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Frequency of Abnormal Electroencephalography in Cases with Ischemic Stroke

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ABSTRACT

Stroke was a common global condition, with low-income countries bearing the highest burden. It leads to reduced cerebral blood flow, limiting oxygen and glucose, and causing cerebral infarction. Electroencephalography has been used as a biomarker to predict outcomes in ischemic stroke during its acute and subacute phases. **Objective:** To determine the frequency of abnormal EEG in cases with ischemic stroke. **Methods:** After obtaining approval from the CPSP research evaluation unit, this cross-sectional study was conducted at the Department of Neurology, Punjab Institute of Neurosciences, Lahore, from January 2019 to June 2019 on 96 ischemic stroke patients. Written informed consent was taken from patients/attendants, and demographic details were noted. Using a CT scan, all cases were diagnosed as ischemic stroke. The EEG was done in all cases within 24 hours of admission. All data were entered and analyzed using SPSS version 26.0. **Results:** In the current study, 57.3% of patients with ischemic stroke were found to have abnormal EEG. Data stratification was found to be significant concerning gender and duration of stroke, p- value = 0.01 and 0.000, respectively. However, abnormal EEG frequency was noted more among 45-60-year-old male patients of normal weight and those who presented within 1-2 days of stroke. **Conclusions:** According to current study findings, more than half of the ischemic stroke cohort was found to have abnormal EEG. The high frequency of aberrant EEG results highlights the importance of EEG as a useful diagnostic tool when evaluating individuals who have had acute ischemic stroke.

INTRODUCTION

Stroke is prevalent disease globally, with the highest burden on low-income countries. In 2016, an estimated 13.7 million people had a stroke, with 87% of cases being ischemic [1]. Stroke often causes severe motor and sensory deficits. Prognosis depends on the brain area affected and the underlying cause [2]. Stroke causes sudden changes in the brain, decreasing cerebral blood flow and reducing oxygen and glucose supply, which results in cerebral infarction [3]. Clinical examination, along with neuroimaging, is essential for diagnosing ischemic stroke and assessing eligibility for reperfusion treatment. CT and MRI were commonly used to evaluate brain injury, but neither is ideal for tracking the progression of brain ischemia in the acute phase [4]. New approach, Electroencephalography (EEG), have recently emerged to address this limitation [5]. EEG offers rapid, non-invasive bedside monitoring, providing real-time brain activity assessment with high temporal resolution. It can detect sudden changes in brain metabolism and cerebral blood flow [6]. Acute ischemic stroke often disrupts neurovascular coupling, leading to changes in brain oscillatory activity that reflect neurophysiological responses to reduced blood flow, depicted by increased delta power and decreased alpha power [7]. Researchers have explored quantitative EEG (qEEG) as a potential biomarker for predicting outcomes in ischemic stroke [8]. Its capability to detect lesion size makes it valuable tool for diagnosis and clinical decision-making [9]. Recent developments in qEEG analysis, including the Brain Symmetry Index and portable systems with minimal electrode requirements, enhance its feasibility in pre-hospital and emergency settings [10, 11]. While studies

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highlight strong links between EEG biomarkers and stroke, further technological advancements and rigorously designed, adequately powered studies were crucial before qEEG can be recommended for routine acute stroke assessment [12]. Despite these advancements, there is limited data on the frequency of abnormal EEG patterns in ischemic stroke, particularly in this locality.

The objective of this study was to determine the frequency of abnormal EEG findings in ischemic stroke cases. By achieving this, the study aimed to contribute to improved stroke management, particularly in resource-limited settings, where timely intervention is critical for better patient outcomes.

