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Focal epileptiform activity described by a large computerised EEG database

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Abstract

Objective: To study the age-related topographical tendency of expressing epileptiform activity, and the effect of focal epileptiform activity (FEA) on the general cortical brain activity.
Methods: 1647 consecutive routine EEGs containing FEA were visually assessed for FEA location and asymmetry. Background activity was compared with that in normal EEGs from 3268 drug-free outpatient controls.
Results: FEA localisation was age-related ($p < 0.0005$) except for the temporal region ($p = 0.22$) where FEA was found equally often in the young and the old. The left hemisphere was more prone to FEA ($p = 0.018$). The left–right asymmetry varied by age ($p = 0.013$). FEA asymmetry occurred most frequently in EEGs from patients older than 80 years, and least frequent in the age-group 20–39 years. FEA was associated with lower alpha rhythm (AR) frequencies ($p = 0.0041$) and higher AR amplitudes ($p = 0.0023$), as well as higher general background activity (GBA) amplitude ($p < 0.0005$), while GBA frequencies were the same ($p = 0.96$).
Conclusions: Topographical localisation of FEA was age-dependent. There was an overall left dominance, but the side asymmetry was modest and varied by age. FEA was associated with changes in AR and GBA.
Significance: The results demonstrate that FEA is associated with cerebral cortical dysfunction also distant from the epileptic focus.

Keywords: Electroencephalography; Databases; Alpha rhythm; Background activity; Asymmetry; Topography

1. Introduction

Epilepsy is a clinical diagnosis, but electroencephalography (EEG) plays a major role in evaluating epilepsy (Flink et al., 2002). EEG provides a convenient and inexpensive way to demonstrate the physiological manifestations of abnormal cortical excitability that underlie epilepsy (Smith, 2005). Epilepsy is the single most studied patient diagnosis in nearly all EEG laboratories, and is the area in which EEG is of greatest clinical value (Binnie and Stefan, 1999). EEG differentiates between epileptic and non-epileptic seizures, seizure types, epilepsy syndromes, focal or generalised epilepsies, and symptomatic or idiopathic epilepsies. Thereby EEG also facilitates the choice of antiepileptic medication and prediction of prognosis. In previous papers, we have described a system for categorization of digital EEG data in a computerised database, thus achieving accessibility of routine EEGs for research and quality control (Aurlien et al., 1999, 2004).

Knowledge about the age-dependency of commonly studied EEG parameters is essential to understand the significance of epileptiform activity both clinically and scientifically. There are, however, only a few published studies concerning age correlated topographical localisation of focal epileptiform activity (FEA). Gibbs and Gibbs

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(1952) analysed crude topographical distribution of FEA more than half a century ago, but not in age-related categories. Koufen and Gast (1981) reported age-related distribution of focal EEG abnormalities, but not specified for FEA. Several authors have reported the left cerebral hemisphere to be more prone to FEA than the right (Dean et al., 1997; Labar et al., 2001; Holmes et al., 2001; Gatzonis et al., 2002; Doherty et al., 2002) but only a few have studied such asymmetries related to age (Doherty et al., 2003a,b).

Abnormal EEG background activity has been described in patients with focal epilepsies using quantitative EEG techniques (Miyauchi et al., 1991; Farkas et al., 1992; Diaz et al., 1998; Drake et al., 1998; Braga et al., 2000). Similar findings have to our knowledge not been published using visual EEG analysis, which is the main EEG method for clinical use (Nuwer, 1997; Flink et al., 2002; Stokes et al., 2004).

EEG-studies concerning epileptiform activity are usually limited to clinically well-defined epilepsy entities or syndromes. This study, in contrast, focuses on the epileptiform activity itself as obtained from a large unselected population of patients referred to EEG examination. Good clinical information is essential for the assessment of the significance of epileptiform activity in clinical practice (Binnie and Stefan, 1999; Sam and So, 2001). Nevertheless, looking at certain important EEG phenomena from an EEGer's point of view, and including a large unselected population, provides an overview that may easily be lost if studying selected clinical entities only. The aim of this study was to study age-related topographical aspects of expressing epileptiform activity, and also the effect of FEA on the general cortical brain activity. Does the expression of epileptiform activity in different brain regions change during life? Is the left hemisphere more prone to FEA? Is FEA asymmetry age-dependent? Does FEA alter the EEG background activity?

2. Methods

2.1. EEG recordings

All EEGs recorded at Haukeland University Hospital from 01.03.2000 to 31.12.2005 were visually evaluated and described. This included 17723 EEGs from 12511 patients. Haukeland University Hospital recruits patients from a population of about 500 000, and is the only provider of EEG within this area. Long-term registrations, EEGs during WADA tests and Tilt tests were not included in this study. The first EEG containing FEA from each patient was included. The total material consisted of 1647 EEGs from 852 females and 795 males.

Postictal activity as well as many drugs acting in the central nervous system affect the EEG background activity (Salinsky et al., 2003; Blume, 2006). To study the effect of FEA per se on the general background activity (GBA), the subgroup of all drug-free outpatient subjects was examined ($N = 341$). The time point for the last epileptic seizure was not registered in the database, but these elective, drug-free outpatients were very unlikely to have had a seizure within the last 24 h before registration.

As a control material all first EEGs from drug-free outpatients without EEG pathology from the study period were chosen ($N = 3268$).

The EEGs were described by one of 6 EEGers irrespective of patient categories. Three of these were certified, experienced EEGers, the other three were trainees under supervision. The agreement between the different EEGers as studied previously using the same method showed minor to moderate differences in absolute values, but always with the same trends for all EEGers (Aurlien et al., 2004).

The EEGs were recorded on the digital EEG system Nervus®. 22 electrodes were placed according to the international 10–20 system (Fp1, Fp2, Fpz, F3, F4, F7, F8, Fz, A1, A2, T3, T4, T5, T6, C1, C2, Cz, P3, P4, Pz, O1, and O2).

2.2. EEG database

The EEG interpretations were structured and categorized in an EEG database using software developed for the purpose (Aurlien et al., 1999). This software automatically collected patient demographic data and administrative test parameters such as name, patient ID, date of birth, patient address, referral doctor, test notes, patient notes, and medication from the hospital patient administrative system and the EEG administrative database. For each EEG, the EEGer set one or more ICD-10 diagnoses on basis of the doctor's referral representing the reason for taking the EEG (Table 1). The system automatically registered all the patients' ICD-10 clinical diagnoses from all hospital contacts. These were diagnoses set by the clinical doctors treating the patients.

2.3. EEG interpretation

The interpretation was divided into three main sections: Alpha rhythm (AR), general background activity

Table 1
The 10 most common referral diagnoses for 1647 consecutive patients with FEA

Diagnosis	*N*	% of patients
Epilepsy	1513	91
Encephalopathy	40	2
Anoxic brain damage	35	2
Syncope or collapse	25	2
Encephalitis	20	1
Somnolence, stupor or coma	19	1
Brain tumour	18	1
Stroke	12	1
Headache	12	1
Mental retardation	11	1

Some patients had more than one diagnosis.