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ABSTRACT

EEGs are commonly requested by physicians in medical wards for patients with altered conscious levels and also in the outpatient setting for investigation of seizures. This article seeks to explain how EEG is performed and explore the correct indications for its use.

Key Words: Electroencephalography; EEG; Indications

Electroencephalography

Electroencephalography (EEG) is the electrical study of brain activity. It was first used on humans by the German psychiatrist, Hans Berger, in 1929 to examine electrical activity within the brain's cortical grey matter[1] and it was later discovered that aberrant cortical activity is seen in many neuro-pathologies. It is especially relevant in seizure disorders, in particular epilepsy. It is a non-invasive, painless procedure that can be performed in both outpatient and inpatient settings, and usually lasts a minimum of 35-45 minutes[2].

EEG & Loss of Consciousness

EEGs have a relatively low sensitivity for diagnosing epilepsy at 25-56%. In a study of over 13,000 military personnel with no history of significant illness or head injury and normal physical examinations, 0.5% had frankly epileptiform discharges on EEG. Only one of these men went on to develop clinical epilepsy[3].

Sam et al reported that epileptic EEG discharges can be seen in up to 12.3% of the community who had no history of unprovoked seizure or epilepsy. Many of these patients had an underlying acute or progressive cerebral disorder[4], and this highlights that epileptiform discharges are present in a number of pathologies other than epilepsy. Likewise, abnormal cortical activity is relatively common, especially in the elderly, migraine patients, those with psychotic illness and those on psychotropic medication[5].

To add further confusion, a normal EEG does not exclude a diagnosis of epilepsy. Definite epileptiform abnormalities are seen in only 29-38% of adults with epilepsy on their first EEG recording[5].

The EEG should not therefore be used in isolation to diagnose epilepsy, where history is most important, nor should it be used to diagnose unexplained losses of consciousness. Performing the investigation in cases of probable syncope in particular incurs the risk of a false positive result and subsequent misdiagnosis[6].

Specific Indications for EEG in Epilepsy

Classification of Epilepsy

Classification of seizure type is essential for offering prognosis and planning the correct treatment. In particular, it is helpful to distinguish between generalised and focal onset epilepsies, where certain medications (e.g. carbamazepine) are usually avoided in generalised epilepsies but not focal onset epilepsies[7].

Furthermore, EEG can facilitate the localisation of an epileptogenic focus and indicate localised structural pathology underlying the seizure disorder, which is helpful if the patient is being considered for resective surgery to cure their epilepsy[1, 5, 8, and 9].

Triggers

If stress testing during the EEG identifies photosensitive epilepsy, the patient can manage their condition by avoiding triggers such as strobe lighting[1].

Use of EEG in Intensive Care

The use of continuous EEG (cEEG) recording in Intensive Care Units (ICU) can now provide prompt and therapeutically important data regarding cerebral function in a cohort of patients who may have only subtle or no clinical signs[10, 11].

Investigating Periods of Altered Consciousness

EEG is important in the management of convulsive status epilepticus: for monitoring seizure activity and assessing the response to IV treatment. This is particularly important in intensive care where convulsions may be masked by sedation, paralysis and antiepileptic drugs[5, 8, 10, and 12].

Whilst convulsive status epilepticus should be clinically evident, a prolonged period of altered consciousness could be due to non-convulsive status epilepticus (NCSE), which can be difficult to distinguish from other confusional states. Privitera et al urge that all patients with persistent, unexplained, altered consciousness receive immediate EEG[13] to exclude NCSE and, where appropriate, allow the prompt initiation of appropriate treatment[8]. Hirsch reports that the difference in mortality between NCSE diagnosed at 30 minutes compared with delays of over 24 hours soars from 36% to 75%, respectively[14].

Other Indications for EEG

There are many reported indications for EEG, including prognosticating head trauma, diagnosis of encephalitis and dementia, measuring the depth of sedation and predicting the outcome and management of patients in a coma of other reasons[2, 10]. However, the EEG is not specific in many of these conditions and should only be used to support diagnosis[8].

Procedure

Electrodes are positioned on the scalp in an arrangement called a montage. They are placed according to the International 10/20 System, which is based on the identification of anatomical landmarks such as nasion and inion and the preauricular points. Electrodes are then placed at consecutive intervals fixed distances from these points in steps of 10 or 20%; thereby allowing for variations in head size[15]. These points are labelled as Frontal pole (Fp), Frontal (F), Central (C), Parietal (P), Occipital (O) and Temporal (T). Odd numbers denote points over the left hemisphere and even numbers the right, whilst 'z' denotes zero and identifies electrodes in the midline[16]. The potential difference recorded between pairs of electrodes is amplified and displayed on a monitor[2, 17, and 18]. The recorded activity is measured in microvolts[18] and represents the postsynaptic potentials of vertically orientated pyramidal cells within the cerebral cortex[17].

