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Article

Power spectral analysis of EEG of brain electrical activity in female patients with epilepsy

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Abstract

Background: Changes in low frequency waves and altered psychological status are associated with epilepsy. Epilepsy can cause anxiety and depression and many other complications. Anti-seizure medication can make the patients lethargic, tired and drowsy. **Objective**: To assess and quantify cortical brain activity in female patients with epilepsy by power spectral analysis of signals of quantitative electroencephalogram (QEEG). **Methods:** This study was carried out on 20 female patients with epilepsy aged 20-40 years and 20 healthy female volunteer of similar age were control. EEG was recorded from 22 scalp electrodes in different region all over the head by an EEG data acquisition device, EEG Traveler Brain Tech 32+ CMEEG-01, India in all participants. Power spectral analysis of EEG data was done with Brain Tech 40+ Standard version 4.47a analysis software by calculating relative band power of delta, theta, alpha and beta brainwaves to assess cortical electrical activity. Data were expressed as mean±SD. For statistical analysis, Independent-Samples t test was used. **Results:** Mean values of relative power of delta and theta were significantly higher and values of alpha and beta were significantly lower in all cortical areas of epilepsy patients compared to control. **Conclusion:** It may be concluded that higher low frequency brain wave and lower high frequency brain wave are associated with epilepsy.

Keywords: Epilepsy, Essential oil, Lemongrass, QEEG, Brainwaves.

Introduction

Epilepsy is the most common, chronic, serious, non-communicable neurological disorder and it is the second highly discussed pathology of brain after stroke affecting 50 million people worldwide.[1] According to International League Against Epilepsy (ILAE), Epilepsy is "A transient occurrence of signs and/or symptoms due to abnormal excessive or hyper synchronous neuronal activity in the brain". It is characterized conceptually as an "Enduring predisposition of the brain to generate epileptic seizures, with neurobiological, cognitive, psychological and social consequences".[2]. In 70% case birth trauma, birth asphyxia and central nervous system infection in neonate and infancy and head trauma, brain tumor, stroke and infections in middle aged and elderly persons are common etiology. [3]

In Asia approximately 23 million people have epilepsy.[4] Epilepsy in Bangladesh is estimated to be 8.4 per 1000 people with prevalence 9.2% in adult male and 7.7% in female.[5]

Being a patient of a chronic and unpredictable disease, patients with epilepsy usually lead a stressfull life.[6] They commonly suffer from anxiety and depression.[7] General and social health and social role in patients with epilepsy usually become impaired due to disease process.[8] Cognitive deficit and intellectual decline also can occur in patients with epilepsy.[9]

For several decades, various kinds of antiseizure medications (ASM) have been used to treat epilepsy.[10] Side effects of these medications can make the patients drowsy, lethargic, tired and also cause memory impairment and problem with concentration.[11]

EEG is believed to reflect a variety of processes of the brain, especially the neocortex, in which our cognitive function and sensorimotor information are processed.[12] EEG activity patterns correlate with changes in cognitive arousal, attention, intention and evaluation.[13] EEG data employed for diagnosis of neurological disorders are usually in qualitative nature. It can only differentiate abnormal brain activity at various location of tracing by visual inspection. Power spectral analysis of EEG is widely used for quantitative analysis of various EEG waves.[14] This method is useful in computerized analysis of EEG using Fast Fourier Transformation. Recently power spectral analysis of EEG signals is widely used in neurological research which can detect the change of power of different frequency waves in different neurological disorders. Studies in neuroscience explored the effects of various intervention on brain activities by analyzing changes in powers of the basic brain waves (delta, theta, alpha and beta).[15] The epileptic seizures in both ictal and interictal states can be diagnosed by EEG .[16]

For this purpose, the aim of the study was to evaluate the EEG power of all brain waves in female epilepsy patients.

