Patterns of Abnormalities and Yield of Electroencephalograms in Young Adults in a Tertiary Care Medical center in Saudi Arabia

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Abstract

Objectives: To determine the yield of electroencephalograms (EEG) in various clinical scenarios, including epilepsy, in young adults.

Methods: EEGs performed on adults of both genders aged between 18 and 50 years between January 2009 and December 2013 at King Abdulaziz Medical City, Riyadh were included. Clinical indication and EEG findings were determined and correlated.

Results: Of 2,631 EEGs, 1,351 (51.3%) were for females. The mean age was 29.9 ± 9.4 years. A total of 1,928 (73%) EEGs were outpatient. Indications included seizure/epilepsy, status epilepticus, altered level of consciousness, brain death, other indications, and unclear indications. Electroencephalograms were normal in 56.2% of the cases for seizure/epilepsy, 69.3% for altered consciousness, and 65.4% for other indications. When the indication was not clear, 50.6% of EEGs were normal. Epileptiform abnormalities were found in 22.3% of the EEGs for seizure/epilepsy ($p < 0.001$). Slowing with or without epileptiform abnormalities was found in 23.1% of the EEGs for altered consciousness. Electroencephalograms for brain death confirmed diagnosis in 46.7% of the cases ($p < 0.001$). The highest frequency of abnormalities was seen in EEGs performed in the intensive care unit (91.2%), followed by wards (66.3%) and the emergency room (49.4%). Outpatient EEGs were abnormal only in 36.8% of the cases. Overall, 43% of EEGs showed some abnormality.

Conclusion: Electroencephalograms had a higher yield of abnormalities when appropriate clinical questions were asked. The greatest number of confirmatory EEGs was observed in brain death evaluations. Almost half of the EEGs for patients with suspected epilepsy were normal, with only 1 in 5 confirming it. Approximately 2 in 5 EEGs showed some abnormality regardless of the indication.

Key words: Electroencephalogram, abnormal patterns, yield, epileptiform discharges, young adults, Saudi Arabia

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Introduction

Electroencephalography (EEG) is a complementary tool used to support the diagnosis of epilepsy and evaluate other neurological conditions, such as psychogenic nonepileptic seizures and encephalopathies. Some special conditions that can be diagnosed with a certain degree of confidence using EEG include Creutzfeldt-Jakob disease and subacute sclerosing panencephalitis (SSPE).[1] Routine EEG has some limitations, which are not widely recognized; consequently, it has been used suboptimally in clinical practice.[1] Several studies have shown that a large proportion of EEG requests could be inappropriate due to the prevalent misconcep-

tion about its diagnostic capabilities.[1,2] The literature indicates that overinterpretation of EEG results can lead to misdiagnosis and unnecessary treatment when used for diagnostic confirmation by non-specialized physicians.[3]

Limited data is available about the diagnostic yield of routine EEGs in general, particularly in young adults. Few studies have investigated the sensitivity and specificity of routine EEGs performed for epilepsy. The yield of a single EEG for epilepsy could be up to 50%, which increases with repeated EEGs up to 80%.[3] A recent study found that pre-test diagnosis of epilepsy, a young patient age, and not using antiepileptic medications increased the yield of routine EEGs.[4] Electroencephalograms requested for syncope usually have very low yield and hardly ever alter the management decisions.[5,6] In this study, we aimed to determine the yield of EEGs when ordered for conditions other than epilepsy. We also tried to determine the EEG yield when the clinical question was epilepsy or status epilepticus. In this paper, we present the results of various indications and their respective patterns of electroencephalographic abnormalities in young adults.

Methods

We conducted a cross-sectional chart review at King Abdulaziz Medical City, MNGHA, Riyadh for EEGs performed from January 2009 until December 2013. The study was approved by King Abdullah International Research Center (KAIMRC) institutional review board. Young adults of both genders were included. We arbitrarily defined young adults as people aged from 18 to 50 years at the time of EEG. We set an upper limit of 50 years because many EEG abnormalities in people older than that are considered nonspecific and age-related.[7] Patients with missing data regarding the interpretation were excluded. The patients' demographic information, clinical indications or questions for EEG, the EEG settings, and patterns of EEG abnormalities were recorded. The data was analyzed using SPSS version 23.0. Categorical data is presented as frequencies and percentages, while continuous data is presented as mean with standard deviations.

