Quantitative Analysis of EEG in Patients with Absence Seizures

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Abstract

Typical absence seizures are spontaneous, short (lasting several seconds), and generalized epileptic seizures. Their characteristic manifestations are the loss of consciousness and the presence of spike and wave discharges (SWD) complexes in the EEG record. These are regular (about 3 Hz), and symmetrical discharges which are the main diagnostic criterion. According to the official definition of the International League Against Epilepsy, absence seizures can be divided into childhood absence epilepsy (CAE), juvenile absence seizures (JAE), the less common juvenile myoclonic absence seizures (JME), and generalized tonic-myoclonic absence seizures (GTCA). In untreated patients, they can be provoked by hyperventilation, sleep deprivation or video games.

This doctoral thesis summarizes the results presented in three scientific papers [1-3] published in the international journals. In particular, I discuss the problems in diagnosis of absence seizures, their automatic detection in electroencephalographic recordings, assessment of the efficacy of pharmacotherapy, and quantitative characterization of the morphology of seizures.

In the first paper *Changes in Interictal Pretreatment and Posttreatment EEG in Childhood Absence Epilepsy* [1] I employed the Morlet wavelet transform to show significant differences in the power of the beta and theta bands in the patients and control group. In addition, a hypothesis was formulated that the increased power in these bands observed in the patients results from abnormal brain activity and the propensity to generate epileptic spikes, respectively. These results are consistent with the theory of cortical focus theory explaining the pathophysiology of absence seizures. The increased wavelet power in the above-mentioned bands could be treated as a biomarker of absence seizure epilepsy. The analysis of follow-up EEG records showed a significant decrease

in wavelet powers, especially in low frequencies. This is the first step in developing a method for monitoring the progress of pharmacotherapy with the possibility of personalized drug titration.

The second publication *Absence Seizure Detection Algorithm for Portable EEG Devices* [2] explores the possibilities of automatic detection of absence seizures using a mobile EEG device. The detection was based on the properties of the continuous wavelet transform in the delta and beta bands. Using only four electrodes, 97.6% of ictal EEG was correctly identified with the false detection rate equal to 0.7 per hour. The appearance of low-cost, portable EEG devices has paved the way for long-term, remote monitoring of CAE and JAE patients. Potential benefits of this type of monitoring include facilitating diagnosis, personalized drug titration, and determining the duration of pharmacotherapy.

The last paper in the series, *EEG phase synchronization during absence seizures* [3], describes changes in EEG synchronization index during absence seizures. A one-second windows with a half-second overlap were used to calculate the Morlet wavelet phase synchronization index. For the 19-channel EEG, the k-NN classifier which employed the synchronization index and the normalized EEG amplitude as the features detected 99.2% of the seizures. Interestingly enough, the overlap of the segments classified as ictal with the actual seizures was equal to only 82.9%. The incomplete overlap is due to the trivial effect of finite resolution of EEG segmentation and, most importantly, fragmentation of absence seizures. This phenomenon has been quantitatively described for the first time and could be used to distinguish CAE and JAE.

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