Methods

Study design and setting

This observational study was carried out in 2024 at the Department of Physiology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Shahbag, Dhaka to observe brain electrical activity in diagnosed patients with Epilepsy by power spectral analysis of EEG.

Study participants

Forty (40) diagnosed patients with epilepsy were enrolled from outpatient department of Neurology, BSMMU. Age, sex and BMI matched 40 apparently healthy subjects were selected as control. All the participants were free from medication that affect central nervous system. All of them were right handed and in interracial sate.

Sampling

Purposive sampling was done to select the patients as well as control subjects.

Exclusion criteria

Smoker, alcoholic, pregnant, lactating, menstruating female patients were excluded. All participants were normotensive, non diabetic and with no thyroid disorder.

Data collection

Informed written consent was taken and detailed history was documented of each participant. Thereafter, all of them were tested for handedness by Edinburgh Handedness Inventory (EHI) scale.[17]

Then the detail procedure and preparation for EEG recording and the sessions was explained to them and requested to arrive at Noorzahan Begum Neurophysiology Laboratory at the Department of Physiology, BSMMU, at 8-8:30 AM on a scheduled day for EEG recording. Preparation for the recording was explained to all participants. For EEG recording, the subject needs to have a sound sleep on the previous night, so that they would not be fatigued or drowsy during the procedure. They were also advised to wash their hair properly the day before experiment to remove oiliness from the scalp with a mild, non-fragrant shampoo and not to apply any sprays, antiperspirants or perfumes twelve hours prior to testing.[18] They were advised to have light breakfast in the morning without any caffeinated beverage such as tea, coffee or cola within 3 hours before the experiment. They were advised to dress up with clean clothes and they should not use any spray, perfumes or any cosmetics on their body.[19] Upon their arrival subjects were provided with clean odorless gown to wear specially made for this experiment. Then they were allowed to sit on a comfortable armchair in a cool and calm environment in the lab for rest for 10-15 minutes before the EEG recording. During this period, the subject was advised not to talk, eat or drink and also not to perform any physical or mental activities even sleep.

Laboratory setting

The laboratory environment was controlled to minimize environmental influences on digital data recording device to ensure maximum possible error free quality data. The temperature of the laboratory was maintained at 23°C-25°C and lights were kept dim & windows were covered by sound and light proof wall to ensure restriction of sunlight and noise from the surroundings.[18] Door was locked and no one was allowed to enter or leave the room during the procedure.

EEG data recording

In all subjects, a set of 22 electrodes including the ground electrode were placed onto the scalp surface using conductive & adhesive EEG paste according to international 10-20 system. EEG recording was done for total 5 minutes in eye closed condition for both groups.

The recording of EEG measures were done by EEG (traveler) BrainTech32+ CMEEG-01(India) and analysis was done by the software Brain Tech 40+ Standard version 4.47a. A high pass filter was set at 1 Hz to reduce lower frequencies and a low pass filter was set at 35 Hz to ensure the signal is limited to the highest frequency of beta band.[20] The gain was set at 7.5 µv/mm. By default Analogue to digital (A/D) conversion will be 24 bits, the notch filter was at 50 Hz, sampling rate was 1024 Hz (Clarity, India). In this device impedance measurement was by default at 20K ohms indicating that the values of impedance should be less than or equal to this. Recorded EEG signals was displayed as brainwaves (analogue) in specific electrode on the window. Using Fast Fourier Transformation (FFT), this analogue signal was digitalized by default A/D converter. The default software of this device then generated a frequency table with the power spectral parameter (relative power) for each specific EEG frequency bands (delta, theta, alpha, and beta) which were recorded.

Statistical analysis

All data was checked for distribution by Shapiro Wilk test. Data were expressed as mean ± SD. Statistical analysis was performed by using SPSS for Windows, version 25. Data were found normally distributed, parametric test Independent- Samples T Test was used.