The EEGs were performed using a Compumedics digital EEG acquisition system (Compumedics Ltd., Melbourne, Australia) with scalp electrodes placed using the international 10-20 system. The EEG settings were categorized into outpatient clinics and inpatient settings, subcategorized as wards, emergency room (ER), and intensive care units (ICU). The indications for EEG were categorized into epilepsy/seizure, status epilepticus, altered level of consciousness, brain death, other indications (for example, syncope, vertigo, or unexplained fall), and unclear indications. All EEG reports were reviewed, and the results were classified as normal, epileptiform activity (focal or generalized), slowing (focal or generalized), electrocerebral silence (brain death), and borderline/nonconclusive. In many patients there were more than one abnormal finding. Normal variants were included in the normal EEG category. A chi-square test was used to determine statistically significant relationships between variables.

Results

A total of 2,631 EEGs were included based on the inclusion criteria. Of those, 1,351 (51.3%) were performed on females. The patients' mean age was 30.0 ± 9.4 years, with a mean age of 29.4 for males and of 30.5 for females. The EEG settings included outpatient and inpatient settings, with a small number of undetermined settings **(Figure 1)**. The distribution of EEGs according to patient setting is shown in **Figure 2**.

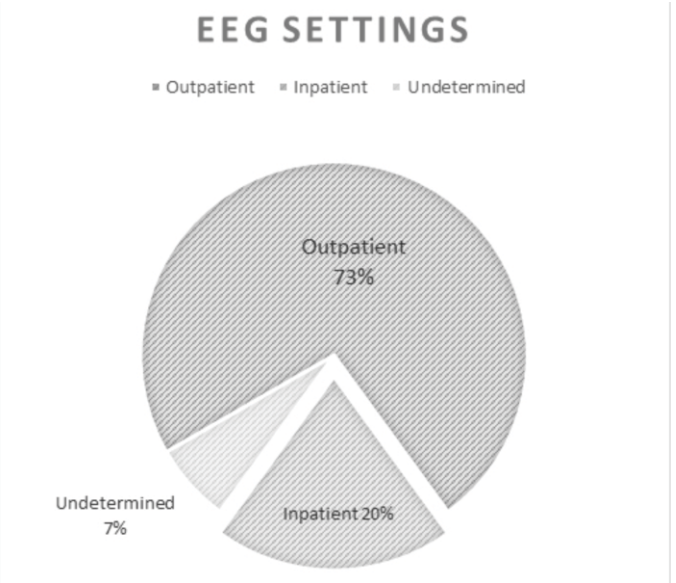

Figure 1 - *Distribution of EEGs According to Clinical Setting*

The indications for the EEGs were categorized as follows: seizure/epilepsy: 2,092 (79.5%); status epilepticus: 26 (1%); altered level of consciousness: 225 (8.6%); brain death: 15 (0.6%); other indications: 188 (7.1%); and unclear indications: 85 (3.2%).

The EEG findings were categorized as follows: norma

Table 1: *EEG Findings in Relation to Various Clinical Questions/Indications*

Indication for EEG		EEG Finding					
		Normal	Brain dead	Slowing*	Epileptiform*	Borderline /nonconclusive*	Total
Seizure/Epilepsy	n	1,175	0	515	467	249	2,092
	%	56.2%	0%	24.6%	22.3%	11.9%	
Status epilepticus	n	2	0	17	12	4	26
	%	7.7%	0%	65.4%	46.2%	15.4%	
Altered level of consciousness	n	156	0	38	26	29	225
	%	69.3%	0%	16.9%	11.6%	12.9%	
Brain death	n	0	7	3	1	5	15
	%	0%	46.7%	20%	6.7%	33.3%	
Other	n	123	0	45	23	13	188
	%	65.4%	0%	23.9%	12.2%	6.9%	
Not clear	n	43	0	29	12	13	85
	%	50.6%	0%	34.1%	14.1%	15.3%	

