

Retrospective Analysis of EEG Patterns in the Patients Referred for EEG at a Tertiary Care Hospital in Western Nepal

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ABSTRACT

Introduction: Electroencephalography is a non-invasive neurophysiological test that records electrical activity in the brain. It can help in the diagnosis and monitoring of various clinical conditions, like seizures and sleep disorders. Extensive research on electroencephalographic patterns is scarce, especially in Western Nepal. The study will also help to avoid the consequences of misinterpreting different waveforms. **Aims:** To analyze various normal and abnormal electroencephalographic wave patterns. **Methods:** This was an observational retrospective study analyzing electroencephalographic reports of the patients referred for electroencephalography in the Department of Psychiatry, Nepalgunj Medical College Teaching Hospital, Kohalpur, from January 2023 to December 2024. Total 290 patients who underwent a 20-minute electroencephalography, meeting the study criteria were selected. Descriptive statistics were used to analyze demographic data and electroencephalographic findings. **Results:** Out of 290 patients, 57.9% were male. The most common condition referred for electroencephalographic evaluation was seizure disorder (51%), followed by psychogenic non-epileptic seizure (24.1%). Patients with normal electroencephalographic waveforms were 79%, whereas 21% had abnormal electroencephalographic waveforms. Among normal variant waveforms, wicket waves were seen more frequently (7.42%), particularly in children and adolescents. Polyspike waves were the most frequently observed (47.54%) among the abnormal waveforms. **Conclusion:** The EEG waveforms were normal in most cases, while a few had abnormal EEG findings. The normal variants must not be misinterpreted as epileptiform discharges to avoid the consequences of misdiagnosis.

Keywords: Electroencephalography, Nepal, Normal Variant Waveforms, Polyspike, Wicket waveforms

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INTRODUCTION

Electroencephalography (EEG) began as a diagnostic tool when a German psychiatrist, Hans Berger, introduced it in 1924. An EEG is a non-invasive electrophysiological method that measures brain electrical signals to detect various neurological disorders. However, in more than half of the patients with a provisional diagnosis of epilepsy, the initial EEG does not show epileptiform activity, and the paroxysmal events are due to its low sensitivity.¹ Its sensitivity depends on various factors like age, recording procedures, and activation procedures such as hyperventilation and photic stimulation.² An abnormal EEG finding in a person without a history of seizure and, conversely, a normal EEG finding in seizure patients are possible.³ Normal variant waveforms are mostly unrecognized and are misdiagnosed as epileptiform discharges in one-third of the patients.⁴ A single normal EEG recording does not exclude the presence

of pathology because electrographic changes are often transient.⁵ It can help in the diagnosis and monitoring of various neurological conditions, including epilepsy and sleep disorders. Moreover, there is a paucity of research analyzing EEG findings in tertiary care settings in Nepal, particularly in the western region.³ Studies of EEG abnormalities can lead to improved neurological diagnosis and management strategies. This study will address the knowledge gap regarding EEG patterns and also help to avoid the consequences of misinterpretation of different EEG waveforms. This study aims to analyse various normal and abnormal EEG wave patterns in patients referred from various departments within the tertiary care hospital.

METHODS

This was an observational retrospective study among the referred patients from various departments who underwent

EEG from January 2023 to December 2024 in Nepalgunj Medical College Teaching Hospital, Kohalpur. The calculated sample size was 290, considering the prevalence of EEG abnormalities in a tertiary care hospital at 18.69%⁶ using a 4.5% margin of error⁷ and 95% confidence interval. Ethical approval was obtained from the Institutional Review Committee (Ref. 60/081-082), Nepalgunj Medical College Teaching Hospital, Kohalpur, and permission to use medical records from the respective hospital departments. However, patient confidentiality was strictly maintained by anonymizing data before analysis. After obtaining ethical approval, the study was started. A convenience sampling technique was used. Data were retrieved from the hospital database. Demographic details, clinical diagnoses, and EEG-related details were collected from medical records. All patients referred from various departments for EEG were included in the study. Patients with incomplete, inadequate data and patients with artifacts affecting EEG interpretation were excluded. Descriptive statistics were used to summarize demographic data and EEG findings. Data were analyzed using SPSS version 25.0.

