Electro encephalography screening of suspected epileptic patients in Erbil City

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Abstract

Background and objective: Electroencephalography is an essential component in the evaluation of patients with epilepsy. Electroencephalography provides important information about background electroencephalography and epileptiform discharges and the interictal spike or sharp waves. This study aimed to differentiate between epileptic and non-epileptic patients through electroencephalography investigation and determine its relationship with certain socio-demographic and clinical characteristics.

Methods: In this cross-sectional study included 400 cases (205 males and 195 females) with a mean age ± SD of 25 ± 14 years, referred to the private neurology clinic, Soran Medical Center between April 2013 and March 2017 for attacks of abnormal movements and or disturbed level of consciousness.

Results: Age-related prevalence of epilepsy showed a significantly higher prevalence (P = 0.001) of the disease among those who were 20 years and more. Epileptic patients showed significantly (P = 0.001) higher sharp slow waves and sharp waves, which were mainly dominated by parietal and occipital regions of the brain. Electroencephalography finding showed higher Beta rhythm followed by Alpha and Delta rhythms (73.5%, 14.3% and 9.0%, respectively), Patients with epilepsy (generalized and focal) had shown best rhythm adoption in Beta rhythm (75.2% and 70.2%, respectively), followed by Alpha rhythm (13.2% and 14.8%, respectively). Focal to bilateral (secondary generalized) and generalized motor epilepsy were the most common diagnosis among the epileptic cases (45.4% and 43.4%, respectively). The overall sensitivity of electroencephalography was 67.8%, and specificity was 63.5%.

Conclusion: The electroencephalography showed good sensitivity and specificity in diagnosing suspected epileptic patients, with interesting higher sensitivity than specificity. Not only the abnormal discharges, but the background dominating activity and the best rhythm adoption can help in the diagnosis of epilepsy.

Keywords: Erbil; Epilepsy; EEG; Sensitivity; Specificity.

Introduction

Electroencephalography (EEG) is an essential component in the evaluation of epilepsy. The EEG provides important information about background EEG and epileptiform discharges and the interictal spike or sharp wave. These discharges may be either generalized or focal in distribution and help to classify whether a focal or generalized seizure disorder is present.[1,2] EEG can help identify seizures type and localization of epileptic focus. Also, some patterns of EEG are predictive of patients who can develop late-onset seizures, in addition,[3] epilepsy is a condition of chronic, recurring seizures and its most disabling aspect is the unpredictability of when and where the next seizure will occur. Its etiology is complex and heterogeneous. Its prevalence varies in relation to ethnicity, geography, age, and sex. Seizure frequency, type, and duration are other important characteristics of epilepsy in a population.[4] It has been estimated that approximately 17-30% of outpatients

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presented to comprehensive epilepsy centers for evaluation have psychogenic non-epileptic seizures (PNES). It is therefore important that epilepsy centers provide an evaluation process in order to differentiate epileptic seizures from other paroxysmal non-epileptic events.[4] Epilepsy is affecting millions of patients worldwide, with a prevalence rate ranging from 16–51 per 100 000 population in the developed countries' to 35–111 per 100 000 population in the developing countries.[6-8] Epilepsy starts in childhood in 60% of cases and most of the clinically significant aspects of the disease occur during childhood.[9] Most studies of epilepsy indicate that males are more frequently affected than females and generalized seizures to be more common than focal seizures.[10] The wrong diagnosis of epilepsy is, unfortunately, common. Of patients diagnosed with epilepsy who are seen at epilepsy centers, 20% to 30% are found to have been misdiagnosed. This percentage is astonishingly consistent across centers, countries, and continents.[11] In the majority of cases when first seen, the causative factors are not evident by history and clinical examination alone. Hence, a diagnostic tool like EEG is employed; normal EEG does not exclude the presence of epilepsy.[12] Our country is a developing country, and clinical characteristics of epilepsy are not yet completely understood in Iraq and the Kurdistan region. Moreover, the scarce data on this important problem in our community provided the impetus to conduct this study. This study aimed to differentiate between epileptic and non-epileptic patients through EEG investigation and determine its relationship with certain socio-demographic and clinical characteristics. This study will provide baseline data for further researches in the area, which may lead to a better understanding of epilepsy features, and could provide better management and control of the disease.