Results

In this study, similar general characteristics (Table I) of patients with epilepsy and healthy control were observed. All the participants were right handed[21]. The relative power (uV²) of each frequency band (delta, theta, alpha, beta) of EEG (Patients and control subjects) was recorded. Data were presented in table II, III, IV, V. Figure I showed topographical mapping of each frequency band. Our results showed significantly ($P \leq 0.05$) higher delta and theta relative power and significantly lower alpha and beta relative power in patients with epilepsy compared to healthy control in all cortical regions.

Table I: The baseline characteristics of the participants (N=80)

Parameters	Patients with epilepsy(n=40)	Control(n=40)	p value
Age(years)	30.27±4.55	31.45±3.74	0.212
BMI(Kg/m²)	22.5±1.46	23±1.75	0.171
Resting pulse(beats/min)	112.75±10.67	113.75±7.48	0.629
Resting SBP(mmHg)	70.12±6.93	73.75±5.85	0.014
Resting DBP(mmHg)	80.8±7.13	80.35±6.58	0.770
Respiratory rate (breaths/min)	13.82±1.23	14.07±1.42	0.404
Temperature(°F)	98.15±0.71	98.37±0.40	0.094
Oxygen saturation (SpO2)	98.9±0.90	98.6±0.87	0.134
Handedness (Score)	79.74±6.74	77.50±7.16	0.152

Data were expressed as Mean ± SD. Statistical analysis was done by Independent- Samples T Test. Here, N-Total number of subjects; n-number of subjects in each group; BMI- Body Mass Index; SBP- Systolic Blood Pressure; DBP- Diastolic Blood Pressure; SpO2-Peripheral oxygen saturation.

Table II: Relative power (uV²) of Delta wave in patients with epilepsy and control (N=80)

Cortical regions	Patients with epilepsy (n=40)	Control (n=40)	p value
Prefrontal	45.4978±8.51515	22.4294±10.36480	0.000
Frontal	39.7433±8.82834	23.7801±8.64709	0.000
Parietal	37.6037±8.39819	19.4323±9.46220	0.000
Temporal	39.2597±9.64937	20.6394±9.32302	0.000
Occipital	41.5551±11.82737	20.6306±9.47249	0.000

Data were expressed as Mean ± SD. Comparison of data was done by Independent- Samples T Test. N= Total number of subjects; n= Total number in each group

Table III: Relative power (uV^2) of Theta wave in patients with epilepsy and control (N=80)

Cortical regions	Patients with epilepsy (n=40)	Control (n=40)	p value
Prefrontal	31.1484±6.523	11.9858±3.85974	0.000
Frontal	33.4584±7.57667	15.3247±4.78489	0.000
Parietal	32.6497±7.38061	13.8462±4.71949	0.000
Temporal	29.8152±8.01228	15.0375±4.58920	0.000
Occipital	27.5229±8.94625	14.5784±4.67570	0.000

Data were expressed as Mean ± SD. Comparison of data was done by Independent- Samples T Test.
N= Total number of subjects; n= Total number in each group

Table IV: Relative power (uV^2) of Alpha wave in patients with epilepsy and control (N=80)

Cortical regions	Patients with epilepsy (n=40)	Control (n=40)	p value
Prefrontal	9.9530±2.66984	35.1709±9.65763	0.000
Frontal	13.0070±3.51095	36.9208±8.71339	0.000
Parietal	14.7053±3.55264	42.3918±11.19434	0.000
Temporal	13.8416±3.89020	41.1991±10.53042	0.000
Occipital	11.1260±3.29238	44.4965±9.65958	0.000

Data were expressed as Mean ± SD. Comparison of data was done by Independent- Samples T Test.
N= Total number of subjects; n= Total number in each group

Table V: Relative power (uV^2) of Beta wave in patients with epilepsy and control (N=80)

