Original article

Role of Electroencephalogram (EEG) as Predictor to Post Stroke Seizures

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Abstract

Background & aim: The predictive value of EEG examinations for functional outcome in stroke patients was already described in the 1980s in small cohorts. Now, electroencephalography (**EEG**) is a sensitive neurophysiological technique in the detection of acute cerebral ischemia and a robust one in the functional assessment of the brain. The aim of this work was to assess the value of EEG as predictor of post stroke seizures. **Methods:** This study was a prospective study conducted in neuropsychiatry department at Benha University hospital, the studied sample was 70 patients with acute ischemic stroke fulfilling criteria. Total sample size was 80 patients, but only 75 were alive after 6 months from which five patients died at ICU from complications, 70 patients had an EEG at this time. Five patients didn't complete the follow-up (6 months). **Results:** There was significant relation between EEG findings & occurrence of post stroke seizures. 7 (10%) patients of total studied sample after 3 months had post stroke seizures. Only 11 with abnormal EEG, 6 (8.5%) patients after 6 months had post stroke seizures with only 10 abnormal EEG so there was significant relation between EEG findings & developing post stroke seizures, also there was significant statistical relation between The National Institutes of Health Stroke Scale (NIHSS) & Early electroencephalography (EEG) findings. **Conclusion:** The EEG abnormalities can be considered as a sensitive predictor for post stroke seizure and also can be used as a diagnostic and prognostic tool.

Key words: Electroencephalogram; EEG; Post Stroke Seizures

Introduction:

Stroke is the second most common cause of death and the third most common cause of disability worldwide. There are frequent complications of stroke including post-stroke seizures and epilepsy, depression and cognitive decline **(1).** In Egypt Stroke

prevalence of 613/10,0000 and crude incidence rate of 202/10,0000 **(2).**

Stroke is a commonly identified as a cause of epilepsy in patients older than 35 and the most common cause of seizures in the elderly **(3).** Clinical stroke severity and infarct dimension are known risk factors for poststroke epileptic seizures and vascular epilepsy **(4).**

Cerebrovascular disease is the main cause of epilepsy in advanced age group, accounting for nearly 50% of epilepsy patients over 60 years old **(5)**.
EEG is commonly used to diagnose epilepsy secondary to stroke in adults; it lets physicians study the characteristics and clinical outcomes of patients, as well as analyze the effectiveness of different antiepileptic treatments **(6***).*
Characterizing and studying electrophysiological signals of the central nervous system with EEG equipment is well established because of different features which make it an optimal clinical evaluation tool. The technique is noninvasive, and equipment is portable and inexpensive. *(6).*

The aim of this work was to investigate whether EEG abnormalities are independent predictors of post stroke epilepsy.

Patients and Methods

I-Technical design:

Type of study: this is a prospective study.

Site of study: Participants were collected from stroke unit, patients at Neuropsychiatry department in Benha University Hospital.

Time of study: The field work (collection of data) started at the beginning of June 2021 till February 2022.

Subjects:

The study enrolled patients with acute ischemic stroke fulfilling criteria.

Sampling:

Participants was chosen by non-random technique, all patients fulfilling the inclusion criteria and agreed to participate were included in the study.

Inclusion criteria:

1. Age≥18 years old, both sexes were included in the study.

2. Ischemic stroke, established by imaging (computed tomography [CT] scan or magnetic resonance imaging [MRI]), within 7 days of clinical evolution.

3. National Institutes of Health Stroke Scale (NIHSS) score was ≥4 upon admission to stroke unite.

Exclusion criteria:

1. Previous history of epilepsy or epileptic seizures.

2. History of cerebral amyloid angiopathy, or head trauma, prior intracranial hemorrhage.

3. Previous history of brain contusion, subdural/epidural hematoma, subarachnoid hemorrhage, neoplastic

lesion, infectious/ inflammatory lesion, or hydrocephalus, intracerebral hemorrhage& sever metabolic diseases

Tool of data collection:

All patients were subjected to the following:

- Medical history.
- Physical &neurological examinations.
- Electrocardiogram.
- Laboratory: Routine investigation to exclude any metabolic disorders:

Complete blood count.

