Abnormal cortical functional connections in Alzheimer’s disease: analysis of inter- and intra-hemispheric EEG coherence

JIAO Zheng-yan (~)
(Department of Psychiatry, Second Affiliated Hospital, School of Medicine, Zhejiang University, Hangzhou 310009, China)
E-mail: Jiang_zju@mail.hz.zj.cn
Received Jun. 7, 2004; revision accepted Nov. 4, 2004

Abstract: To investigate inter- and intra-hemispheric electroencephalography (EEG) coherence at rest and during photic stimulation of patients with Alzheimer’s disease (AD). Thirty-five patients (12 males, 23 females; 52–64 y) and 33 sex- and age-matched controls (12 males, 21 females; 56–65 y) were recruited in the present study. EEG signals from C3-C4, P3-P4, T5-T6 and O1-O2 electrode pairs resulted from the inter-hemispheric action, and EEG signals from C3-P3, C4-P4, P3-O1, P4-O2, C3-O1, C4-O2, T5-O1 and T6-O2 electrode pairs resulted from the intra-hemispheric action. The influence of inter- and intra-hemispheric coherence on EEG activity with eyes closed was examined, using fast Fourier transformation from the 16 sampled channels. The frequencies of photic stimulation were fixed at 5, 10 and 15 Hz, respectively. The general decrease of AD patients in inter- and intra-hemispheric EEG coherence was more significant than that of the normal controls at the resting EEG, with most striking decrease observed in the alpha-1 (8.0–9.0 Hz) and alpha-2 (9.5–12.5 Hz) bands. During photic stimulation, inter- and intra-hemispheric EEG coherences of the AD patients having lower values in the alpha (9.5–10.5 Hz) band than those of the control group. It suggests that under stimulated and non-stimulated conditions, AD patients had impaired inter- and intra-hemispheric functional connections, indicating failure of brain activation in alpha-related frequency.

Key words: Alzheimer’s disease (AD), Electroencephalography (EEG), Coherence, Photic stimulation, Cortical connectivity

INTRODUCTION

Electroencephalography (EEG) coherence obtained from spectral EEG analysis is a noninvasive technique for studying functional relationships between brain regions. It provides the sources of information about potential cortico-cortico interactions (Hogan et al., 2003). Applying coherence to the examination of function changes associated with the performance of a perceptual or cognitive task is considered to be useful for the assessment of cerebral functioning (Hogan et al., 2003; Beaumont et al., 1978; Tucker et al., 1986). Many papers have reported the deviating findings of background EEG activity in Alzheimer’s disease (AD) using, initially, data derived by visual inspection and, more recently, quantitative EEG analysis (Wada et al., 1997). However, there is little published information about inter- and intra-hemispheric EEG coherence abnormalities in AD patients.

Photic stimulation is the most common method of cerebral activation for routine EEG examinations. This technique has been validated as a useful tool to investigate neurological disorders such as epilepsy. A recent report revealed abnormal quantitative EEG during photic stimulation in schizophrenic patients (Jiang, 2002) which is easily performed, requires minimal cooperation from the patients, and has clinical use for evaluation of dementia patients.
To our knowledge, there is no reported study on inter- and intra-hemispheric coherence during resting and photic stimulation. The objective of the present study is to estimate the inter- and intra-hemispheric EEG coherence in AD patients under the conditions of resting and photic stimulation, and to compare them with those of the normal controls.

METHODS

Subjects

The patient group consisted of 35 patients with DSM-IV (American Psychiatric Association, 1994) diagnosis of primary degenerative dementia, Alzheimer's disease (23 women and 12 men; aged 52–64 y, mean 57.6±3.1 y). They were outpatients or inpatients from the Department of Psychiatry, Second Affiliated Hospital, Zhejiang University, China. The diagnosis was based on general medical, psychiatric and neuropsychological testing. Laboratory tests included neurological, serological and neuroimaging (MRI and/or CT) studies. None of the patients had received medications acting upon the central nervous system. Each patient was assessed with Functional Assessment Stages (FAST) and a Chinese version of the Mini-Mental State Examination (MMSE). According to the FAST results, 23 patients had mild (FAST 3), 12 patients moderate (FAST 4). Their MMSE scores were from 10 to 23, mean 15.2±3.4.

Thirty-three healthy volunteers (21 women and 12 men; aged 56–65 y, mean 59.0±3.2 y) were recruited as a control group, without personal or family history of psychiatric or neurological disease. The control group was not significantly different from the AD group in age and sex. Their MMSE score was above 25. All subjects were right-handed and agreed to participate in the study with full knowledge of the experimental nature of the research.

EEG recording and analysis

During EEG recording the subjects were in a resting state with eyes closed, sitting in a semi-darkened, electrically shielded, sound attenuated room. According to the international 10–20 systems, all EEGs were recorded by trained EEG technologists using a 16-channel electroencephalog-