RESULTS

A total of 290 patients were included in the study (Table I). The majority of patients (53.8%) were in the age group of 1–18 years, followed by 33.1% who were 18 years or older, and 13.1% who were under one year of age. Males accounted for 57.9% of the sample, while females represented 42.1%. In terms of residence, 60.7% of the patients were from urban areas, whereas 39.3% were from rural areas. The most common religion among the patients was Hinduism (77.6%), followed by Christianity (11%), Buddhism (10.7%) and Islam (0.7%). Regarding the referring departments, half of the patients (50%) were referred from the Pediatrics department, 37.2% from Neurosurgery, 6.9% from Medicine and 5.9% from Psychiatry. Clinically, seizure was the most common diagnosis (51%), followed by psychogenic non-epileptic seizure (24.1%), febrile seizure (19.3%), primary headache (3.1%), and traumatic brain injury (2.4%). Based on waveform analysis, 79% of patients exhibited normal waveforms, whereas 21% showed abnormal waveforms.

Variable	Categories	Frequency (Percentage)
Age	<1 year	38 (13.10)
	1-18	156 (53.80)
	≥18	96 (33.10)
Sex	Male	168 (57.90)
	Female	122 (42.10)

Residence	Rural	114 (39.30)
	Urban	176 (60.70)
Religion	Hindu	225 (77.60)
	Buddhist	31 (10.70)
	Islam	2 (0.70)

Table I: Demographic and clinical profiles of the patients

Normal variant Waveform	Age Groups			Total (%)
	<1	1-18	>18	
Positive occipital sharp transients	1	4	1	6 (2.62)
6 Hz spike and wave	0	2	0	2 (0.87)
14 and 6 Hz spikes	0	4	0	4 (1.75)
Vertex sharp Transients	2	0	0	2 (0.87)
Benign Epileptiform Transients of Sleep	2	10	1	13 (5.69)
Wicket waves	2	13	2	17 (7.42)
Rhythmic mid-temporal theta of drowsiness	0	2	0	2 (0.87)
Subclinical rhythmic electroencephalographic discharges of acute	0	0	2	2 (0.87)
None	16	91	74	181 (79.04)

Table II: Normal Variant Waveform in relation to age

A total of 229 EEG recordings were analysed across various age groups to identify the distribution of normal EEG waveforms (Table II). The majority of patients (79.04%) exhibited no normal variant waveforms. Among the normal variants, wicket waves were the most common, observed in 17 patients (7.42%), with the highest occurrence particularly in children and adolescents (1–18 age group). Benign Epileptiform Transients of Sleep (BETS) were found in 13 patients (5.69%), predominantly in the 1–18 age group, followed by the <1 year and >18 age groups. Positive Occipital Sharp Transients (POSTs) were observed in 6 patients (2.62%) across all age groups. Whereas 14 and 6 Hz spikes were seen in 4 patients (1.75%), exclusively in the 1–18 age group. Vertex sharp transients were present in 2 patients (0.87%), all under the age of one. Other waveforms observed included 6 Hz spike and wave, Rhythmic Mid-Temporal Theta

of Drowsiness (RMTD), and Subclinical Rhythmic Electroencephalographic Discharges of Adults (SREDA), each identified in 2 patients (0.87%). Overall, normal variant waveforms were more frequently seen in the 1–18 age group compared to the other age categories.

Abnormal EEG waveform	Total (Percentage)
3 Hz and spike wave	5 (8.19)
Poly spike-waves	29 (47.54)
Generalized spike and waves	1 (1.64)
Lateralized periodic discharges	4 (6.56)
Centro-temporal spikes	1 (1.64)
Generalized periodic discharges	3 (4.91)
Continuous spike-wave during sleep	2 (3.28)
Slow spike-waves	13 (21.32)
Slowing temporal intermittent rhythm	1 (1.64)
Hypsarrhythmia	2 (3.28)

Table III: Distribution of abnormal EEG waveforms

A total of 61 (21%) EEG records with abnormal waveforms were analysed (Table III). Among the patients with abnormal EEG findings, the most frequently observed waveform was poly spike-waves, present in 29 patients (47.54%). This was followed by slow spike-waves in 13 patients (21.32%). Other notable abnormal patterns included 3 Hz spike and wave discharges in 5 patients (8.19%) and Lateralized Periodic Discharges (LPDs) in 4 patients (6.56%). Generalized Periodic Discharges (GPDs) were observed in 3 patients (4.91%), while continuous spike-wave during sleep and hypsarrhythmia were each seen in 2 patients (3.28%). Less commonly detected patterns included generalized spike and wave, centro-temporal spikes, and slowing temporal intermittent rhythm, each found in 1 patient (1.64%). These findings suggest a predominance of epileptiform discharges, particularly poly spike waves, among the patients with abnormal EEG waveforms.

