generates abnormal activity that propagates through the cortex, leading to the various seizure types noted. In an important study of four patients with hypothalamic hamartoma presenting with epileptic manifestations, EEG source analysis based on scalp recordings was able to estimate that the epileptiform spikes have deep sources in the neighborhood of the hamartoma, which later spread to the cortical area (23). A subsequent study from the same group of patients using simultaneous EEG and fMRI recordings of several seizures indicated that the epileptic activity appeared to originate in the area around the tumor and propagate to the left fornix to the temporal lobe and later through the cingulate fasciculus to the left frontal lobe (9,24).

It is obviously not possible to determine the type of tumor by EEG, but several general observations provide useful guidelines. Slow growing extraxial lesions such as meningiomas usually produce the least changes on the EEG. Rapidly growing intraparenchymal lesions such as glioblastoma multiforme, malignant gliomas, and other aggressive tumors result in the pronounced abnormalities in terms of focal continuous polymorphic delta activity and localized attenuation of background activities (12). Bilateral but lateralized slow-wave activities are characteristic of frontal lobe tumors.

Subfrontal and diencephalic tumors are most likely to produce bilateral but asymmetrical IRDA. Bilateral arrhythmic slowing with bursts of IRDA reflects hydrocephalus or mass effect with shift. Parasellar and hypothalamic tumors do not cause EEG changes unless they obstruct the third ventricle or extend into the temporal lobe on one side.

Infections

Brain Abscess

Because of the increased number of patients on immunomodulators or immunosuppressants after organ transplantation, there has been a resurgence of brain abscess cases. A recent case series of patients with brain abscesses mentioned both epileptiform activity such as focal sharp waves and PLEDs as the most common EEG abnormalities (Fig. 8.11) (25,26). Importantly, although EEG is localizing in most cases, it has been reported to be falsely localizing in some patients with a cerebellar abscess. Thus, EEG may be useful in localizing cortical abscesses in many cases, but it can also be misleading or even normal in others.

Encephalitis

Electroencephalographic findings are particularly important in the diagnosis of encephalitis caused by herpes simplex virus (HSV) type 1, and some reports have suggested a normal EEG excludes the diagnosis. Many types of abnormalities have been described, including focal or diffuse slow-wave activity, focal epileptiform discharges, electrical seizure patterns, localized attenuation of background activity, and PLEDs (27–29). Because HSV-1 causes severe hemorrhagic necrosis, mainly the inferior and medial parts of the temporal lobes and the orbital frontal regions, focal or lateralized findings that are maximal in these areas are highly suggestive of herpes encephalitis and can also be helpful in determining the best site for brain biopsy. The acute destructive nature of the lesions probably accounts for the frequency with which PLEDs are seen.

PLEDs appear in the acute phase of the illness, usually between the 5th and 12th day after the onset of neurological symptoms. They consist of 100- to 500-mV sharply contoured slow waves or polyphasic spikes that typically recur at 1.5- to 2.5-second intervals, although both slower and faster rates can be seen (30). The periodic complexes are usually unilateral, but they can also be bilateral and occur either independently or time-locked on the two sides, such as in the case of BIPLEDs or generalized periodic epileptiform
discharges (GPEDs). PLEDs usually appear before changes on head CT but not before abnormalities on brain MRI. Although this periodic pattern is usually seen in adults with herpes simplex encephalitis, it has been reported in infants and children.

HSV type 2 causes encephalitis in neonates and this is associated with a distinctive periodic EEG pattern. The periodic discharges are often not restricted to the temporal lobe and are multifocal. Discharges often have their own morphology and periodic interval depending on the cortical generator from which they emanate. Focal spikes and seizures are also common. Other forms of focal encephalitis cause focal slowing and spikes, but PLEDs are rare (31).

Two other encephalitides have characteristic EEG patterns. Prion diseases such as CJD, fatal familial insomnia, and others are neurodegenerative diseases characterized by rapidly progressive dementia and neuropsychiatric symptoms. They are briefly discussed here as a type of encephalitis. Initial EEG changes are nonspecific and mild. However, as the disease progresses, the EEG becomes more characteristic, consisting of continuous generalized, bisynchronous, periodic sharp waves occurring at intervals of 0.5 to 1 second with a duration of 200 to 400 milliseconds. This pattern evolves with disease progression to a burst-suppression pattern and ultimately diffuses suppression (32).

Subacute sclerosing panencephalitis (SSPE) is a late complication in children who survived a measles infection and is associated with rapid intellectual decline, anorexia, spasticity, seizures, and other symptoms. The signature EEG in this condition is characterized by periodic large-amplitude complexes consisting of high-voltage, repetitive polyphasic and sharp-