Clinical neurophysiology

Robin P Kennett
Sidra Aurangzeb

Abstract

Clinical neurophysiology uses measurement of electrical activity in the nervous system to diagnose and monitor disease. Electroencephalography (EEG) and nerve conduction studies (NCS) with electromyography (EMG) are the tests most used in general medical patients. Specialized investigations for neurological diseases and operative or long-term monitoring are available, but are beyond the scope of this article.

The EEG is a simple, non-invasive test of brain function used mostly to diagnose and classify epilepsy. Bilateral three per second spike and slow-wave complexes are seen in primary generalized epilepsy, and localized spike discharges in focal seizures. Prolonged recordings of seizures, allowing a clinical and electrographic correlation, are sometimes needed for precise diagnosis. Characteristic EEG waveforms (slow waves, triphasic or repetitive complexes) can help in the management and prognosis of other disorders such as encephalitis and encephalopathy. Nerve conduction and needle EMG studies investigate peripheral neuromuscular disorders, especially to confirm and assess the severity of peripheral nerve disease. Clinical neurophysiologists are often asked to investigate patients with undiagnosed neurological symptoms, and these tests can provide objective information as an extension of the clinical examination. Measurement of sensory nerve action potentials helps to locate lesions in sensory pathways. A combination of motor nerve conduction and needle EMG studies is particularly useful when investigating patients with weakness.

Keywords Electroencephalogram; electromyography; epilepsy; motor neuron disease; nerve conduction; peripheral neuropathy

Key points

- Scalp electroencephalography (EEG) is non-invasive, available and can be specific in epilepsy, but has limited sensitivity. A normal standard EEG does not exclude the diagnosis of epilepsy
- Long-term EEG and video-telemetry (simultaneous video and EEG recordings) can be diagnostic in patients with unexplained recurrent symptoms, including non-epileptic attack disorder
- EEG is important in the management of status epilepticus, especially non-convulsive status, and in the assessment of patients with hypoxic-ischaemic encephalopathy
- Nerve conduction studies and electromyography provide objective evidence of peripheral nerve disease and aid management of the common entrapment neuropathies
- Nerve conduction studies differentiate demyelinating from axonal generalized peripheral neuropathy. In acute neuropathies such as acute inflammatory demyelinating polyneuropathy (Guillan–Barré syndrome), tests can be normal in the first few weeks
- Peripheral neurophysiological studies are helpful in the diagnosis of patients presenting with weakness and normal sensation, such as in motor neuron disease and myasthenia gravis

Electroencephalography (EEG)

Electrodes attached to the scalp with conductive paste record electrical potentials originating in the cerebral cortex. The signals vary in frequency and amplitude in different regions; the most consistently observed activity is at 8–12 cycles/second over the occipital region with the eyes closed (α-rhythm). The mechanism of EEG rhythms is not fully understood but probably involves diffusely projecting neuronal circuits between the thalamus and cerebral cortex. The normal EEG changes with levels of alertness and with development from birth to adulthood. A wide range of patterns is seen in healthy individuals. Diagnosis can be difficult, but the abnormalities shown in Figure 1 (slow waves, spike and slow waves, repetitive complexes) are strongly associated with disorders of cortical function.

EEG in epilepsy

A single 20–60-minute EEG reveals interictal epileptic discharges (IEDs) in about 50% of patients with epilepsy. Sensitivity increases to more than 90% with repeated recordings and activation procedures (photic stimulation and over-breathing enhance electrical abnormalities in primary generalized epilepsy, and sleep or sleep deprivation can trigger IEDs in most types of epilepsy). In many patients with epilepsy, standard EEGs can be used for diagnosis and syndromic classification, but, because of the low sensitivity, a normal standard EEG cannot exclude a diagnosis of epilepsy. False-positive EEGs showing spike and slow-wave complexes occur in less than 0.5% of adults without epilepsy.[1]

Standard EEGs are usually recorded with a simultaneous patient video to help identify artefacts and allow correlation between electrical abnormalities and symptoms. When doubt remains, prolonged recording can be helpful, using either ambulatory outpatient recording or inpatient video-telemetry, in which time-locked EEG and video recordings allowing precise

Robin P Kennett *BSc MD FRCP(Lon) FRCP(Ed) is Consultant in Clinical Neurophysiology at the John Radcliffe Hospital, Oxford, UK. His interests include diagnosis of neuromuscular disorders and indications for surgical treatment of epilepsy. Competing interests: none declared.*

Sidra Aurangzeb *MB BS (Pakistan) MRCP (UK) FCPS Neurology (Pakistan) is Specialist Registrar in Neurology and Clinical Neurophysiology at the John Radcliffe Hospital, Oxford, UK. Competing interests: none declared.*

