SENSITIVITY AND SPECIFICITY OF ELECTROENCEPHALOGRAPHY (EEG) AMONG PATIENTS REFERRED TO AN ELECTROPHYSIOLOGY LAB IN BANGLADESH

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Abstract

Objective: To measure the changes in electro encephalogram (EEG) along with its sensitivity and specificity with clinical seizure among epilepsy patients referred to an electrophysiology lab in a tertiary care hospital of Bangladesh.

Methods: This retrospective chart review was carried out in the electrophysiology laboratory of Dhaka Medical College Hospital from January 2011 to December 2013, which included 1154 patients. EEG was obtained through scalp electrodes following international 10/20 system. Information regarding patients was collected from the laboratory register with the help of a checklist. The EEG findings and clinical seizure events were then compared.

Result: Among the 1154 patients, age varied from birth to 75 years. The mean age at presentation was 17±11.4 years and most of the patients were less than 10 years old (44.4%). The male predominated in our study (59.2%). Clinically diagnosed seizure was present in 970 patients (84.1%), among which Generalized tonic clonic seizure (GTCS) was the most common clinical type of seizure, followed by secondary generalized seizure in 19.4% (n=224) and focal seizure in 2% (n=30) patients and 6.8% (n=79) patients had pseudoseizure. Among the abnormal EEG (59%), generalized epileptiform discharge was found in 29%, whereas focal and secondary generalized discharge was found in 30%. The most common site of origin of epileptiform discharge was temporal lobe (28.3%). The overall sensitivity of EEG was 66% (ranged from 62% to 68% with a confidence interval (CI) at 95%) and specificity was 79% (72-84% at 95% CI). The positive predictive value was 58% (55-61% at 95% CI) and negative predictive value was 41% (38-44% at 95% CI).

Conclusion: Our study brings out the fact that EEG has a reasonable sensitivity and specificity as a diagnostic test and the superiority being the higher specificity of EEG.

Key words: Intertical EEG, generalized tonic clonic seizure (GTCS).

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Introduction:
The first description of an epileptic crisis dates back to 3000 b.c. But the human electroencephalogram (EEG) was discovered by the German psychiatrist, Hans Berger, in 1929. As Gibbs and his colleagues1 discovered the pattern of epileptic discharges in 1935, its potential applications in epilepsy rapidly became clear. EEG has been playing a central role in diagnosing and managing epilepsy, as

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it is a convenient and relatively inexpensive way to demonstrate the physiological manifestations of abnormal cortical events that underlie epilepsy.

Epilepsy is often defined as the tendency to have recurrent unprovoked seizure, whilst a seizure is any clinical event caused by abnormal electrical discharge in the brain\(^2\). The incidence of epilepsy varies worldwide\(^3\) with a higher prevalence in developing countries\(^4\) - \(^6\). The life time prevalence of epilepsy also varies from 1.5 to 14 per 1000 population among different countries\(^7\) - \(^15\). More than half of the 50 million people with epilepsy worldwide live in Asian countries. WHO estimated that there are 1.5-2 million people suffering from epilepsy in Bangladesh\(^16\).

Though scalp EEG has a number of limitations, it can help to determine the seizure types and epilepsy syndromes among patients with epilepsy. There is a significant association between the interpreted presence of epileptiform discharges (EDs) and a subsequent seizure\(^17\) - \(^18\). Interestingly enough, the frequency of reported EEG abnormalities in patients with seizures varies widely between studies (29-69%)\(^19\) - \(^21\) and when are repeated in the same subject, the results are often inconsistent\(^22\) - \(^23\). The interictal spike/sharp are the hallmark of epilepsy, which demonstrates the cortical hyperexcitability and hypersynchrony, which may persists in the “normal” interictal state. The objective of our study was to determine the sensitivity and specificity of EEG among Bangladeshi patients with clinically suspected seizure events.

**Material and methods:**
This retrospective chart review was carried out in Electrophysiology Laboratory in Neurology Department of Dhaka Medical College Hospital, Dhaka, from January 2011 to December 2013. Our study population included 1154 epilepsy patients. Consultant neurologists took meticulous history along with proper physical examination in the lab. All the information was recorded in black and white. Our selection criteria included all the cases with convincing history of seizure events, which were sent for EEG and those with complete set of desired information in hospital recorded. They were advised to wash hair with shampoo and not to sleep overnight. EEG was done within one to six months of seizure event. Each recording of EEG were obtained through digital equipments with minimal duration of 20-30 minutes and electrode positioned on scalp according to international 10-20 system. Recording was done in both awake and sleep state, except those who didn’t sleep, only awakened state recording was taken. Provocative stimuli like hyperventilation, photic stimulation were given for three minutes each. For standardization, the background activity was classified as normal (organized and symmetrical) or abnormal (disorganized and/or asymmetrical). The EEG was interpreted by consultant neurologist, trained and experienced in electro-physiologic studies. The EEG was examined for specific epileptiform abnormality, the interictal spike or sharp wave. The abnormal electroencephalographic activity was also classified as generalized or focal. The presence and topography of bursts of slow waves and epileptiform paroxysms were evaluated. The latter were classified as spike-wave, sharp-wave and polispike. EEG was done within one month of last seizure and mostly after a single event. Though a total of 1187 patients were initially included, 33 patients with marked artifacts on EEG were excluded from this study.