METHODS

This cross sectional study was conducted at Department of Neurology, Punjab Institute of Neurosciences, Lahore, from 1st Jan 2019 to 30th June 2019, after approval of synopsis from CPSP (CPSP/REU/NEU-2017-069-441). 96 cases were estimated by 95% confidence level with 10% margin of error and using percentages of abnormal EEG in 53.7% cases [13]. Non-Probability Consecutive sampling technique was used. Patients with acute ischemic stroke (history of weakness of one or more part of body, and CT scan on which focal cerebral ischemic lasting more than 24 hours), aged 18-60 years of either gender were included. However, those with history of ischemic heart disease or atrial fibrillation (as determined on ECG findings), or those with previous ischemic or hemorrhagic CVA (on available record) were excluded. All cases were enrolled after taking informed written consent from patients/ attendants. Data were recorded by using proforma. Detailed demographic information like name, age, gender and contact details was taken. Risk factors including diabetes (HbA1c >6.5%), hypertension, and active smoking status was noted. Using CT scan, all cases were diagnosed as ischemic stroke cases as per operational definition. EEG was performed on all cases within 24 hours of admission to capture cerebral electrical activity across the scalp, reflecting the firing of neurons within the cerebral cortex. EEG recordings were obtained using a standardized 10-20 electrode placement system, ensuring consistent electrode positioning for optimal data reliability. The sampling rate was set at [specific sampling rate, e.g., 256 Hz], allowing high-resolution recordings of cortical activity. EEG recordings captured excitatory and inhibitory postsynaptic potentials in neuronal dendrites, particularly within the superficial regions of the cerebral cortex. Abnormal EEG findings were defined based on specific Cerebral Blood Flow (CBF) thresholds; (a) At a CBF of 25-35 ml/100g/min, the EEG may show a decrease in amplitude of faster frequencies. (b) As CBF decreases to 18-25 ml/100g/min, theta frequencies become apparent, and marked suppression of faster frequencies may appear with a further CBF drop to 12-18 ml/100g/min. (c) Suppression of all frequencies is seen when CBF drops below 8-10 ml/100g/min. All EEGs were interpreted by a single consultant with over five years of experience to minimize inter-observer variability and avoid potential bias. Data were analyzed using SPSS version 26.0. Mean ± SD was computed for quantitative data and frequency and percentage for qualitative data. Data were stratified for age, gender, BMI and duration of stroke to address the effect modifiers. Post-stratification, chi-square test was applied, p-value ≤0.05 was taken as significant.

RESULTS

In table 1, mean age of study population calculated was 52 ± 6.63 years, among them 32 (33.3%) patients belong to age group < 45 years and 64 (66.7%) belong to age ≥45 years. There were more male patient's 64% as compared to 36% females. According to BMI 46 (47.9%) patients had normal weight, 39 (40.6%) patients were overweight and 11 (11.5%) were obese. 59 (61.5%) patients presented within 1-2 days of clinical symptoms, while 37 (55%) patients presented after 2 days of symptoms. Risk factors were studied among study participants; DM was noted in 36%, HTN in 42%, and 29% patients were found to be active smokers.

Table 1: Socio-demographic Characteristics of Study Groups (n=96)

Age	N (%) / (Mean ± SD)
<45 Years	32 (33.3%)
≥45 Years	64 (66.7%)
Age (Years)	52.00 ± 6.63
Gender	
Male	61 (64%)
Female	35 (36%)
BMI	
Normal	46 (47.9%)
Overweight	39 (40.6%)
Obese	11 (11.5%)
Duration Of Stroke	
1-2 Days	59 (61.5%)
>2 Days	37 (55%)
Risk Factors	
DM	35 (36%)
HTN	40 (42%)
Active Smoking	2 (29%)

Table 2 showed that, out of 96 study participants presented with ischemic stroke 55 (57.3%) patients found to have abnormal EEG.

Table 2: Frequency of Abnormal EEG

Abnormal	EEG N (%)
Yes	55 (57.3%)
No	41 (42.7%)
Total	96 (100%)

Data stratification was done, as shown in table 3, found to be significant for gender and duration of stroke p- Value 0.01 and 0.000, respectively. However abnormal EEG was noted more among patients with age 45-60 years, male

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gender, among normal weight patients, and those who presented with 1-2 days of symptoms onset.