- Liver function test.
- Kidney function test.
- Lipid profile.
- Cardiac enzymes

Radiological:

- CT brain to exclude hemorrhage and any structural brain lesions.
- MRI brain with DWI to detect acute ischemic stroke.
- Carotid artery duplex

Electroencephalogram (**EEG**):

Was performed in the first 72 h (Initial EEG) then in case of neurological deterioration & before discharge from the hospital and at 3 & 6 months after stroke.

The EEG was done under standardized condition, the background was alpha waves reactive and dominant occipitally.

Telephone follow up was performed for every patient in our sample for the occurrence of at least one acute unprovoked seizure (post stroke epilepsy), with epileptiform activity on at least one EEG during the hospital stay & in case of occurrence of any episode of transient neurology manifestation suggest epileptic seizure will perform EEG.

Statistical Methods

Data management: The clinical data were recorded on a report form. These data were tabulated and analyzed using the computer program SPSS (Statistical package for social science) version 26 to obtain:

Descriptive data: Descriptive statistics were calculated for the data in the form of:

1. Mean and standard deviation S.D. for quantitative data.

2. Frequency and distribution for qualitative data.

Analytical statistics: In the statistical comparison between the different groups, the significance of difference was tested using one of the following tests:

1- Student's t-test: - Used to compare mean of two groups of quantitative data.

2- ANOVA test (F value): -Used to compare mean of more than two groups of quantitative data.

Inter-group comparison of categorical data was performed by using chi square test (X2-

value) and fisher exact test (FET).

A *p* value <0.05 was considered statistically significant (*) while >0.05 statistically insignificant *p* value <0.01 was considered highly significant (**) in all analyses.

Results:

Table (1) shows that the mean age of studied patients was 59.09 ±7.25years. Most of our studied patients are males (54.3%) versus 45.7% females.

Table (2) and figure (1) show comparison between ischemic stroke in males & females according to (EEG findings). 12 patients had abnormal EEG & 58 had normal EEG (58). Male patients were predominant (66.7%) among the studied group in abnormal EEG in comparison with femal**es (**33.3%) with no statistically significant difference among the two groups. It also shows that the mean age in abnormal group was 58.17±6.10 years old while the mean age of normal group was 59.28±7.49 years old with no statistically significant difference among the two groups.

Table (3) and figure (2) show different types of seizures in stroke patients, where focal seizures was detected in 8 patients (53.3%) as an early seizures, in 4 patients (57.1%) after 3 months and in 3 patients (50.0 %) after 6 months. While generalized tonic & colonic seizures in stroke patients were found in 7 patients (46.6 %) as an early

seizures, in 3 patients (42.8 %) after 3 months and in 3 patients (50.0 %) after 6 months.

Table (4) shows that there was significant statistical difference between the occurrence of seizures & EEG findings.

Table (5) show that only 3 patients have EEG asymmetrical changes while after 3 months 2 patients had asymmetrical changes & after 6 months just one patient had asymmetrical pattern. There was focal spike slow waves in (3 patients) 25.0% at early EEG, (5 patients) 45.4% after 3 months and (4 patients) 40.0% after 6 months. While focal sharp slow waves were seen in (6 patients) 50.5% on the first EEG, (4 patients) after 3 months and in 5 patients after 6 months. Moreover, theta waves were detected in 2 patients on the first EEG and in 1 patient after 3 months. Delta waves were also detected in 1 patient on the first EEG, after 3 months and after 6 months. slowing waves type statistically insignificant. A receiver operating characteristic (ROC) curve signifies NIHSS as a predictor of abnormal EEG after 6 months. ROC curve show validity of NIHSS prediction of abnormality of EEG after 6 months in which sensitivity of NIHSS was 60.0, specificity was 61.7 %, accuracy 61.4% and AUC (95% CI) was 0.655 (0.461-0.849) which is statistically insignificant.

Table (1) Distribution of the studied group according to personal data

	All patients (70)	
	No	%
Sex		
Male	38	54.3
Female	32	45.7
Age /y mean ± SD	59.09±7.25	

