Interictal Electroencephalogram and MRI of Brain in the Localization of Focal Epilepsy: An Observational Study in a Tertiary Care Hospital

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Abstract

Background: *Focal epilepsy is commonly associated with focal epileptogenic lesions and identification of these lesions are vital for management. Electroencephalogram (EEG) and Magnetic Resonance Imaging (MRI) of brain are commonly used neurodiagnostic procedures to localize the lesions.* **Objective:** *The study aims to observe the diagnostic yields of interictal EEG and MRI of the brain in the localization of focal epilepsy.* **Materials and Methods:** *This cross-sectional study was carried out in the Department of Neurology at National Institute of Neurosciences & Hospital (NINS&H), Dhaka from January, 2021 to June, 2022. A total number of 105 focal epilepsy patients were included in this study based on inclusion and exclusion criteria with ages above 12 years of both sex. Detailed history, clinical examination, EEG and MRI evaluation were done and recorded. Chi-Square test was performed to compare the EEG and MRI data and p value of <0.05 was considered significant.* **Results:** *The age range was 13 to 75 years with male female ratio of 1.6:1. Mean age of the patients was 26.65±2.70(SD) years and the majority from the age group 18-30 years. Frequently found seizure type was focal to bilateral tonic-clonic (60, 57.10%). Abnormal EEG was found in 50.5% (n = 53) and abnormal MRI in 45.7% (n = 48) respondents. Both MRI and EEG were found abnormal in 21% of cases and in 24.8% of cases, both MRI and EEG were normal. With normal EEG findings, 24.8% of patients had abnormal MRI findings and 29.5% had abnormal EEG findings with normal MRI findings. No significant association was observed between EEG and MRI findings.* **Conclusion:** *A number of MRI abnormalities were found in patients with normal EEG and vice versa. Our results did not reveal any correlation between EEG and MRI in the localization of epileptogenic lesions in focal epilepsy.*

Key words: *Focal epilepsy, Electroencephalography, Magnetic resonance imaging.*

Introduction

Epilepsy is a neurological disorder characterized by recurrent unprovoked seizures that are transient symptoms or signs of abnormal excessive and synchronous neuronal activity in the brain.[1] It is a chronic non-communicable disease of the brain that affects around 50 million people worldwide and 80% of them reside in developing countries.[2] The risk of having epilepsy at some point in the average life span of any individual varies between 2.0 to 5.0 %.[3] There are about 2 million epilepsy patients in Bangladesh and the overall prevalence per 1000 people is 8.4.[4,5]

Epilepsy is associated with an increased risk of morbidity and mortality with adverse socioeconomic outcomes. Common causes of death in epilepsy

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are sudden unexpected death in epilepsy (SUDEP), an accident during seizure, underlying neurological disorder, status epilepticus, suicide and treatment-related death.[2, 6]

According to the revised classification of the International League Against Epilepsy (ILAE) based on seizure onset; epilepsy is classified as focal, generalized, combined generalized and focal and unknown.[7] Study reported that focal epilepsy comprises about 60% of the total epilepsy population.8 The seizure focus can be localized by taking a medical history, seizure semiology, clinical examination and different investigations. No single modality can identify the seizure focus, hence a combination should be used. MRI and EEG are widely used in the investigation for assessment of epilepsy to localize the lesion.[9]

EEG is the most helpful test to see ictal or interictal discharge and classify epilepsy.10 Abnormal EEG is an excellent predictor of seizure recurrence.[11] Even in patients with a history of seizures, the data concerning the diagnostic yield of EEG is confusing. However, the incidence of epileptiform discharge in routine EEG is 0.5% in healthy adults and 2-4% in healthy children also normal EEG does not exclude epilepsy, as around 10% of patients never show epileptiform discharges.10 Finding out the structural lesion, MRI is the method of choice and with Epilepsy protocol gives more precise information than standard one.[12,13]

Despite modern anti-epileptic drug treatment, different study shows, that approximately 30% of epilepsies remain medically refractory. Epilepsy surgery is the most effective and widely accepted treatment option for drug resistant focal epilepsy. Multiple studies show approximately 60% of patients become seizure-free after surgery. Data about the association between EEG andMRI findings in focal epilepsy are limited and no data is available in Bangladesh. The purpose of this study was to systematically describe the nature of EEG and MRI abnormalities and to compare the diagnostic yield of them. The relationship between electrophysiological abnormalities on EEG and structural abnormalities on MRI could provide important information to assist in the assessment of focal epilepsy patients.

