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Seizures and adverse events during routine scalp electroencephalography: A clinical and EEG analysis of 1000 records

Heather Angus-Leppan *

Department of Clinical Neurosciences, Royal Free Hospital, University College London, Pond Street, London NW3 2QG, UK

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Abstract

Objective: To quantify the incidence of seizures and adverse events during standard electroencephalography (EEG).
Methods: A retrospective random sample of 1000 of a total of 3391 reports of standard scalp EEG recordings during 2002 at Kings College Hospital were studied, and adverse events during standard EEG were recorded. Photic induced seizures and epileptiform activity were compared with the resting, hyperventilation and sleep EEG.
Results: Adverse events occurred in 131 records (13.1%), including seizures in 60 records (45 electro-clinical and 15 non-epileptic seizures). The overall incidence of electro-clinical seizures was not statistically different during the resting EEG (2.8%), sleep EEG (2%), hyperventilation EEG (2.1%) and during photic stimulation EEG (1.4%). There was a higher frequency of electro-clinical seizures during hyperventilation and sleep in those with a diagnosis of idiopathic generalised epilepsy (31.5%) and during photic stimulation in photosensitive patients (31%). The incidence of electro-clinical seizures was significantly less during activation procedures in focal epilepsies (2.6%). Activation techniques made a unique diagnostic contribution when routine resting EEG was normal or equivocal in 11% of cases.
Conclusions: Adverse events occurred in 13.1% of records, and most were minor. Sixty of the adverse events were seizures. Those generated during the EEG were brief and safety precautions operated successfully. In those without a prior diagnosis, the chance of seizures is the same during both resting and activation EEG. In those patients with generalised epilepsy or photosensitivity, activation procedures have a higher rate of seizure induction.
Significance: This study has implications for informed consent for EEG.

Keywords: Adverse events; Seizures; Electroencephalography; Scalp EEG; Photic stimulation; Hyperventilation; Sleep EEG; Activation procedures

1. Introduction

Electroencephalography (EEG) is a readily available functional test of cerebral activity used in the diagnosis, assessment and classification of epilepsy in adults and children. Standard scalp EEG is often carried out with activation techniques (hyperventilation, photic stimulation and sleep) to increase the diagnostic yield. For example, sleep studies increase the overall diagnostic yield of EEG from 50% to 80% (Marsan and Zivin, 1970).

There are studies on the risks of invasive EEG (Simon et al., 2003) and long term monitoring (Sanders et al., 1996), but little information on the risk of standard EEG. There are case reports of complications such as skin reactions (Day, 1968) and hyperventilation induced stroke in patients with sickle cell anaemia (Fatunde et al., 2000), but no published large clinical series or audits of complications of standard EEG were found.

In the United Kingdom a seizure during an EEG prevents driving for a period determined by the driving regulatory body (DVLA, 2006). The British Society for Clinical Neurophysiology was unsuccessful in gauging the risk of seizures during photic stimulation using current protocols (Dr. Robin Kennett, personal communication). After examining the issue, a working party of the British

* Tel.: +44 2082165472; fax: +44 2074726829.
E-mail address: Heather.Angus-Leppan@bcf.nhs.uk

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Society for Clinical Neurophysiology recommended that all patients should be consented for EEG, in discussion with the referring doctor and with an information leaflet provided in advance. This warns specifically that photic stimulation may "very rarely cause a seizure in people that are sensitive" (British Society for Clinical Neurophysiology, 2003). It does not warn about seizures occurring at other times during the EEG.

This study sought to quantify the incidence of seizures and adverse events during standard EEG recordings in a large series and to examine when these seizures occurred: whether during routine (non-activated) EEG, or during sleep, during hyperventilation or during intermittent photic stimulation (IPS). This information is important in informing subjects about potential risks of standard resting and activated EEG. This study has been reported in abstract form (Angus-Leppan, 2004).