Cortical regions	Patients with epilepsy (n=40)	Control (n=40)	p value
Prefrontal	6.364±2.13235	15.9511±3.67935	0.000
Frontal	7.9743±2.19979	18.1607±4.35373	0.000
Parietal	7.4636±2.22772	19.0095±5.78957	0.000
Temporal	8.8905±3.30391	18.9662±4.58830	0.000
Occipital	6.6098±2.40332	14.1880±3.85676	0.000

Data were expressed as Mean ± SD. Comparison of data was done by Independent- Samples T Test.
N= Total number of subjects; n= Total number in each group

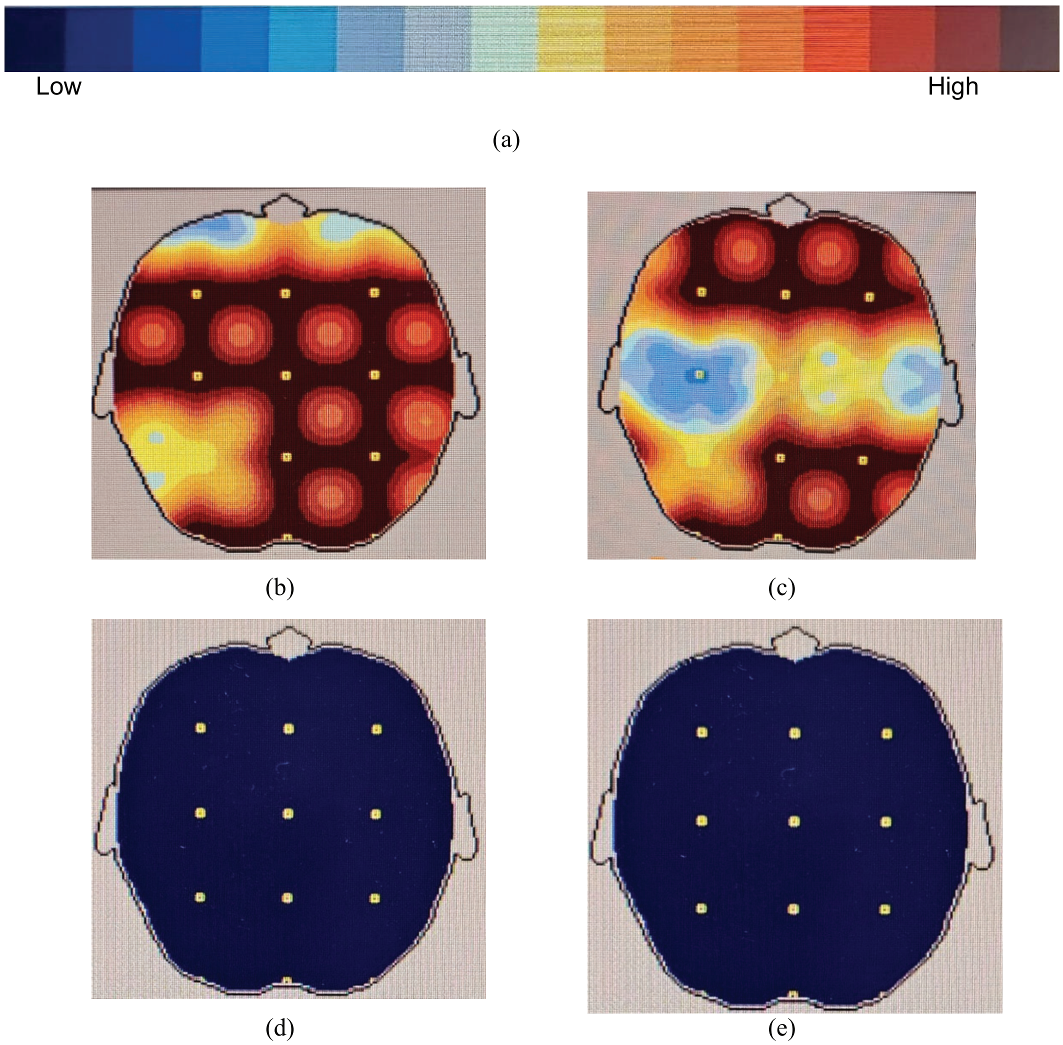

Figure 1: Topographical presentation of Relative power (uV²) in patients with epilepsy group (a) a color coded scale representing lower to higher power values; (b) distribution of delta wave (c) distribution of theta wave (d) distribution of alpha wave (e) distribution of beta wave