Methods

This cross-sectional study included 400 cases referred to the private clinic in Soran Medical Center between April 2013 and March 2017 for attacks of abnormal movements and or disturbed level of consciousness aiming to differentiate between epileptic and non- epileptic patients. The study was conducted in Erbil governorate with a catchment population of around 1,750,000 population.[13] Soran Medical Center was established in 2008 in Erbil city, and includes different specialties. The center is equipped with 1.5 Tesla MRI machine, spiral CT scan and 20 electrodes advanced EEG machine from Xai-medicacompany. The neurology unit in the center is run by a consultant neurologist. Patients were informed about the study, and then informed consent was obtained from each patient. Their demographic characteristics, including age, sex, and history of epilepsy, were documented. The EEG study, including four sessions; background, activation reaction, rhythmic stimulation, and hyperventilation were recorded in dark and calm room. Each study lasts for about 30 minutes. Physiological electrical brain activity can be recorded within these rhythms, including alpha(8-12 Hz), beta(12-30 Hz), theta (4-7 Hz) and delta (0.5-3 Hz) rhythms. Classically, presence of sharp waves, sharp slow waves, spikes, and spike slow wave complex discharges focally or generalized are regarded to be abnormal. Other electroencephalographic findings were also documented including, background dominating activities, rhythmic stimulation rhythm adoption, the focus of the discharges, and finally the diagnosis. According to the protocol followed in the clinic, each patient should be assessed by an adult neurologist to obtain a detailed history and perform the neurological examinations, followed by an EEG. Epilepsy was suspected on history, clinical presentation and confirmed/categorized by EEG. Those who are diagnosed to be epileptic were thoroughly investigated by

hematological workup and neuroimaging (computerized tomography C.T. or magnetic resonance imaging M.R.I. of the brain) according to indication for the cause of epilepsy. Patients of all ages and both sexes having a seizure-like presentation (attacks of recurrent reversible neurological disturbances) were included. All those patients with physical disorders not related to epilepsy like transient ischemic attacks (TIA), drop attacks, syncope, cardiac dysrhythmias, psychiatric disorders and those who refused to participate were excluded. Ethical approval was granted by the Research Ethics Committee of the College of Medicine, Hawler Medical University. Microsoft Excel was used for data processing, summarization. Tables and figures were used for presentation of the findings. Statistical analysis was performed by the statistical package for the social sciences (version 18). Chi-Square and Fischer's exact association tests were used to compare categorical variables. A P value of ≤0.05 was regarded as statistically significant.

Results

A total of 400 patients with suspected epilepsy were included in the current study. Their age ranged from two to 81 years with a mean age ± SD of 25 ±14 years. Among them, 76.0% had history of fits. Of those below 20 years, 85.5% had history of fits, while 68.2% of those aged 20 years or more had history of fits with significant statistical association between age groups of the participants and history of fits (P = 0.001). Among the males, 79.5% had history of fits, while only 72.3% of females had history of fits with a male to female ratio of 1.05:1and no significant statistical difference (P = 0.102) in relation to the history of fits (Table 1).

**Table1:** Association between socio-demographic variables and history of fits.

Variables	History suggestive of fits			P value
	Yes No. (%)	No No. (%)	Total No. (%)	
Age groups				
<20 years	154 (85.5)	26 (14.5)	180 (100.0)	
				0.001
≥ 20 years	150 (68.2)	70 (31.8)	220 (100.0)	
Gender				
Male	163 (79.5)	42 (20.5)	205 (100.0)	
				0.102
Female	141 (72.3)	54 (27.7)	195 (100.0)	
Total	**304 (76.0)**	**96 (24.0)**	**400 (100.0)**	

Age-related prevalence of epilepsy showed statistically significant association between age groups of the patients and types of epilepsy (P = 0.001). Among those who were 20 years and more, generalized epilepsy was the most common type (33.2%), and focal epilepsy was more prevalent (41.6%) among those younger than 20 years. Gender-related prevalence of the disease had shown no significant difference (P = 0.403) in relation to the type of epilepsy. Focal epilepsy was more prevalent (33.2%) in males, while generalized epilepsy was more prevalent (32.3%) in females (Table 2). Regarding background dominating activities, the EEG findings showed that 46.3% of the dominating activities were from the parietal region of the brain, followed by occipital and temporal regions (26.3% and 22.8%, respectively), as shown in Figure 1.