2. Methods

This was a retrospective study on computerised reports of standard EEG recordings done at Kings College Hospital for 2002. Reports comprised a factual report by an accredited trained technician, and a conclusion by a consultant epileptologist (neurophysiologist or neurologist with epilepsy training).

2.1. Terminology

Adverse events were defined as an incident or occurrence from which potential or actual "harm resulted to a person receiving health care" (Stevens, 1986) occurring at or immediately around the time of the EEG. It does not imply that the EEG caused the event. Sometimes the event had benefits as well as potentially causing harm. For example a seizure during an EEG may clarify the diagnosis, classification and the correct treatment, as well as preventing driving for a year in the United Kingdom.

Activation techniques are defined as methods used to elicit or accentuate abnormal cerebral activity (Kaufmann and Watson, 1949). Activation techniques used in this study were sleep, IPS and hyperventilation.

The term standard EEG is used to refer to both routine EEG and combined routine and sleep EEG. Routine EEG refers to resting scalp EEG with or without hyperventilation and/or photic stimulation. Routine EEG without any activation procedure is referred to as a routine resting or non-activation EEG. Sleep EEG refers to scalp EEG recorded during spontaneous, sleep deprived or induced sleep.

Seizures were classified as electro-clinical seizures, clinical seizures without EEG change, possible seizures and non-epileptic seizures. Possible seizures were events judged to have a moderate to high likelihood of being an epileptic seizure on combined clinical and electrical grounds, without conclusive evidence. Non-epileptic seizure was defined as a clinical event without EEG evidence of a seizure, presumed to have a psychological or psychiatric mechanism. It was not used as a blanket term for all non-epileptic events, which were classified elsewhere. Sometimes there was strong positive evidence against an epileptic mechanism – for example, apparent loss of consciousness with preserved alpha rhythm.

Seizures were subdivided according to whether they occurred during routine recording, sleep, hyperventilation, photic stimulation, or unspecified time.

The term "epileptiform activity" (EA) was used to denote "spiky waveforms in epileptic subjects due to abnormal, excessive, hypersynchronous cerebral neuronal activity", (Binnie and Holder, 1999). Spiky waveforms are subjectively assessed as pointed and distinguished from background activity (Chatrian et al., 1983). EA consists of paroxysmal waveforms of cerebral origin with a high correlation with a seizure disorder (Westmoreland, 1985) subdivided into spikes (transients less than 80 ms in duration), sharp waves (transients 80–120 ms in duration), and spike and wave complexes (spike followed by slow wave of more than 120 ms) (Binnie and Holder, 1999) and less common types (slow spike and wave, atypical spike and wave discharges, paroxysmal rhythmic fast activity and hypsarrhythmia (Binnie and Holder, 1999).

2.2. Sample

Demographic data on sex and type of EEG were recorded for all 3391 scalp EEG (1763 males and 1673 females) for 2002. There were 2380 (70%) routine EEG studies, and 1011 (30%) routine and sleep EEG studies.

One thousand randomly selected records of routine EEGs were analysed in detail. Randomisation was done using computer generated random numbers for a discrete uniform distribution. This sub-group of reports was on 522 males, 477 females (one sex not recorded) ranging in age from two days to 101 years (mean 31.3 years, SD 20.9). Eighty-one were emergency (bedside) recordings. Within the 1000 records, repeat studies were done in five patients (a total of 10 records for these five patients). These were analysed within the total group.

2.3. Techniques

Digital EEG recordings were carried out using the Maudsley electrode placement system, with one recording channel for concurrent electrocardiograph (ECG) recordings. In 855 of the 1000 reports, one or more activation procedures were recorded, after resting recordings of approximately 20 min.

Sleep studies were considered satisfactory if recorded during sleep to at least Stages I or II (Hughes, 1982; Billiard, 1982). They were completed in 342 studies and incomplete in 10. Sleep studies, of variable duration, were usually performed using medication – in children over the age of two years, alimemazine tartrate and in adults, quinalbarbitone. In a few patients, sleep was spontaneous