Discussion

The result of this study revealed higher relative power of delta and theta in almost all brain cortical regions of both hemispheres in epilepsy patients which is similar to the observations of several previous studies though some differences were there in distribution of the scalp area and treatment discrimination.[22, 23, 24]

A similar study observed relative power with similar pattern in heterogeneous idiopathic generalized epilepsy (IGE) patients under treatment with ASM compared to control with no significant hemispheric difference[23]. Pegg et al.[24] also found higher spectral power in delta and theta band, mostly located in the central area and in left hemisphere in IGE patients. Clemens et al[22] also found similar changes in common IGE patient group with some variation of relative power in subcategories such as juvenile absence epilepsy (JAE), juvenile myoclonic epilepsy

(JME) and epilepsy with grand mal seizures on awakening (EGMA). In all these above studies EEG were recorded during interictal phase.

In our study, the patients were also under ASM and interictal state. The changes in the spectral power EEG was induced by epilepsy but independent of an ASM. Pegg et al.[24] compared the spectral power of EEG between control and drug resistant and drug compliant patients and did not find influence of antiseizure medication on changes in delta and theta power in epilepsy.

It has been published in literature that 50% of epilepsy patients present some kind of psychiatric illness.[25]

In our study, the patients were not undergone any kind of psychiatric assessment but the presence of higher power of slow frequency waves in our patients suggests that these patients might be affected with depressive illness. Several researchers observed higher delta and theta in major depressive disorder patients compared to control.[26, 27, 28] Relative power estimates the contribution of the specific frequency band to the neuronal synchronization. It has also been stated that increased or decreased synchronization, reflected by the changes of these power values hints toward the underlying neurophysiological disturbance in epilepsy.[23] In epilepsy patients, increased power of neuronal synchronization in slow wave band and decreased power of synchronization in fast frequency wave is also evident from the results of our study.

In this study, lower relative power of alpha and beta waves in all cortical regions in epilepsy patients compared to healthy control were similar to the observation of other researches in similar studies.

Lower relative power of alpha and beta without hemispheric asymmetry was reported in IGE as well as in common and different sub categories of generalized epilepsy.[22,23]

Alpha waves are normally predominant in awake but in a state of quiet, resting cerebration reflecting moderate cortical activity and commonly localized in occipital cortex and thalamus. They are prominent in adults and occur when an individual is temporarily idle but still alert.[29, 13] Alpha brain waves are related with cognitive performance associated with enhanced state of relaxation and calmness. Beta wave is found when an awake person's attention is directed to some specific type of mental activity. It represents active concentration and heightened state of awareness or vigilance.[13, 30]

Lower alpha and reduced beta power suggest decreased state of relaxation and decreased cognitive and motor activity.[31] It was also suggested that reduced alpha power is also associated with hyperactive cortex.[15] Decreased beta activity results in increased sleepiness.[13] These features are found in our study in patients. So, lower alpha and beta power might be its cause.

The findings of our study act as index of epilepsy induced less relaxing capability and compromised attention and other higher cognitive task in epileptic patient. The design of our study only could explore the altered functional status of brain cortical activity in epilepsy.

Conclusion

From the results of our study, it may be concluded that higher low frequency brain waves and lower high frequency brain waves are associated with epilepsy.

Conflict of interest

There is no conflict of interests pertaining to this study.

Ethical clearance

The aspects of this study protocol involving human subjects followed the Helsinki (1964) ethical guidance and was first approved by the departmental ethical and academic committee. It was then further reviewed and approved by Institutional Review Board of BSMMU.

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