Table 2: Association between socio-demographic characteristics of the patients and types of epilepsy

Variables	Types of epilepsy				*P* value
	Normal EEG No. (%)	Generalized No. (%)	Focal No. (%)	Total No. (%)	
Age groups					
< 20 years	57 (31.7)	48 (26.7)	75 (41.6)	180 (100.0)	0.001
≥ 20 years	101 (45.9)	73 (33.2)	46 (20.9)	220 (100.0)	
Gender					
Male	79 (38.5)	58 (28.3)	68 (33.2)	205 (100.0)	0.403
Female	79 (40.5)	63 (32.3)	53 (27.2)	195 (100.0)	
Total	**158 (39.5)**	**121 (28.25)**	**121(28.25)**	**400 (100.0)**	
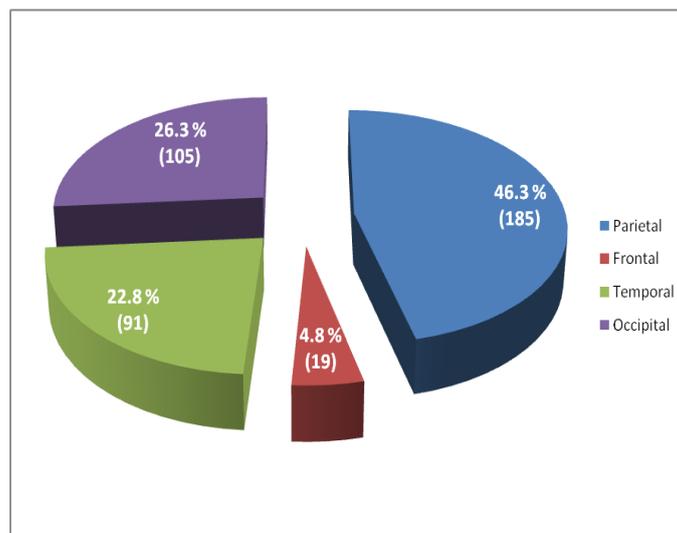
Figure 1: Background dominating activities by EEG finding.

The dominating activities were mainly from parietal, temporal and occipital regions of the brain, and there was a significant statistical association (P = 0.001) between abnormal discharges and background dominating activities, where sharp slow waves and sharp waves were the most dominating abnormal discharges. Sharp slow waves were more dominant in parietal, temporal then occipital lobes (47.0%, 32.9%, and 16.8%, respectively). However, sharp waves were more dominant in parietal, occipital, and temporal regions (54.1%, 30.5%, and 12.5%, respectively). Epileptic patients (those with generalized epilepsy) had more dominating activities in the parietal and temporal regions (36.4% and 33.1%, respectively), and those with focal to bilateral epilepsy (secondary generalized) showed more dominating activities in the parietal and temporal regions (59.5% and 24.8%, respectively), with significant statistical association (P = 0.001) between types of epilepsy and background dominating activities (Table 3).

Table 3: Background dominating activities in relation to abnormal discharges, and focus of the discharges.

| Variables	Background dominating activities No. and (%)					P value
	Parietal	**Frontal**	**Temporal**	**Occipital**	**Total**	
Abnormal discharges						
Sharp waves	39 (54.1)	2 (2.8)	9 (12.5)	22 (30.5)	72(100.0)	
Spikes	2 (40.0)	0 (0.0)	2(40.0)	1 (20.0)	5 (100.0)	
Sharp slow waves	70 (47.0)	5 (3.3)	49 (32.9)	25 (16.8)	149 (100.0)	0.001*
Spike slow waves	4(26.6)	0(0.0)	10 (66.7)	1 (6.7)	15 (100.0)	
Theta activity	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	1(100.0)	
Types of the epilepsy						
Normal EEG	69 (43.7)	12 (7.6)	21 (13.3)	56 (35.4)	158 (100.0)	
Generalized	44 (36.4)	6 (5.0)	40 (33.1)	31 (25.6)	121 (100.0)	0.001
Focal**	72 (59.5)	1 (0.8)	30 (24.8)	18 (14.9)	121 (100.0)	
Total	**185 (46.25)**	**19 (4.75)**	**91 (22.75)**	**105 (26.25)**	**400 (100.0)**	