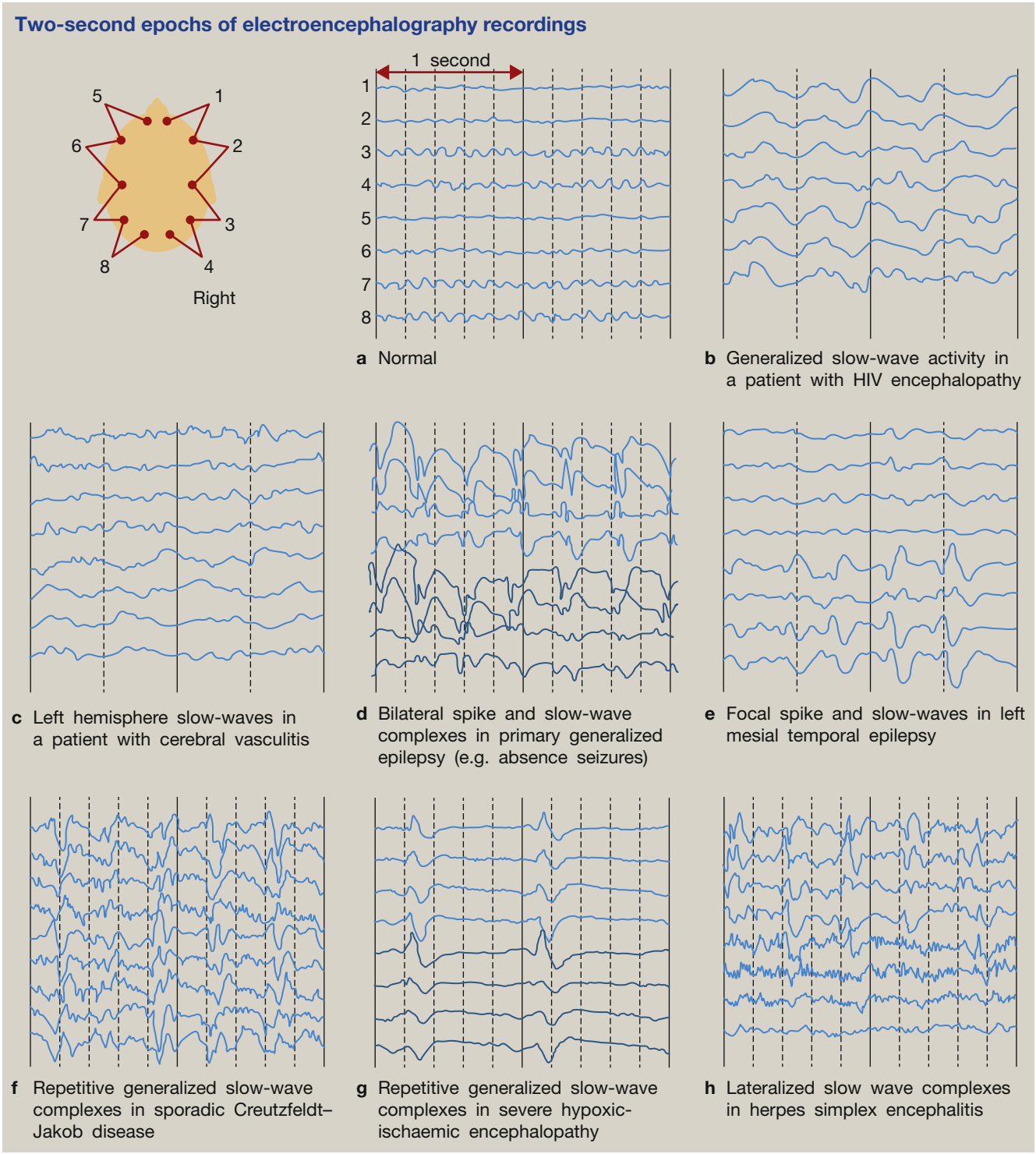

Figure 1

correlation. This technique is most useful in preoperative assessment of potential candidates for epilepsy surgery and in non-epileptic attack disorders.[2]

Spike and slow-wave complexes: these are the hallmark of epilepsy, seen during seizures (ictal discharges) or, more often, subclinically between IEDs. Generalized spike and slow-wave complexes in primary generalized epilepsy have a frequency of three per second and are bilaterally synchronous and maximal frontally. In photosensitive patients, these discharges can be provoked by light flickering at about 18 flashes/second. Localized spike and slow-wave discharges are seen in focal epilepsy, usually over the relevant cortical region (mostly the temporal or frontal lobes).