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Materials and methods

This single-center hospital-based cross-sectional study was conducted at the Department of Neurology, National Institute of Neurosciences and Hospital, Dhaka from January 2021 to December 2021. We investigated patients over 12 years of both sexes with focal epilepsy and patients with provoked seizure, generalized and unclassified epilepsy were excluded. The study was conducted after receiving approval from the Ethical Committee and written informed consent was obtained from all the participants. A surface EEG was recorded to detect interictal discharge with a digital EEG system (Nihon Kohden EEG-1200, Japan). T1 weighted sequence (T1W), an axial T2 Standard protocol was followed as per American Clinical Neurophysiology Society (2016) guideline.14 MRI study was performed on 1.5 Tesla (Siemens MAGNETOM Avanto MRI system, Germany) with standardized epilepsy protocol. The protocol consists of a sagittal weighted sequence (T2W), an axial fluid attenuation inversion recovery sequence (FLAIR), diffusion-weighted imaging (DWI) and an axial gradient echo (GRE).15 SPSS version 22.0 software (SPSS Inc., USA) was used to analyze the data. The results were expressed as frequency, percentage and mean ± SD. Chi-Square test was performed to compare qualitative data between the diagnostic yields of EEG and MRI. P value <0.05 was considered for significant results.

Results

A total number of 105 subjects were included in this study based on inclusion and exclusion criteria with ages ranging from 13 to 75 years. The mean±SD age of the study subjects was 26.65±12.70 years and the majority were e"18 years (79; 79%). Sixty one percent (64) of respondents were male with a male-to-female ratio 1.6:1; 50.5% (53) study subjects came from the urban majority and 42 (40%) of the study subjects had their education upto secondary level. The majority (45; 42.9%) of the respondents were students. The majority (46; 43.8%) of the study subjects came from lower-middle-income families. Clinical diagnosis revealed the majority (60; 57.1 %) of the study subjects had focal to bilateral tonic clonic seizure onset (Table I).

Table-I
Distribution of study subjects according to demographic data and clinical diagnosis (n=105)

Variable	Frequency (n)	Percentage
Age group (Years)<18	26	24.8
18-30	49	46.60
31-50	26	24.80
50-70	2	1.90
>70Mean + SD26.65+12.70	2	1.90
Range(13-75)		
Sex		
Male	64	61
Female	41	39
Residence		
Urban	53	50.5
Rural	52	49.5
Level of education		
No education	0	0
Primary	18	17.1
Secondary	42	40
Higher Secondary	29	27.6
Above	16	15.2
Occupation		
Services	8	7.6
Business	16	15.2
Homemaker	15	14.3
Student	45	42.9
Unemployed	5	4.8
Others	16	15.2
Yearly Income level		
Lower	32	30.5
Lower-middle	46	43.8
Upper-middle	25	23.8
High-income	2	1.9
Clinical diagnosis		
Focal aware seizure	4	3.8
Focal impaired aware seizure	1	1
Focal motor onset seizure	29	27.6
Focal non motor onset seizure	11	10.5
Focal to bilateral tonic clonic	60	57.1

EEG showed abnormal EEG in 53 (50.5%) respondents. Among them, 24 (45.3%) had right-sided, 23 (43.4%) had left-sided and 6(11.3%) had both-sided epileptiform discharge. Those discharges were mostly from the temporal (20; 37.7%) lobe and frequently found the pattern of discharge was sharp and wave (23; 43.4%) (Table II).