*: Fischer exact test
**: focal or focal to bilateral

Comparing the best rhythm adoption in rhythmic stimulation part of the EEG to the affected brain lobes by EEG finding, showed higher Beta rhythm followed by Alpha and Delta rhythm (73.5%, 14.3%, and 9.0%, respectively) as shown in Figure 2. The parietal region showed higher Beta rhythm followed by Alpha and Delta rhythm (76.8%, 9.7% and 8.5%, respectively). The same is true in both frontal and occipital regions, with no significant statistical difference (P = 0.190).

Beta rhythm stimulation was the most dominating one in relation to all the discharged waves followed by Alpha rhythm with no statistical difference (P = 0.855). Patients with epilepsy (generalized and focal) had shown best rhythm adoption in Beta rhythm (75.2% and 70.2%, respectively), followed by Alpha rhythm (13.2% and 14.8%, respectively), with no significant statistical difference (P = 0.958) as shown in Table 4.

Table 4: The best rhythm adoption in relation to affected lobe by EEG finding, abnormal discharges, and type of epilepsy.

Variables	Best rhythm adoption No. and (%)					P value
	Delta	Theta	Alpha	Beta	Total	
Affected lobe by EEG findings						
Normal	13 (8.2)	4 (2.5)	23 (14.5)	118 (74.8)	158 (100.0)	
Abnormal						
Parietal	7 (8.5)	4 (4.9)	8 (9.7)	63 (76.8)	82 (100.0)	0.190
Frontal	5 (7.5)	1 (1.5)	15 (22.7)	45 (68.1)	66 (100.0)	
Temporal	8 (21.6)	2 (5.4)	4 (10.8)	23 (62.1)	37 (100.0)	
Occipital	3 (5.3)	2 (3.5)	7 (12.3)	45 (79.0)	57 (100.0)	
Abnormal discharges						
No discharges	13 (8.2)	4 (2.5)	23 (14.5)	118 (74.8)	158 (100.0)	
Sharp waves	3 (4.1)	2 (2.8)	11 (15.3)	56 (77.7)	72 (100.0)	
Spikes	1 (20.0)	0 (0.0)	0 (0.0)	4 (80.0)	5 (100.0)	0.855
Sharp slow Waves	18 (12.0)	7 (4.7)	21 (14.0)	103 (69.1)	149 (100.0)	
Spike slow Waves	1 (6.6)	0 (0.0)	2 (13.3)	12 (80.0)	15 (100.0)	
Theta activity	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	1 (100.0)	
Type of the epilepsy						
Normal EEG	13 (8.2)	4 (2.5)	23 (14.5)	118 (74.8)	158 (100.0)	
Generalized	10 (8.2)	4 (3.3)	16 (13.2)	91 (75.2)	121 (100.0)	0.958
Focal	13 (10.7)	5 (4.1)	18 (14.8)	85 (70.2)	121 (100.0)	
Total	**36 (9.0)**	**13 (3.3)**	**57 (14.2)**	**294 (73.5)**	**400 (100.0)**	
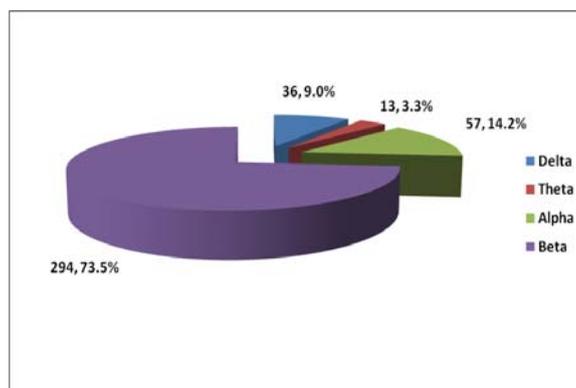
Figure 2: Frequency and percentage of best rhythm adoption by EEG finding.
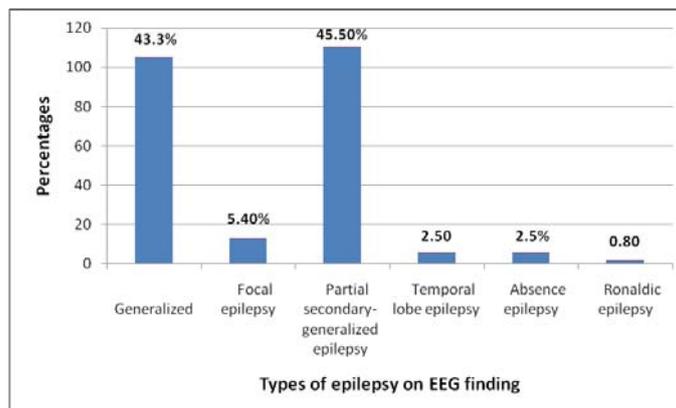
The final diagnosis of the patients by the EEG findings revealed that 158 (39.5%) of the patients were normal compared to 242 (60.5%) of abnormal cases (epileptics). Of all the patients, 15% had no history suggestive of fits, while 85% had history suggestive of fits, with a significant statistical association (P = 0.001). Focal to bilateral epilepsy and generalized epilepsy were the most common diagnosis among the epileptic patients (45.5% and 43.3%, respectively) and was more dominant among patients with a history suggestive of fits (Figure 3). There was a significant statistical difference (P = 0.001) in comparing the active brain lobes in EEG finding to history suggestive of fits. The parietal and frontal regions were the main focus of epilepsy with more focus of discharges (76.0%) among those with history suggestive of fits, compared to 24.0% of those who had no history suggestive of fits (Table 5).