* Some EEGs showed more than one type of abnormality and are reported as separate findings.

l: 1,499 (57%); slowing: 647 (24.6%; focal: 326 [12.4%], generalized: 377 [14.3%]); electrocerebral silence: 7 (0.3%); borderline/nonconclusive: 313 (11.9%); epileptiform: 541 (20.6%; focal: 395 [15%], generalized: 180 [6.8%]). **Table 1** shows the relationship between various indications for EEG and the corresponding findings. The relationship between EEG findings and the EEG settings is shown in **Table 2**. Some patients exhibited more than one type of abnormality in the same EEG and are reported as separate findings.

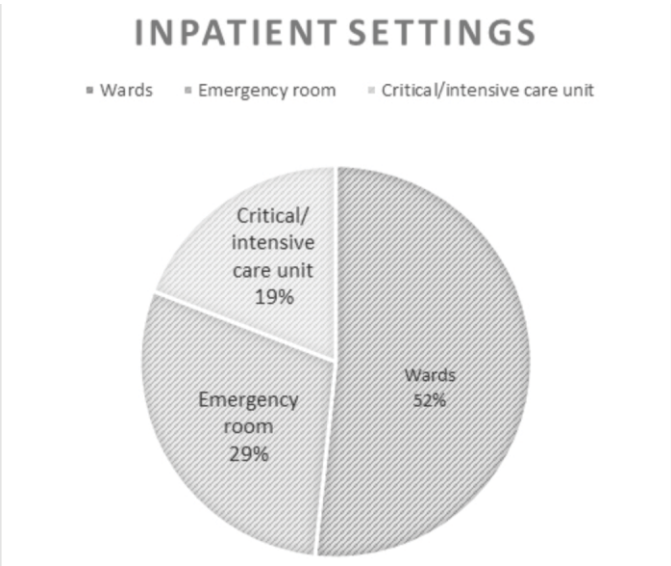

Figure 2 - *Distribution of Inpatient EEGs According to Setting*

Approximately three-quarters of the EEGs in our cohort were performed in outpatient settings, whereas one-fifths were performed in inpatient settings. For the remaining, the exact setting could not be determined retrospectively. Among the inpatient EEGs, 52% were performed in wards, 29% in the emergency room, and 19% in critical/intensive care units. Almost 9 out of 10 (91.2%) EEGs performed in an ICU setting showed some kind of abnormality. Generalized slowing was noted in 61.8% of all ICU EEGs, epileptiform abnormalities were seen in 15.7% of the cases, and electrocerebral silence was seen in 5% of the EEGs.

Table 2: *EEG Findings in Relation to Settings*

Finding		Setting				
		Out-patient	Wards	ICU	ER	Undeter-mined
Normal	n	1,218	92	9	78	102
	%	63.2%	33.7%	8.8%	50.7%	58.6%
Brain death	n	0	1	6	0	0
	%	0%	0.4%	5.9%	0%	0%
Slowing	n	360	132	69	44	42
	%	18.7%	48.4%	67.7%	28.6%	24.1%
Epileptiform	n	402	59	16	32	32
	%	20.9%	21.6%	15.7%	20.8%	18.4%
Borderline/ nonconclusive	n	208	49	19	20	17
	%	10.8%	18.0%	18.6%	13.0%	9.8%

ICU - intensive care unit, ER - emergency room.

Table 3: *EEG Requests According to Gender*

Indication	Gender				
	Male (n = 1,280)		Female (n = 1,351)		
	n	%	n	%	p-value
Seizure/Epilepsy	1,024	80%	1,068	79.1%	0.547
Status epilepticus	20	1.6%	6	0.4%	0.004
Altered level of consciousness	75	5.9%	150	11.1%	<0.001
Brain death	14	1.1%	1	0.1%	0.001
Other	100	7.8%	88	6.5%	0.196
Not clear	47	3.7%	38	2.8%	0.213

The gender differences between the number of EEGs requested for various indications are shown in Table 3. Male patients had significantly more requests for status epilepticus and brain death, while females had more requests for altered level of consciousness.