Table (2) Age and sex in studied group on admission

			Abnormal EEG (12)		Normal EEG (58)		Statistical test	*p* value
			No	%	No	%		
Sex								
Male	38	/70	8	66.7	30	51.7	X2= 0.895	0.344
Female	32/	70	4	33.3	28	48.3		
Age/y **mean ±SD**			58.17±6.10		59.28±7.49		St t= 0.48	0.63
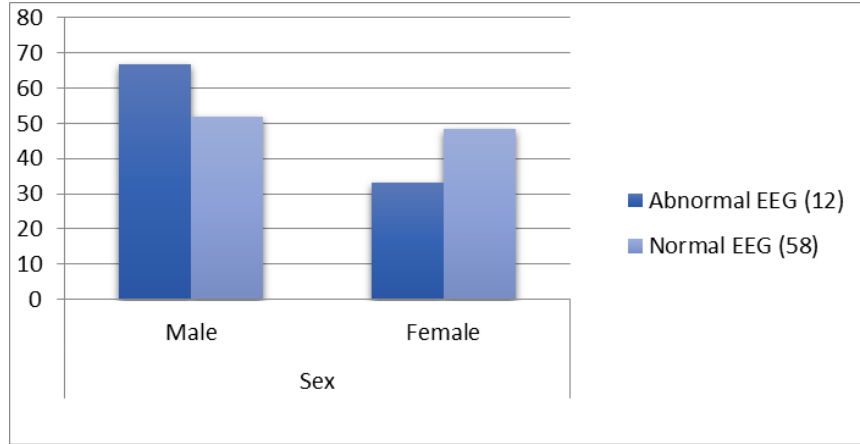
Fig. (1): Age and sex in studied group on admission

Table (3): seizures' type at studied group

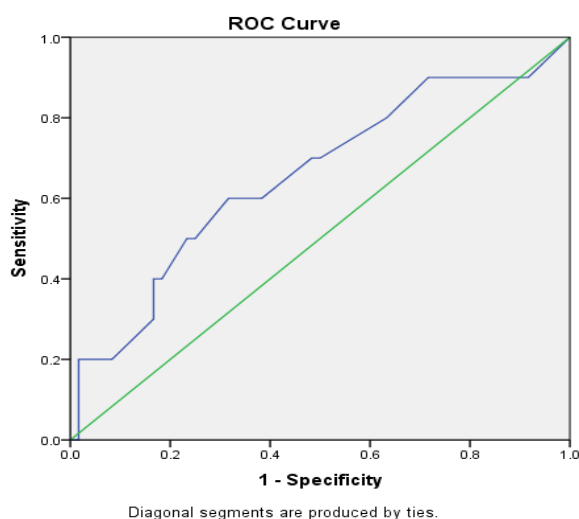| Seizures type	Early seizures (15)		3m after (7)		6m after (6)	
	No	%	No	%	No	%
Focal	8	53.3	4	57.1	3	50.0
Generalized	7	46.6	3	42.8	3	50.0
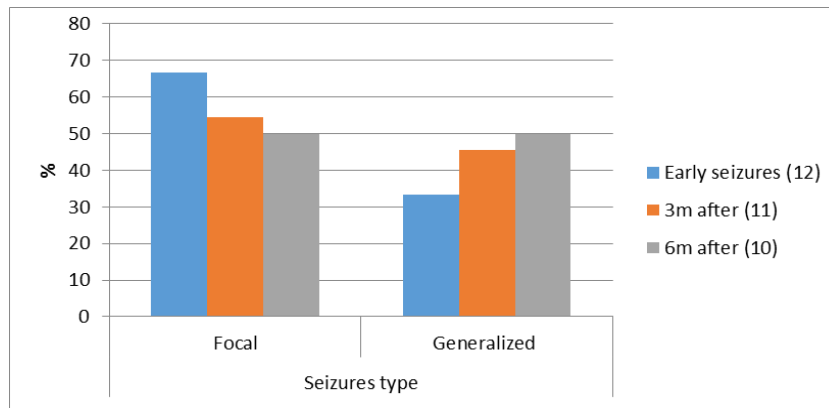
Fig. (2): seizures type at studied group

Table (4): Seizures' occurrence & EEG abnormalities on admission , after 3 months & 6months

Initial seizures		Abnormal EEG (12)		Normal EEG (58)		Statistical test	p value
		No	%	No	%		
Seizures Present		12	100	3	5.2	FET= 47.62	<0.001**
Absent		0	0.0	55	94.8		
After 3 m		**Abnormal EEG (11)**		**Normal EEG (59)**		**Statistical test**	**P value**
		No	%	No	%		
Seizures Present		7	63.6	0	0.0	FET= 34.95	<0.001**
Absent		4	36.4	59	100		
	After 6m	**Abnormal EEG (10)**		**Normal EEG (60)**		**Statistical test**	**P value**
		No	%	No	%		
Seizures Present		5	50.0	1	1.7	FET= 19.76	<0.001**
Absent		5	50.0	59	98.3		