Table 5: Clinical characteristics of the study sample by EEG findings in relation to the history of fits.

Variables	History suggestive of fits			P value
	Yes No. (%)	No No. (%)	Total No. (%)	
Diagnosis				
Normal	98 (62.0)	60 (38.0)	158 (100.0)	
Abnormal				
Generalized	95 (90.5)	10 (9.5)	105 (100.0)	
Focal epilepsy	11(84.6)	2 (15.4)	13 (100.0)	0.001*
Focalto bilateral epilepsy (secondary generalized)	87 (79.0)	23 (21.0)	110 (100.0)	
Focal with impaired awareness (temporal lobe epilepsy)	5 (83.3)	1(16.7)	6 (100.0)	
Generalized non motor (absence seizure)	6 (100.0)	0 (0.0)	6 (100.0)	
Rolandic (focal) epilepsy	2 (100.0)	0 (0.0)	2 (100.0)	
Subtotal	206 (85.0)	36 (15.0)	242 (100.0)	
Focus of epilepsy on EEG finding				
Normal	(62.0) 98	(38.0) 60	158(100.0)	
Abnormal				
Parietal	(85.3) 70	12 (14.2)	(100.0) 82	0.001
Frontal	57(86.3)	9 (13.7)	66(100.0)	
Temporal	31 (83.8)	(16.2) 6	37(100.0)	
Occipital	48(84.2)	9 (15.8)	57(100.0)	
Total	304 (76.0)	96 (24.0)	400 (100.0)	

* Fischer exact test

Figure 3: The final diagnosis of epileptic patients by EEG finding.

The EEG was normal among 98 patients who were clinically suggestive of seizure and was abnormal in 36 patients who had a vague description of fainting attacks. The overall sensitivity of EEG was 67.8% (95% confidence interval (CI) 62.19% to 72.99%) and specificity was 63.5% (95% CI 52.03% to 72.18), as shown in Table 6.