Abnormal MRI was found in 48 (45.70%) patients. Among them, right-sided, left and both-sided lesions were reported in 19 (39.60%), 16 (33.30%) and 13 (27.10%) respondents. The majority had multifocal (23; 47.92%) lesions and after that, 14 (29.16%) had temporal lobe lesions. Among different epileptogenic brain lesions, the most frequent were gliosis (45.80%) others are mesial temporal sclerosis (18.80%), others lesion (16.70%), cystic lesion (6.30%), cortical

dysplasia (4.20%), vascular lesion (4.20%) tubercular lesion (2.10%) and demyelinating lesion (2.10%) (Table III). Among different epileptogenic brain lesions, the most frequent were gliosis (45.80%) others are mesial temporal sclerosis (18.80%), others lesion (16.70%), cystic lesion (6.30%), cortical dysplasia (4.20%), vascular lesion (4.20%) tubercular lesion (2.10%) and demyelinating lesion (2.10%) (Table III).

Table-II
Distribution of study subjects according to EEG findings (n=105)

EEG findings	Frequency (n)	Percentage
Normal	52	49.5
Abnormal	53	50.5
Side of abnormal EEG found		
Right	24	45.3
Left	23	43.4
Both	6	11.3
Anatomical location of abnormal EEG		
Temporal	20	37.7
Frontal	10	18.9
Parietal	1	1.9
Occipital	1	1.9
Multifocal	19	35.8
Hemispheric	2	3.8
Pattern of EEG changes		
Sharp and wave	23	43.4
Spike and wave	20	37.7
Focal slowing	2	3.8
Both sharp and wave	8	15.1

Table-III

Distribution of study subjects according to MRI findings (n=105)

MRI findings	Frequency (n)	Percentage
Normal	57	54.30
Abnormal	48	45.70
Side of lesion		
Right	16	33.30
Left	19	39.60
Both	13	27.10
Anatomical LocationTemporal	14	29.16
Frontal	6	12.51
Parietal	3	6.25
Occipital	1	2.08
Multifocal	23	47.92
Hemispheric	1	2.08
Pattern of changesMesial temporal sclerosis	9	18.80
Cortical dysplasia	2	4.20
Cystic lesion	3	6.30
Demyelinating	1	2.10
Vascular lesion	2	4.20
Tubercular lesion	1	2.10
Gliosis	22	45.80
Others	8	16.70

Others lesion included temporal horn dilatation, Focal encephalitis and HypomyelinationTable 4: Comparison of EEG and MRI findings of the study subjects (n=105) Comparison of EEG and MRI findings showed, both EEG and MRI was abnormal in 22 (21%) cases and normal in 26 (24.8%) patients. MRI findings were normal and EEG findings were abnormal in 31 (29.5%) cases, and MRI findings were classified as abnormal and EEG findings were classified as normal in 26 (24.8%) cases. Furthermore, the association between EEG and MRI findings was not significant (P= 0.383) (Table IV).

Table-IV

Comparison of EEG and MRI findings of the study subjects (n=105)

EEG	MRI			P value
	Abnormal	Normal	Total	
Abnormal	22 (21%)	31 (29.5%)	53 (50.5%)	0.383
Normal	26 (24.8%)	26 (24.8%)	52 (49.5%)	
Total	48 (45.7%)	57 (54.3%)	105 (100%)	

Data were expressed as frequency and percentage. Percentages are over grand total. Chi-Square test was performed to compare qualitative data between the groups.

Discussion

Focal epilepsy usually occurs due to focal epileptogenic lesion. EEG and MRI are widely accepted investigations for the recognition of functional and structural abnormalities to localize the lesion. But sometimes incompatible results are found between those investigations. Our study originated from this idea to evaluate the comparison between EEG and MRI findings in focal epilepsy

The Mean±SD age of the study subjects was 26.65±12.70 years with the majority being in the age group of 18 to 30 years. Different study showed the mean age of patients was 32.9 ± 14.1 years and 31.97±15.44 years.[16,17] Dissimilarities between those study findings may be due to including different age group and both generalized and focal epilepsy. 61% of the respondents were male with a male-to-female ratio of 1.6:1. Different studies showed similar results with male predominance.[17,18,19] A systematic review showed that males had a higher incidence of epilepsy compared with women which may be explained by the fact that males are more vulnerable to common risk factors.[20]

In the present study, 50.5% of study subjects came from urban areas. Different studies performed in Bangladesh showed

56%and 72.3% of patients belonged to rural areas.[5,21] As the study had a small sample size and was conducted in a singlecenter in the capital

of the nation, the true scenario might not have been reflected in the study.