Table (5): EEG pattern and type of waves abnormality in studied group

Patterns	Base line		3m after		6m after		Statistical test	P value
	No	%	No	%	No	%		
Symmetrical	67	95.7	68	97.1	69	98.6	FET= 0.39	0.82
Asymmetrical Slowness	3	4.3	2	2.9	1	1.4		
Spike	3	25.0	5	45.4	4	40.0	FET= 1.46	0.96
Theta	2	16.7	1	9.1	0	0.0		
Sharp	6	50.0	4	36.4	5	50.0		
Delta	1	8.3	1	9.1	1	10.0		

Diagonal segments are produced by ties.

ROC curve and NIHSS after (6) months:

Discussion

In this study the mean age of the studied sample was 59 ±7 years old ranging between 18 and 85 years; it included 38 male patients (54.3%) compared to 32 female patients (45.7 %) with no significant relation between increase in risk of developing post stroke seizures in studied group patients regarding gender and age. Our study matches with another study who found no significant relation between sex & the post stroke seizures **(7)**.

In this study, 15 (21.4%) patients of the total studied sample had early post stroke seizures with only (80% with abnormal EEG. There is significant relation between EEG findings & post stroke seizures. This study matches with another study that found abnormal early EEG (95%), EEG was significant predictors of post-stroke epilepsy **(8)**; it also matches with another study who reported that a statistically significant association between EEG changes and the development of PSE **(9). Furthermore,** a group of researchers reported that the first EEG background activity asymmetry was a predictor of unprovoked seizures **(10)**.

In this study, 7 (10%) patients of total studied sample after 3 months had post stroke seizures with only 11patients with between epileptiform EEG activity and development of seizures in retrospective study on 50 stroke patients in an intensive care unit **(13)**. The variation in results may be due to that the study use Video-EEG to be monitoring findings to predict development of seizures and survival during follow up.

abnormal EEG, 6 (8.5%) patients after 6 months had post stroke seizures with only 10 patients with abnormal EEG. There was a significant relation between EEG findings & post stroke seizures in our study which matched with another study who found that after following up their patients for 6 months to 1 year the asymmetry of EEG background activity and interictal epileptiform activity were predictors of unprovoked seizures and therefore PSE **(4)**. It also, matched with another group of researchers who assumed that if early EEG showed epileptiform discharges, there was a 3.8 times greater risk of seizures compared with patients with a normal early post-stroke EEG **(11)**. Our study in contrary with another study, found no statistically significant correlation between epileptiform EEG activity and development of seizures **(12)**. The variation in result may be due to that small sample size as 28.6% (12/42) of patients presented with new-onset seizures as an isolated episode without recurrence within 1-year of follow up with a similar incidence of early and late seizures within this group, time of follow up was 1 year & patients were controlled with monotherapy. This study in contrary with another study found no statistically significant relation

In this study there is significant statistical relation between The *National Institutes of Health Stroke Scale* **(NIHSS)** & early *electroencephalography* **(EEG)**. Our study matched with group of researchers who found NIHSS at admission ≥11 higher risk of acute symptomatic seizures & there was significant statistical correlation between

NIHSS & early **EEG (8)**. Also, another study reported a significant correlation between NIHSS at 30 days and delta-alpha ratio (DAR) **(1)**. Another study considered the NIHSS variable as possible predictors of early seizures **(14)**. In this study the infarction size was small in 34 stroke patients, medium size in 32 stroke patients and large size in 4 stroke patients and there was significant statistical correlation between **EEG** & the infarction size in developing post stroke seizures Our study matched with group of researchers a significant association between larger stroke size and poorer clinical outcome **(12)**.

Conclusion:

The study results showed that according to **EEG** findings, the risk of post stroke unprovoked seizures was higher in most patients with initial **EEG** background activity asymmetry and higher if the epileptiform activity was displayed in this recording. We found early neurophysiological markers of an increased risk of **EEG** epileptiform activity during the hospital stay, there by identifying patients who might benefit from an extended neurophysiological study. **EEG** can be used as a diagnostic and prognostic tool, or to track antiepileptic therapy during stroke recovery.

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