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Original Research Article

Diagnostic utility of electroencephalography and magnetic resonance imaging in children with a first unprovoked seizure: a prospective observational study

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ABSTRACT

Background: Electroencephalography (EEG) is recommended as part of the neurodiagnostic evaluation of children presenting with a first unprovoked seizure. However, the role of neuroimaging, particularly magnetic resonance imaging (MRI), remains less clearly defined. This study aimed to evaluate the diagnostic utility of EEG and MRI in children presenting with a first episode of unprovoked seizure.
Methods: This prospective observational study was conducted at Mysore Medical College, Mysuru. Children presenting with a first unprovoked seizure were enrolled after obtaining parental consent. Detailed clinical and developmental histories were taken and general and neurological examinations were done. A complete blood count, blood glucose, serum sodium, potassium, and calcium were done to rule out metabolic causes. Seizures were classified according to the International League Against Epilepsy classification. EEG was done within 48 hours of the seizure using the 18-channel EEG machine and interpreted by a pediatric neurologist. Cranial MRI was performed on a 1.5-Tesla scanner. EEG and MRI findings were classified as normal or abnormal.
Results: EEG abnormalities were present in 62.5% of children and MRI abnormalities in 25%. MRI abnormalities were identified in some children with normal EEG findings, including developmental abnormalities and ring-enhancing lesions.
Conclusions: EEG demonstrated a substantial diagnostic yield and should be considered an important investigation in children presenting with a first unprovoked seizure. MRI abnormalities were less common but can provide further diagnostic information for some children with normal EEG findings and may aid in detection of structural and developmental problems.

Keywords: First unprovoked seizure, EEG, MRI, Epilepsy, Neuroimaging

INTRODUCTION

Seizures are among the common neurological presentations in childhood, and a first unprovoked seizure may represent the initial manifestation of epilepsy or an underlying structural or neurological disorder. Approximately 10% of individuals experience at least one seizure during their lifetime, and seizures account for a significant proportion of emergency department visits, particularly among infants and young children.[1-3] A first unprovoked seizure therefore warrants careful clinical assessment to establish the diagnosis, identify an underlying cause, and estimate the risk of subsequent seizures.

Electroencephalography (EEG) is an important component of the diagnostic evaluation following a first unprovoked seizure. It provides information regarding epileptiform

activity and may assist in seizure classification and assessment of the risk of recurrence.[4,5]

Abnormal epileptiform activity on EEG can provide supportive evidence for an underlying epilepsy syndrome even when the neurological examination and structural neuroimaging are normal. Thus, EEG has an established role in the evaluation of children presenting with a first unprovoked seizure.[4,5]

Neuroimaging is primarily performed to identify structural abnormalities that may be responsible for seizures. Magnetic resonance imaging (MRI), because of its superior soft-tissue resolution and absence of ionizing radiation, is particularly useful for detecting cortical malformations, focal structural lesions, and other abnormalities that may not be evident clinically. However, the yield and appropriate indications for routine neuroimaging after a first unprovoked seizure in children remain less clearly defined. Previous studies have reported variable rates of abnormalities on neuroimaging, and the decision to perform MRI may depend on factors such as seizure characteristics, neurological examination, and clinical suspicion of an underlying structural lesion.[5]

Although EEG and MRI provide complementary information regarding the functional and structural aspects of seizure disorders, limited data are available describing their findings together in children presenting with a first episode of unprovoked seizure. The identification of abnormalities on either investigation may have implications for diagnosis, prognostication, and subsequent management. Therefore, evaluating both modalities may provide a more comprehensive assessment of children following their first unprovoked seizure.

The present study was undertaken to determine the frequency of EEG and MRI abnormalities in children presenting with a first episode of unprovoked seizure and to assess the correlation between EEG and MRI findings. The study was conducted prospectively at a tertiary care hospital in Mysuru. The rationale and objectives are consistent with the original study protocol, which identified the limited evidence regarding routine neuroimaging and aimed to evaluate the relationship between EEG and neuroimaging findings. The results of this study will contribute to better understanding for the effective use of these diagnostic tools in clinical practice. The objective of this study is to find out the trends of EEG and MRI findings for better management and treatment of children with unprovoked seizures.