The majority (40%) of the study subjects had their education up to secondary level. Among the study subjects, the majority (42.9%) of the respondents were students. Occupations of remaining respondents included businessmen (15.2%), homemakers (14.3%) and others (15.2%) including day laborers, industrial workers, farmers, rickshaw/van pullers, drivers, field workers, shopkeepers and weavers. Khan et al. reported that the majority (43%) of respondents were students which is similar to our study.[21]

Economic status was classified according to New World Bank country classifications by income level: 2020-2021 and found that the majority (43.8%) of the study subjects came from lower-middle-income families.[22] Similar study was not found to compare our findings but as per WHO nearly 80% of epilepsy patients live in low and middle-income countries.

Clinical diagnosis revealed the majority (57.1 %) of the study subjects had focal to bilateral tonic-clonic seizure onset. No study was observed to compare all the clinical characteristics and findings due to differences in methodology, age group and Electrophysiological evaluation by EEG showed abnormal EEG in 53 (50.5%) respondents. Among them, the majority had a right (45.3%) sided epileptiform discharge. Locations of those discharges were mostly from the temporal (37.7%) lobe and frequently found a pattern of discharge was sharp and wave (43.4%). Multiple studies found EEG were abnormal from 35.5% to 75.9% which is similar to our study.[16,18,19,23] Another study observed 40% spikes or spikes with slow waves on their EEG.[19]

They established that the presence of spikes or spikes with slow waves predicts the seizure and is associated with a higher risk of recurrence. All the findings above were comparable with our study though they included their patient after the first seizure of both focal and generalized epilepsy.

Abnormal MRI was found in 48 (45.70%) respondents. Among them, 19 had left-sided, 16 had right-sided and 13 had both-sided lesions. The majority of the respondents had multifocal (47.92%) lesions and after that, 29.16% had temporal lobe lesions. Multiple studies found MRI were abnormal from 23% to 67% which is similar to our study though they included different epilepsies after the first seizure.[20, 21] Among different epileptogenic brain lesions, frequently found lesions were gliosis (45.80%). Similar results were demonstrated by previous studies.[18] Different studies found different epileptogenic lesions as their frequent findings. Infection and inflammation were found as major causes (28%) of epileptogenic lesions.[24] Another study found the majority of cases to be cortical lesions like cortical dysplasia, heterotopias and hippocampal lesions.[23] These indicate different populations of different countries are vulnerable to different risk factors. The incidence of mesial temporal sclerosis (18.80%) is similar to the previous studies, which have reported the incidence from 8% to 30%.[20,24]

Comparison between EEG and MRI data showed, significant number of MRI findings were normal in EEG abnormal cases 31 (29.5%) and EEG findings were normal in MRI abnormal 26 (24.8%) cases. Possible causes of these discordant results are 10% epilepsy patients do not show interictal epileptiform discharges (IED), antiepileptic drugs can suppress IED, and small epileptogenic lesions may not be detected in conventional MRI. The association between EEG and MRI findings was non-significant (P= 0.383). Previous studies reported similar findings though they included different age groups and epilepsies.[23]

Drug-resistant epilepsy with negative MRI is frequently seen in patients considered for epilepsy surgery; however, clinical evaluation and surgical treatment are very complex and challenging. Advanced imaging techniques and intracranial EEG recording are required to detect the location of the epileptogenic zone.

Conclusions
EEG and MRI give ideal information for finding epileptogenic brain lesions, which are the usual cause of focal seizures. This study showed several discordant results between EEG and MRI findings in patients with focal epilepsy. Although EEG and

MRI are excellent diagnostic tools, our results did not reveal any correlation between EEG and MRI in the localization of epileptogenic lesions in focal epilepsy.

Ethical Clearance: Ethical clearance was taken from the institutional review board.

Conflicts of interest: There are no conflicts of interest.

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