Table 3: Data Stratification with Respect to effect Modifiers

Variables	Abnormal EEG N (%)		Total N (%)	p-value
Age Groups	**Yes**	**No**		
<45 Years	20 (36.4%)	12 (29.3%)	32 (33.3%)	0.46
45-60 Years	35 (63.6%)	29 (70.7%)	64 (66.7%)	
Total	55 (100%)	41 (100%)	96 (100%)	
Gender	**Abnormal EEG N (%)**		**Total N (%)**	0.01
	Yes	**No**		
Male	29 (52.7%)	32 (78%)	61 (63.5%)	
Female	26 (47.3%)	9 (22%)	35 (36.5%)	
Total	55 (100%)	41 (100%)	96 (100%)	
BMI	**Abnormal EEG N (%)**		**Total N (%)**	0.28
	Yes	**No**		
Normal Weight	28 (50.9%)	18(43.9%)	46(47.9%)	
Overweight	19 (34.5%)	20 (48.8%)	39 (40.6%)	
Obese	81 (4.5%)	3 (7.3%)	11 (11.5%)	
Total	55 (100%)	41 (100%)	96 (100%)	
Duration	**Abnormal EEG N (%)**		**Total N (%)**	0.00
	Yes	**No**		
1-2 Days	53 (96.4%)	6 (14.6%)	59 (61.5%)	
>2 Days	2 (3.6%)	35 (85.4%)	37 (38.5%)	
Total	55 (100%)	41 (100%)	96 (100%)	

DISCUSSION

In the current study, the mean age of patients with ischemic stroke was calculated to be 52 ± 6.63 years, with a predominance of male patients. Most patients, based on BMI, were of normal weight (47.9%), followed by overweight (40.6%), and only 11.5% were classified as obese. Studies have documented age variations among stroke patients. Previous research shows that younger stroke patients typically have a mean age between 36.4 and 36.9 years, while older patients have a mean age between 60.9 and 70.3 years [14-16]. Unlike these studies, which focused on specific age groups, this study included a broader age range of 20-60 years. In line with these findings, one study reported also male predominance in ischemic stroke patients, reported 59.9% males and 40.1% females [17]. Additionally, a large cohort study on acute ischemic stroke found that only 12.6% of patients were obese, consistent with these results [18]. Another study further supports this, reporting a mean BMI within the normal range among stroke patients [19]. In this study, 57.3% of ischemic stroke patients showed abnormal EEG findings. Similarly, Ag Lamat MS *et al.*, in (2023) reported that 51.5% of acute ischemic stroke patients had abnormal EEGs, most often with localized slowing (28.2%), followed by generalized slowing (18.9%) and epileptiform changes (4.4%) [20]. Unlike their study, we did not further classify EEG abnormalities. A strong correlation was found between seizures and abnormal EEG results, with EEG abnormalities predicting post-stroke seizures [21]. EEG was useful in Acute Ischemic Stroke (AIS), but its sensitivity varies. Some patients may show normal EEG results despite significant ischemic changes, underscoring the need for a comprehensive diagnostic approach, as noted by Wijaya SK *et al.*, in 2015 [22]. In contrast, one study reported lower percentage of EEG abnormalities (37.9%), in ischemic stroke patients [23]. Recent research on focal cerebral ischemia outcomes has identified EEG suppression as part of malignant EEG patterns, marking it as a poor indicator for diffuse cerebral ischemia. This feature has also been shown to independently predict functional outcomes one year after stroke [24]. The potential for improving diagnosis, treatment, and patient outcomes in ischemic stroke patients presents serious global health challenges. Although conventional neuroimaging methods offer vital information, they might not be able to keep up with the quick development of acute cerebral ischemia. Results from abnormal EEGs can be useful biomarkers for early diagnosis and prognosis, allowing for prompt interventions and well-informed therapy choices. Knowing the patterns and frequency of these EEG alterations might help develop better management techniques, particularly in environments with limited resources, which will ultimately enhance patient outcomes and quality of life for stroke survivors. This study has certain limitation that needs to be addressed in future work. Firstly, this study was done on broader age range have not classified according to age related stroke patterns, neither we have studied brain volume effected, and we have not followed patients for short and long term outcomes. Furthermore, we not further classified EEG. In future more studies will be needed to cover these limitations.

CONCLUSIONS

According to current study findings, more than half of ischemic stroke cohort found to have abnormal EEG. The high frequency of aberrant EEG results highlights the importance of EEG as useful diagnostic tool when evaluating individuals who have had acute ischemic stroke.

Authors Contribution

Conceptualization: AY
Methodology: MM, MTR, MI, RI
Formal analysis: MM
Writing, review and editing: AY, QY, MTR, MI, RI

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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