METHODS

Study design and setting

This was a hospital-based prospective observational study conducted in the Department of Pediatrics, Mysore Medical College and Research Institute, over a period of 18 months from March 2023 to September 2024. The study was undertaken to evaluate EEG and MRI findings in children presenting with a first episode of unprovoked seizure.[5]

Study population

Children aged 2 months to 18 years who were admitted to Mysore Medical College with a first episode of an unprovoked afebrile seizure were eligible for inclusion. A total sample size of 40 children was included in the study. The sample size was calculated using the formula given, with an expected prevalence of 2.5%, a 95% confidence level, and a 5% margin of error. Simple random sampling was used.

$$S = Z^2PQ/D^2$$

Inclusion criteria

Children aged 2 months to 18 years who presented with a first episode of an unprovoked, afebrile seizure and were admitted to Mysore Medical College during the study period were included.

Exclusion criteria

Children were excluded if the seizure was associated with an acute situational cause such as infection, toxin exposure, or trauma. Children with chronic neurological disorders affecting activities of daily living, developmental disorders, abnormal neurological examination, or simple febrile seizures were also excluded.

Clinical evaluation

Written informed consent was obtained from the parents or guardians. The demographic and clinical details like age, sex, type and duration of seizures, family history of seizures, antenatal history and developmental history were recorded on a proforma. A complete clinical and developmental history was obtained and a general and neurological examination was done. Seizure types were classified as per international league against epilepsy (ILAE) classification.[5,6]

Laboratory investigations

Routine laboratory investigations were performed at admission to exclude metabolic causes and assist in clinical evaluation. These included complete blood count, blood glucose, serum sodium, potassium, calcium, C-reactive protein, liver function tests, renal function tests, and serum electrolytes.

Electroencephalography

EEG was performed in all participants within 48 hours of the first unprovoked seizure using an 18-channel EEG machine (model EE18, recorder and Medicare system). A

total of 22 electrodes were placed using the pediatric montage. EEG recordings were interpreted by a pediatric neurologist. EEG findings were subsequently categorized as normal or abnormal.[4,5]

Magnetic resonance imaging

Cranial MRI was performed in all study participants using a 1.5-Tesla MRI system. MRI reports were categorized as normal or abnormal. Abnormal MRI findings were further classified into cortical lesions, white-matter lesions, cortical atrophy, hyperintense lesions, and miscellaneous abnormalities.[5]

Outcome measures

The primary outcomes were the proportion of children with abnormal EEG and abnormal MRI following a first episode of unprovoked seizure. The relationship between EEG and MRI findings was also evaluated by categorizing participants according to the presence or absence of abnormalities on each investigation.

Statistical analysis

Data were recorded and analyzed using Microsoft excel and statistical package for the social sciences (SPSS) version 27.0. Categorical variables were expressed as percentages and frequencies and continuous variables were expressed as mean and standard deviation. Results data from the studies were used to assess the association between EEG and MRI abnormalities.

Ethical considerations

Institutional ethical approval was obtained for the study, and informed consent was obtained from the parents or guardians of participating children before enrollment.

RESULTS

A total of 40 children presenting with a first episode of unprovoked seizure were enrolled in the study. The data indicates that seizures were most commonly observed in children between 11 to 15 years (35%), followed closely by those in the 6 to 10 years category (32.5%). The lowest incidence was noted in the 16 to 18 years group (12.5%), while younger children aged 6 months to 5 years constituted 20% of the total cases. According to the data, there was male predominant i.e., 25 (62.5%) of the cases were males, while 15 (37.5%) were females. The data on seizure type distribution among patients experiencing a first episode of unprovoked seizures indicates a higher prevalence of generalized tonic-clonic seizures (GTCS) compared to focal seizures. Specifically, 31 (77.5%) of children experienced GTCS, while 9 (22.5%) had focal seizures. The data on family history of seizures shows that 5 (12.5%) of patients had a positive family history of seizures, while 35 (87.5%) had no known family history of seizures (Table 1).

Table 1: Baseline demographic and clinical characteristics of study participants.

Characteristics	Frequency (%)
Age group (years)	
6 months - 5 years	8 (20.0)
6-10	13 (32.5)
11–15	14 (35.0)
16–18	5 (12.5)
Gender	
Male	25 (62.5)
Female	15 (37.5)
Seizure type	
Generalized tonic-clonic seizure	31 (77.5)
Focal seizure	9 (22.5)
Family history of seizure	
No	35 (87.5)
Yes	5 (12.5)

EEG findings

The data on EEG abnormalities suggested that 25 (62.5%) children had abnormal EEG findings, whereas 15 (37.5%) had a normal EEG. Among EEG abnormalities, generalized discharges where the predominant finding as were seen in 6 (15%) children, followed by fronto-temporal discharges in 5 (12.5%) and temporal discharges in 4 (10%). Centro-parieto-temporal discharges were seen in 3 (7.5%), while frontal, fronto-central and parieto-temporal abnormalities were each observed in 2 (5.0%) children. A centro-parietal abnormality was observed in 1 (2.5%) child (Table 2).