Routine EEGs now commonly include so-called activation procedures to enhance the diagnostic sensitivity. During activation, EEG recordings are made when a patient undergoes hyperventilation or exposure to flashing lights at various frequencies (photic simulation). Binnie et al report that a waking EEG of at least 30 minutes duration, with hyperventilation and photic stimulation, will demonstrate inter-ictal epileptiform discharges (IEDs) in about 50% of adults with epilepsy[8].

National Institute for Clinical Excellent (NICE) guidelines on the diagnosis and management of epilepsy recommends that photic stimulation and hyperventilation should remain part of the standard EEG assessment. The patient must however be warned that such procedures may induce a seizure and they have a right to refuse[6].

Sleep and sleep deprivation can also increase the likelihood of IEDs being recorded as some wave-forms are more evident during sleep, and tiredness can trigger seizures. Sleep recordings are helpful in identifying epileptiform discharges in patients who have normal EEGs in the waking state, and so can aid epilepsy classification[8]. In particular, there is evidence that sleep deprivation activates IEDs in idiopathic generalised epilepsies[1].

NICE recommend that a sleep EEG is performed when routine EEG has not contributed to a diagnosis or classification of epilepsy[6].

Interpreting EEG Results

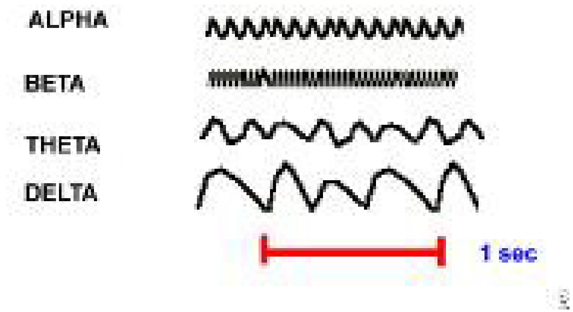

FIGURE 3: waveforms seen on EEG. Reproduced with permission from: *Medscape Reference.* Jan 2013, available at: http://emedicine.medscape.com/article/1139332-overview[19].

Alpha Waves

8-13Hz rhythm is seen symmetrically and posteriorly when the eyes are closed, this activity is attenuated in drowsiness and is blocked with eye opening. Alpha waves are normal in adults[2, 17 and 18].

Beta Waves

>13Hz activity is seen symmetrically and frontally in healthy adults. This is unaffected by eye opening but may be absent of reduced in areas of cortical damage[16].

Theta Waves

4-7Hz rhythm is normal in children up to 13 years of age[16]. It is a normal finding in drowsy adults and becomes more apparent in light sleep. Presence of theta waves in an alert adult can indicate brain dysfunction[20].

Delta Waves

<4Hz rhythm is normal in infants under 1 year[16]. They are only normal in adults in moderate to deep sleep and their presence in an alert adult suggests brain dysfunction[20].

Theta and delta rhythms are both seen in children and young adults with frontal and temporal predominance and usually disappear in adulthood.

Generalised spike-wave activity is commonly seen in patients with typical absence epilepsy and may also be seen in some generalised epilepsy syndromes, whereas focal IEDs are suggestive of partial seizure disorders such as temporal lobe epilepsy[17]. Binnie et al observed that hyperventilation provokes spike-wave activity in patients with absence seizures so consistently that the lack of this finding in an untreated person who hyperventilates efficiently must cast doubt on the diagnosis[8].

Other changes often seen on EEG include generalised slowing, indicating an encephalopathic state, and focal excess slow activity indicating a unilateral structural lesion.

Conclusion

EEG is a commonly ordered investigation in hospital settings, often for the wrong reasons[5]. This leads to misdiagnosis with potentially significant adverse outcomes. It is important that patients are only referred for EEG in the correct clinical context i.e. to confirm clinical findings from thorough history and examination.

Learning Points

- EEG is used to monitor cortical activity
- Activation procedures increase the diagnostic sensitivity of EEG
- When used in the correct context, EEG can be used to support a clinical diagnosis of epilepsy, classify some seizure syndromes and identify epileptogenic foci
- It should not be used in isolation to diagnose epilepsy (in cases of suspected seizure or unexplained loss of consciousness)
- EEG can be useful in the diagnosis and management of encephalopathies, status epilepticus and confusional states

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