**Results:**
In our study, the patient’s age ranged from birth to 75 years. The mean age at presentation to the EEG room was 17±11.4 years i.e. most of the patients were less than 10 years old (44.4%). About Three fourth of the patients (72.9%) were aged less than 20 years. Only 3.7% were older than 50 years (Table-I). The male predominated in our study (59.2%). Clinically diagnosed seizure was present in 970 patients (84.1%). Generalized tonic clonic seizure (GTCS) was the most common clinical type of seizure encoured at the electro-physiology lab, followed by secondary generalized seizure in 19.4% (n=224) and focal seizure in 2% (n=30) patients. About 6.8% (n=79) patients had pseudoseizure (Table-II).

EEG was found to be normal in 473 patients (41%). Among the abnormal EEG (59%), generalized epileptiform discharge was found
in 29%, whereas focal and secondary generalized discharge was found in 30%. The most common site of origin of epileptiform discharge was temporal lobe (28.3%). The origin was hemispheric in 26.5%, paracentric in 17.6% and Frontal in 9.24%. We could not identify the site of origin in 63 patients (18.2%) (Table-III).

The EEG was normal among 332 patients who had clinically confirmed seizure and was abnormal in 39 patients who did not have any clinical seizure event. The overall sensitivity of EEG was 66% (ranged from 62% to 68% with a confidence interval (CI) at 95%) and specificity was 79% (72-84% at 95% CI). The positive predictive value was 58% (55-61% at 95% CI) and negative predictive value was 41% (38-44% at 95% CI) (Table-IV).

### Table-I

**Distribution of patients by age and sex (n=1154)**

<table>
<thead>
<tr>
<th>Age Group (in years)</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>512</td>
<td>44.4</td>
</tr>
<tr>
<td>11-20</td>
<td>239</td>
<td>20.5</td>
</tr>
<tr>
<td>21-30</td>
<td>171</td>
<td>14.8</td>
</tr>
<tr>
<td>31-40</td>
<td>65</td>
<td>5.6</td>
</tr>
<tr>
<td>41-50</td>
<td>34</td>
<td>3.0</td>
</tr>
<tr>
<td>51-60</td>
<td>23</td>
<td>2.0</td>
</tr>
<tr>
<td>&gt;60</td>
<td>20</td>
<td>1.7</td>
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</table>

<table>
<thead>
<tr>
<th>Sex</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>683</td>
<td>59.2</td>
</tr>
<tr>
<td>Female</td>
<td>471</td>
<td>40.8</td>
</tr>
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</table>

### Table-II

**Clinical seizure events (n=1154)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seizure Event</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>970</td>
<td>84.1</td>
</tr>
<tr>
<td>Absent</td>
<td>184</td>
<td>15.9</td>
</tr>
<tr>
<td><strong>Seizure Types</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focal</td>
<td>30</td>
<td>2.6</td>
</tr>
<tr>
<td>Secondary Generalized</td>
<td>224</td>
<td>19.4</td>
</tr>
<tr>
<td>Generalized</td>
<td>641</td>
<td>55.5</td>
</tr>
<tr>
<td>Pseudo seizure</td>
<td>75</td>
<td>6.7</td>
</tr>
</tbody>
</table>

### Table-III

**Findings in EEG (n=1154)**

<table>
<thead>
<tr>
<th>Findings</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Normal</strong></td>
<td>473</td>
<td>41</td>
</tr>
<tr>
<td>Abnormal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GE</td>
<td>333</td>
<td>28.9</td>
</tr>
<tr>
<td>LRE</td>
<td>346</td>
<td>30</td>
</tr>
</tbody>
</table>

**Site of epileptogenesis of LRE**

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporal</td>
<td>98</td>
<td>28.3</td>
</tr>
<tr>
<td>Frontal</td>
<td>32</td>
<td>9.24</td>
</tr>
<tr>
<td>Paracentral</td>
<td>61</td>
<td>17.63</td>
</tr>
<tr>
<td>Hemispheric</td>
<td>92</td>
<td>26.5</td>
</tr>
<tr>
<td>Undetermined</td>
<td>63</td>
<td>18.2</td>
</tr>
</tbody>
</table>
Discussion:
EEG is an old and established investigation. One may ask the rationale for conducting this study again in Bangladesh as there are many published reports regarding sensitivity and specificity of EEG. In most published series, patients having epileptiform discharges detected on an interictal EEG are significantly more likely to have another seizure than those with normal results on EEG. That means, there is a significant association between the presence of epileptiform discharges and a subsequent seizure\textsuperscript{24,25}. But, the frequency of reported EEG abnormalities in patients with seizures varies widely between studies. The sensitivities of EEG range from 29 to 69\%\textsuperscript{26-29}. In addition, when EEGs are repeated in the same subject, the results are often inconsistent\textsuperscript{30}. Variations in reported test characteristics may be related to differences in patient characteristics or to differences in reader thresholds for interpreting tests as positive. Tests with wide interobserver or intersubject variability may yield inaccurate or uninterpretable results\textsuperscript{31}. This variation from both the patients and observer side made us conducting the study in our own population.