MRI findings

MRI was normal in 30 (75%) children and showed abnormal findings in 10 (25%) of children. Among abnormalities, post-hypoxic ischaemic encephalopathy (HIE) change was the most frequent, occurring in 3 (7.5%) children. Cystic lesion with surrounding oedema, developmental venous anomaly, focal cortical atrophy, neurocysticercosis, ring-enhancing lesion suggestive of tuberculoma, T2 hyperintensity in the thalamus, and T2 hyperintensity involving the thalamus and lentiform nucleus were each identified in 1 (2.5%) child (Table 3).

Correlation between EEG and MRI

Both EEG and MRI were abnormal in 7 (17.5%) children. EEG was abnormal despite a normal MRI in 18 (45%). MRI was abnormal despite a normal EEG in 3 (7.5%). Both MRI and EEG were normal in 12 (30%) children (Table 4).

Thus, EEG abnormalities were more frequently observed than MRI abnormalities in this cohort, and abnormalities on the two investigations did not consistently overlap. The findings indicate that EEG and MRI provided

complementary information in the evaluation of children with a first episode of unprovoked seizure.

Table 2: Distribution of EEG findings among children with first unprovoked seizure.

EEG finding	Frequency (%)
Normal EEG	15 (37.5)
Generalized discharges	6 (15)
Fronto temporal	5 (12.5)
Temporal discharges	4 (10)
Centro-parieto temporal	3 (7.5)
Frontal discharges	2 (5)
Fronto central	2 (5)
Parieto temporal	2 (5)
Centro parietal	1 (2.5)
Total	40 (100)

Table 3: Distribution of MRI findings among children with first unprovoked seizure.

MRI findings	Frequency (%)
Normal MRI	30 (75)
Post hypoxic-ischemic encephalopathy (HIE)	3 (7.5)
Cystic lesion with surrounding edema	1 (2.5)
Developemental venous anomaly	1 (2.5)
Focal cortical atrophy	1 (2.5)
Neurocysticercosis (NCC)	1 (2.5)
Ring enhancing lesion (tuberculoma)	1 (2.5)
T2 hyperintensity in thalamus	1 (2.5)
T2 hyperintensity in thalamus and lentiform nucleus	1 (2.5)
Total	40 (100)

Table 4: Correlation between EEG and MRI findings.

EEG finding	MRI finding	N (%)
Abnormal EEG	Abnormal MRI	7 (17.5)
Abnormal EEG	Normal MRI	18 (45.0)
Normal EEG	Abnormal MRI	3 (7.5)
Normal EEG	Normal MRI	12 (30.0)
Total		40 (100)

DISCUSSION

The present prospective study evaluated the diagnostic utility of EEG and MRI in children presenting with a first episode of unprovoked seizure. Among the 40 children studied, EEG abnormalities were observed in 62.5% of cases, while MRI abnormalities were detected in 25%. 17.5% of children showed abnormal EEG and MRI while 45% showed abnormal EEG with normal MRI. In contrast, 7.5% of children had abnormal MRI but normal EEG. EEG and MRI provide complementary rather than interchangeable information in the assessment of first unprovoked seizures, these findings suggest.

The age of most children in the current study was 6-15 years. The study population was 62.5% male. The most common type of seizures was generalized tonic clonic seizures (GTCS) (77.5%). Similar findings have been reported in previous pediatric studies in which generalized seizures were more common than focal seizures in children presenting with first afebrile seizures. Generalized seizures were the most frequent presentation as reported by Hauser et al, Ottman et al, and Shinnar et al.[2,7,8] The predominance of generalized seizures in our study may be due to referral patterns and the fact that generalized seizures are more likely to lead to hospital admissions.

EEG abnormalities

In the present study EEG abnormalities were seen in 62.5% of children, with the most common being generalized epileptiform discharges, followed by fronto-temporal and temporal discharges. This observation highlights the important role of EEG in detecting functional cerebral abnormalities after a first unprovoked seizure.