DISCUSSION

This study aimed to analyse the distribution of normal and abnormal EEG waveform patterns among patients undergoing EEG evaluation at a tertiary care hospital in Western Nepal. Our findings revealed that 79% of the EEGs were normal, while 21% showed abnormalities among 290 patients. This result

is consistent with the findings of Ko et al⁸, who reported abnormal EEGs in 21.3% of their study population. In contrast, a study conducted in South India by Priyavathani et al⁹ reported a higher prevalence of abnormal EEGs at 33.9%. This variability may be attributed to differences in clinical settings, diagnostic protocols, and patient demographics. Among the normal variant waveforms, wicket waves were the most commonly observed (7.42%), followed by Benign Epileptiform Transients of Sleep (BETS) (5.69%), Positive Occipital Sharp Transients (POSTs) (2.62%) and 14 and 6 Hz spikes (1.75%). Other normal variants observed at lower frequencies (0.87% each) included 6 Hz spike-and-wave discharges, vertex sharp transients, rhythmic mid-temporal theta of drowsiness (RMTD) and sub-clinical rhythmic electroencephalographic discharges of adults (SREDA). Our findings show some similarity to those reported by Radhakrishnan et al¹⁰ who found Benign Epileptiform Transients of Sleep (BETS) in 8.2% of subjects, wicket waves in 1%, 14 and 6 Hz positive spikes in 5.7%, 6 Hz spike-waves in 2.8%, and RMTDs in 0.8%. In a much larger study by Santosh kumar et al¹¹ involving 35,249 subjects, Benign Epileptiform Transients of Sleep (BETS) were reported in 1.85%, wicket waves in only 0.03%, 14 and 6 Hz positive spikes in 0.52%, 6 Hz spike-and-wave discharges in 1.02%, RMTDs in 0.12% and SREDA in 0.07%. Our observation that SREDA was rare aligns with the findings of Azman et al¹² and Van Cott AC¹³ who reported a prevalence of only 0.06% and 0.05%, respectively. Similarly, our data on RMTDs fall within the range of 0.1% to 2.1% reported in young adults by Macorig et al.¹⁴

In our study, the analysis of abnormal EEG patterns revealed that polyspikes were the most frequently observed abnormality, present in 47.54% of cases. Polyspike discharges are typically associated with generalized epilepsy syndromes, particularly juvenile myoclonic epilepsy¹⁵ and other idiopathic generalized epilepsies. Their high frequency in this study may reflect the underlying diagnostic profile of the referred population. Following polyspikes, slow spike-and-wave discharges were the second most common abnormality, seen in 21.32% of cases. This pattern is often linked to symptomatic or cryptogenic generalized epilepsies, such as Lennox-Gastaut syndrome, and indicates more severe epileptic encephalopathies. The presence of 3 Hz spike-and-wave discharges in 8.19% of patients further supports the predominance of generalized epilepsy forms in our cohort, as this pattern is characteristic of typical absence seizures. Less frequently observed patterns included lateralized periodic discharges (LPDs) (6.56%) and generalized periodic discharges (GPDs) (4.91%), both of which are often associated with acute structural or metabolic brain insults, such as encephalitis, stroke, or hypoxic injury. The detection of continuous spike-wave during sleep (CSWS) and hypsarrhythmia in 3.28% of cases each highlights the presence of severe childhood-onset epileptic syndromes, such as electrical status epilepticus during slow-wave sleep (ESES) and West syndrome respectively.

Finally, generalized spike-and-wave discharges and temporal intermittent rhythmic slowing were each observed in 1.64% of abnormal EEGs. While generalized spike-and-wave activity further supports the diagnosis of idiopathic generalized epilepsy,

temporal intermittent slowing is a nonspecific finding that may indicate focal cerebral dysfunction, particularly in the temporal lobe.¹⁶

LIMITATIONS

The study was conducted in a single tertiary care hospital, which may not reflect the EEG pattern in other regions of Nepal. A relatively small sample size in our study may limit its generalizability. The retrospective nature of this study may limit the reliability of our findings due to inconsistency or missing data. Moreover, inter-observer variability in EEG interpretation might have introduced subjective bias.

CONCLUSION

The EEG waveforms were normal in most cases, while a few had abnormal EEG findings. Normal variant EEG waveforms were seen in many cases, particularly in children and adolescents. The normal variants must not be misinterpreted as epileptiform discharges to avoid the consequences of misdiagnosis. Our findings emphasize the need for continued EEG evaluation to support diagnosis and management. Twenty-four-hour EEG recording or Video-EEG monitoring (VEEG) may be more useful than routine EEG recording.

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