Discussion

The profile of epilepsy varies across various cultures,[14] and the frequency of reported EEG abnormalities in patients with seizures commonly differs between studies. The sensitivities of EEG range from 29 to 69%. Even when EEGs are repeated in the same patient, the results are often not consistent. Differences in reported test characteristics could be related to variations in patient characteristics or to reader's threshold variations for interpreting tests as positive.[15] Results of the study showed that age-related prevalence of epilepsy showed a significantly higher prevalence of the disease among those who were 20 years or above. Among them, generalized epilepsy was the most common type, and focal epilepsy was more prevalent among those aged less than 20 years. Focal epilepsy was more prevalent among males, followed by a higher prevalence of generalized epilepsy in females. Studies in Pakistan and Saudi Arabia revealed that generalized seizures were the most common seizure type.[16,17] Another study in Egypt showed that focal seizures were the commonest type.[18] As the age is increased, the EEGs findings showed more generalized epileptic potentials; this was in contrast to a study in India.[19] These differences could be due to different patients characteristics from genetic factors, to other socio-demographic factors. Gender-related prevalence of the disease had shown no significant difference in relation to the type of epilepsy. A study in Bangladesh showed a higher incidence of the disease among younger age groups, with more prevalence among males, and for most incidence studies, sex-specific differences in incidence are not statistically significant.[15] Another study in the USA revealed no significant statistical differences by age group and gender among the study participants.[20] This could be due to greater outdoor activities and more exposure to risk factors, which might expose males to a higher risk of epilepsy than females. Regarding background dominating activities, the study showed that the main dominating activities were from the parietal region of the brain, followed by occipital and temporal regions; this is inconsistent with a study in Bangladesh, which showed that the most common site of origin of epileptiform discharge was temporal lobe (28.3%).[15] About two-thirds of the patients showed epileptic discharges, almost similar results were reported in an Indian study, where more than 70% of the patients had abnormal EEG findings.[21] Among those with abnormal discharges showed significantly higher sharp slow waves and sharp waves, almost similar results were reported in another Indian study, where the sharp waves were the most predominant

Table 6: Sensitivity and specificity of EEG.

Test	History suggestive of seizures		Total	Sensitivity (95% CI)	Specificity (95% CI)
EEG	Yes	No			
Abnormal	206(85.0%)	36 (15.0%)	242		
Normal	98 (62.0%)	60 (38.0%)	158	67.8 (62.19- 72.99)	62.5 (52.03- 72.18)
Total	**304**	**96**	**400**		

waveforms.[22] Also, similar results were reported in a study in Pakistan showed that the commonest epileptiform discharges were focal sharp and slow waves seen in 9.8% of patients.[3] This could be attributed to the pattern of the disease and good sensitivity and specificity of the EEG. Comparing the best rhythm adoption to the affected brain lobes by EEG finding, showed higher Beta rhythm followed by Alpha and Delta and one-fifth of all the rhythmic stimulation was from the parietal region. In contrast, a study in Japan revealed a significant difference only in the delta frequency power bands in the frontal region of the brain.[23] Another study in Norway showed higher Alpha activity in parieto-occipital and temporal regions of the brain;[24] this could be due to the background etiology of the disease and some other clinical features of the patients. The final diagnosis of the patients obtained by the EEG revealed that 39.5% of the patients were normal compared to 60.5% of abnormal cases (epileptics). Focal to bilateral epilepsy and generalized epilepsy were the most common diagnosis among the epileptic cases, and the parietal and frontal regions of the brain were the main focus of epilepsy. A study in Bangladesh revealed that among the abnormal EEG findings (59%), the generalized epileptiform discharge was found in 29%, whereas focal and secondary generalized (focal to bilateral) discharge was found in 30% of the cases. The most common site of origin of epileptiform discharge was temporal lobe (28.3%).[15] This could be due to the background etiology of the disease, patients' clinical features, and sensitivity and specificity of the EEG. The overall sensitivity of EEG was 67.8% (95% CI 62.19%-72.99%), and the specificity was 63.5% (95% CI 52.03%-72.18); almost similar results were reported in other studies in Bangladesh, Pakistan and Netherland.[15,16,25] The current study is the first study in the Kurdistan region and Iraq addressing sensitivity and specificity of EEG among suspected patients with epilepsy. This study has a number of limitations. Some demographic and social characteristics of the patients were not addressed in addition to the possible underlying causes and family history of the disease that could contribute more to epileptiform discharges.

Conclusion

This study had concluded that the EEG showed good sensitivity and specificity in diagnosing suspected epileptic patients, with interesting higher sensitivity than specificity, which may indicate that EEG still remains the best investigation tool in diagnosing patients with a suggestive history of fits.

Competing interests

The author declares no competing interests.

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