The proportion of abnormal EEG findings in our study is higher than the 42% reported by Shinnar et al in a study of children with a first unprovoked seizure.[8] However, it is comparable to the findings of Özdemir et al, who reported abnormal early EEG findings in 63% of children presenting with a first unprovoked seizure.[9] Variations in EEG abnormality rates across studies may be attributed to differences in age distribution, seizure type, timing of EEG recording, duration of monitoring, and inclusion criteria. Early EEG recording, especially within 24-48 hours of seizure onset, has been shown to increase the diagnostic yield by enhancing the detection of epileptiform abnormalities.[9]

An abnormal EEG following a first seizure has important prognostic implications. Shinnar et al demonstrated that children with abnormal EEG findings had a significantly higher risk of seizure recurrence compared with those with normal EEGs.[8] Similarly, long-term follow-up studies have identified EEG abnormalities as an independent predictor of recurrence and progression to epilepsy.[10] Thus, EEG serves not only as a diagnostic tool but also as an important aid in counselling families regarding prognosis and planning follow-up.

MRI findings

MRI abnormalities were observed in 25% of children in the present study. Post-HIE changes constituted the most common abnormality, followed by focal cortical atrophy, developmental venous anomaly, neurocysticercosis, tuberculoma and other focal lesions. These findings underscore the role of MRI in identifying structural

abnormalities that may not be apparent clinically or on EEG.

The prevalence of MRI abnormalities in our study is similar to that reported by Shinnar et al, who identified neuroimaging abnormalities in 21% of children with a first unprovoked seizure.[11] Likewise, Rasool et al reported abnormal neuroimaging in approximately one-fifth of children with new-onset seizures.[12] A multicentric study from Tehran demonstrated MRI abnormalities in 27.1% of children with first unprovoked seizures, which is similar to the findings of the present study.[13]

The detection of neurocysticercosis and tuberculoma in individual patients in our study is particularly relevant in developing countries, where infectious granulomatous lesions remain important causes of childhood seizures. Bagla et al, in a randomized study comparing EEG and MRI as initial investigations in neurologically normal children with first afebrile seizures, reported inflammatory granulomas as the most common MRI abnormalities and concluded that MRI had a high diagnostic yield in establishing etiology.[14] These findings suggest that MRI is especially valuable in regions where infectious and structural causes of seizures are prevalent.

Correlation between EEG and MRI findings

An important observation in the present study was the limited concordance between EEG and MRI findings Only 17.5% of children had abnormalities in both investigations. A significant proportion (45%) had abnormal EEG findings with normal MRI. Abnormal EEG findings were present in a large part (45%) with normal MRI.

This pattern of findings suggests that EEG and MRI explore different aspects of seizure disorders. EEG demonstrates functional neuronal abnormalities and epileptiform activity, whereas MRI identifies structural lesions that may contribute to seizure generation.

Similar observations have been reported by Rasool et al, who found that although abnormal EEG findings increased the likelihood of detecting MRI abnormalities, a normal EEG did not exclude structural brain lesions.[12]

Complementary roles of EEG and MRI have important clinical implications. EEG may be especially helpful for classifying seizures, identifying epilepsy syndromes and predicting the risk of recurrence, whereas MRI is indispensable for the detection of potentially treatable structural lesions.

Therefore, neither investigation should be considered a substitute for the other. Current guidelines recommend that neuroimaging should be considered in children with focal seizures, abnormal neurological examination, developmental delay or other features suggestive of structural pathology.[14]

The strengths of the present study include its prospective design and the systematic evaluation of all participants using both EEG and MRI. However, several limitations should be acknowledged. The study was conducted at a single tertiary care centre and included a relatively small sample size, limiting the generalizability of the findings. Long-term follow-up was not performed; therefore, the prognostic significance of EEG and MRI abnormalities with respect to seizure recurrence could not be assessed. Additionally, the low frequency of individual MRI abnormalities precluded subgroup analysis.

CONCLUSION

The present study demonstrates that EEG abnormalities are more frequent than MRI abnormalities in children presenting with a first unprovoked seizure. However, MRI identifies structural lesions in a significant proportion of children, including some with normal EEG findings. The limited overlap between EEG and MRI abnormalities supports the concept that these investigations provide complementary diagnostic information. An integrated approach combining clinical assessment, EEG and selective MRI may optimize the evaluation and management of children with first unprovoked seizures.

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