The highest abnormality frequencies were seen in EEGs performed in ICUs (91.2%), followed by wards (66.3%) and the emergency room (49.4%). The outpatient EEGs were abnormal only in 36.8% of the cases. Overall, 43% of the EEGs showed some abnormality. EEGs requested for brain death confirmed diagnosis in 46.7% ($p < 0.001$), while none of the EEGs performed for status epilepticus confirmed it.

When analyzing the sensitivity and specificity of clinical suspicion of seizures/epilepsy, we found that EEG was sensitive in 22.3% of the suspected seizure/epilepsy cases and specific in 87.9%.

Discussion

Although many different pathological processes disturb brain function, the EEG abnormality findings are limited. Moreover, despite reliably indicating brain dysfunction, EEG rarely distinguishes between abnormality etiology and pathology.[8] It has been shown to have greater potential and to be of more crucial value when trying to answer specific, clearly defined questions.[9]

In the field of electroencephalography, it is known that certain findings seen in patients of older age may easily be misinterpreted as abnormalities. As many as 52% of EEGs in asymptomatic elderly people can be considered abnormal when compared to healthy young adults due to normal variants, EEG artifacts, and other factors.[7] In our study, we arbitrarily defined young adults as people aged between 18 and 50 years to avoid potential misinterpretation of the findings. We considered the age of 50 as our upper limit because the Saudi population is still a young population with a current life expectancy of 74 years.[10]

Electroencephalograms are commonly used for the evaluation of patients with suspected epilepsy. However, they have also been used for a variety of other conditions and indications. Head trauma, encephalitis, and memory impairment are some of the common indications. In our study, an EEG was requested for epilepsy or suspected seizures in 79.5% of the cases. In addition to altered level of consciousness, suspected brain death, and suspected status epilepticus, a number of EEGs were requested for other conditions, such as vertigo, dizziness, migraine, hallucinations, abnormal behavior, memory impairment, and postural imbalance.

Electroencephalograms can show nonspecific abnormalities in a number of conditions, such as dementia, migraine, and psychotic illnesses.[8] Even epileptiform abnormalities can be seen in patients who have never suffered from unprovoked seizures or epilepsy.[8] Electroencephalogram abnormalities should always be interpreted in a clinical context and considered supportive evidence.[2] In our series, a little less than half of all EEGs showed some kind of abnormality regardless of the indication. Epileptiform abnormalities were found in almost one-fifth of all EEGs. When the clinical question was epilepsy/seizure, epileptiform abnormalities were found in little more than 20% of the cases, while more than half of all EEGs performed for epilepsy were normal. The rest of the EEGs for epilepsy/seizure showed nonspecific slowing or were nonconclusive/borderline. This is consistent with previous studies, where the sensitivity of the first EEG for epilepsy was reported to be between 17% and 29%.[11,12]

The yield of outpatient EEGs is generally considered low, particularly when the pre-test diagnosis is not clear or is other than epilepsy/seizure. Epilepsy or suspected seizure was the reason for requesting 82.3% of all outpatient EEGs. As expected, majority of all outpatient EEGs were normal, while 20.9% showed epileptiform abnormalities (7.2% generalized and 14.9% focal). A recent study assessing the yield of routine EEGs in an outpatient setting reported similar results, with normal EEGs accounting for 66.7% and epileptiform abnormalities accounting for 13.2% (6.2% generalized and 7% focal).[4]