The incidence of epilepsy varies with age. A number of studies report the incidence of epilepsy in specific age groups. These include studies of children, adults, and the elderly\textsuperscript{32-38}. Contrary to popular belief, epilepsy is a disease with onset at the extremes of life, we found a higher proportion of patients under 10 years of age and the elderly being very small in number. This finding is also not inconsistent with other studies, where provided, age-specific incidence is consistently high in the youngest age groups, with highest incidence occurring during the first few months of life. Incidence falls dramatically after the first year of life, seems relatively stable through the first decade of life, and falls again during adolescence\textsuperscript{44-46}. Seizure was also more frequent in male. In most total population studies, incidence of epilepsy or of unprovoked seizures is higher in males than in females. This seems true even after the higher incidence in males of definitive risk factors for epilepsy (i.e., head injury, stroke, central nervous system infection) is taken into account\textsuperscript{6-12,47,48}. For most but not all incidence studies, sex-specific differences in incidence are not statistically significant. The consistency of the male-to-female difference across studies suggests that males are at higher risk than females for unprovoked seizures and epilepsy.

Seizure-specific incidence or proportions of cases with a specific seizure type based on the International Classification of Epileptic Seizures are provided in several contemporary incidence studies\textsuperscript{49-53}. The frequency of both partial seizure and GTCS varied among different studies, which might account for the difference in methodological and geographical perspective. Granieri et al\textsuperscript{49}, Olafsson et al\textsuperscript{51} and Tekle-Haimanot et al\textsuperscript{53} found a higher proportion of HTCS like our study. Studies on adult epilepsies showed that the chance of detecting interictal epileptiform discharges (IEDs) from the first EEG varies between 29\% and 55\%\textsuperscript{54-56}. A Repeat EEG may ultimately demonstrated the IEDs in 80\%-90\% of the patients\textsuperscript{54,56}. We had a similar yield of abnormal report in EEG. There is wide variation in sensitivity (23\% - 77\%) and specificity (24\%-99\%) of reported EEG in general population\textsuperscript{58-67}. Donald L et al\textsuperscript{68} concluded three important

<table>
<thead>
<tr>
<th>Test</th>
<th>Seizure Event</th>
<th>Total</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EEG</td>
<td>Normal</td>
<td>332</td>
<td>145</td>
<td>477</td>
</tr>
<tr>
<td></td>
<td>Abnormal</td>
<td>638</td>
<td>39</td>
<td>677</td>
</tr>
<tr>
<td>Total</td>
<td>970</td>
<td>184</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table-IV
Sensitivity and specificity of EEG (n=1154)
findings related to wide variation in sensitivity and specificity of EEG. “The first is that the sensitivity and specificity of EEG varies widely among published studies. The second finding is that a large proportion of this variance appears to be accounted for by the interpretation threshold of the neurologist readers. The third finding is that there is an uneven trade-off between specificity and sensitivity in EEG interpretations. Higher specificity readers had greater diagnostic accuracy in predicting seizure recurrence than did higher sensitivity readers”. We found a higher specificity than sensitivity of EEG. The positive predictive value of EEG as a diagnostic test was also higher than the negative predictive value.

Some individuals who do not have epilepsy may have interictal discharges (IED). The probability that an IED indicates epilepsy relates to the location of the discharge. Only about 40% of individuals with central-mid-temporal spikes and 50% of those with occipital spikes have seizures. A photoparoxysmal response and generalized spike–wave discharges are often found in asymptomatic individuals, who may carry the genetic trait for spike–wave discharges, but lack the susceptibility of seizure, which might be the explanation of these negative EEG. The photoparoxysmal response accounts for 63% of IEDs found in subjects without epilepsy, who are not apt to develop seizures later in life. In contrast, people with midline, anterior temporal, midtemporal, and multifocal spikes usually have epilepsy; up to 90–95% of these individuals have epilepsy.

**Conclusion:**

Even though the diagnosis of epilepsy is clinical and based mostly on the acquisition of correct history, the EEG remains a key supportive investigation with a reasonable sensitivity and specificity. One interesting observation in our study was that it had higher specificity than sensitivity which may suggest that a patient with a negative EEG is less likely to have a seizure event.

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Sensitivity and Specificity of EEG Among Patients Referred


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