None of the EEGs performed for the question of brain death was normal. Although very few EEGs for status epilepticus were normal, all the abnormal EEGs showed epileptiform discharges or slowing, but none confirmed electrographic status epilepticus. This could be related to the possibility that EEGs were performed after initiating treatment based on clinical suspicion or to the possibility that the actual cause of unconsciousness was other than nonconvulsive status epilepticus. When EEGs were performed without clearly stated or with nonspecific indications, we still found that 12–14% showed epileptiform activity. This is more than the expected rate for the general population, which has been reported to be around 2.2%.[13] Possible explanations could be that the history was not appropriately recorded by the requesting physician, or that it was for epilepsy/

seizures, but the requesting physician did not mention it. We found that when the clinical pre-test probability was high, as in cases of brain death evaluation, the yield of EEG was high, whereas it was very low when it was for altered level of consciousness, unclear indications, or other indications. Previous reports also found a positive correlation between routine EEG and pre-test diagnosis/indication.[4]

Regarding specific abnormalities based on clinical questions or indications, the EEGs were found abnormal in 22.3% of all cases for epilepsy/seizure. Electrocerebral silence was noted in 46.7% of all EEGs requested for suspected brain death. Slowing or epileptiform activity was found in 23.1% of patients with an altered level of consciousness. A total of 34.6% of the EEGs performed for other indications showed abnormal findings. Among the EEGs with unclear indications, 47.7% were abnormal with nonspecific abnormalities, including epileptiform activity.

There was a male preponderance in EEGs performed for brain death and status epilepticus, whereas EEGs for altered level of consciousness were more frequently performed on females. Traumatic brain injury is one the most common causes of brain death.[14] As our center is a trauma center, it is possible that this male preponderance of EEGs for brain death is related to traumatic brain injuries common among male Saudi motor vehicle drivers, as until recently driving was a male prerogative in Saudi Arabia. Psychogenic nonepileptic events are more common in women and manifest in a variety of semiologies.[15] The higher frequency of EEGs for altered level of consciousness in females can possibly be explained by a great number of symptoms of nonepileptic events.

The yield of EEG varies depending on the setting, the experience or specialty of the ordering physician, and the indication or pre-test probability.[4,6] In our study, we found a higher yield in EEGs performed in ICUs, inpatient/ward settings, or the ER compared to outpatient EEGs. Only 8.8% of the ICU EEGs were normal, while 67.6% showed nonspecific slowing, and 15.7% showed epileptiform abnormalities. A recent study in an adult ICU in Saudi Arabia showed epileptiform abnormalities in 18.4% of the cases.[16]

Our study had a number of limitations. A major limitation was the retrospective study design. We had to rely on information documented in the medical records, which were not adequately detailed in some cases. We could not always identify the experience and specialty of the ordering physician; hence, we could not correlate it to the yield. The pre-test probable diagnosis was not confirmed by any gold standard, and we assumed the clinical suspicion to be the appropriate diagnosis. There was no radiological correlation to ascertain the etiology and the abnormality patterns. The indication was unclear or nonspecific in almost 1 out of every 10 EEGs. As this was a single-center study, the findings may not be generalizable to the entire country.

Conclusions

The yield of EEGs performed on young adults for indications other than epilepsy is low. A large number of EEGs performed for suspected epilepsy/seizure, as well as for altered consciousness and nonspecific indications are normal. The confirmatory or diagnostic abnormalities are few and are affected by the pre-test diagnosis or clinical suspicion.

Clinicians should be aware of the limitations of EEG. Pre-test diagnosis or specific clinical questions should be included in the EEG requests to improve the yield and avoid incidental findings, which may adversely affect patient management. Electroencephalography should not be considered an isolated diagnostic tool; rather, its findings should be clinically correlated and integrated into the entire clinical scenario.

Conflict of Interest and Disclosures

None of the authors had any disclosures for this study. There was no special funding for this study.

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Authors Contribution

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A.A.S: Conceptualization of Project/Data Collection/Literature Search/Writing of Manuscript

A.A.B: Data Collection/Revision/Approval of Manuscript H.AIOt.: Data Collection/Revision/Approval of Manuscript

E.M: Data Analysis/Writing of Manuscript/ Approval of Manuscript

A.A.A: Conceptualization of Project/Data Analysis/ Literature Search/Writing of Manuscript

I.A.K: Conceptualization of Project/Data Analysis/ Literature Search/Writing of Manuscript