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Original Research Article

Clinical Spectrum, EEG and Neuroimaging Abnormalities in Infants and Children with Seizure Disorders: A Cross-Sectional Study

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Abstract

Background: Seizures are the most common neurological disorder with 4-10% of children suffering at least one seizure in the first 16 years of life. No recent study from Eastern part of India has described the epidemiology of seizure disorder in children.

Materials and Methods: This prospective study included children of 1 to 14 yrs with seizure disorder on AEDs over two-year period. Clinical and investigation details (EEG, imaging, and laboratory results) were recorded in pre-designed proforma. Data were analyzed with appropriate statistics

Results: A total of 210 children were included. The most common age group was 5-10 years (40%) followed by 1-5 years age group (30.5%). The least common age group was infants (<1 year, 8.6%). Males were more commonly affected (53%) as compared to females (47%) with a male to female ratio of 1:1.2. Majority were generalised seizures. The most common underlying etiology was infective followed by epilepsy. EEG was abnormal in 73%, MRI abnormal in 70%, and CT brain abnormal in 45%. There was no significant association between the gender and the type of seizure or between the type of EEG abnormality and the type of seizure seen. There was a statistically significant relationship between the type of seizure and the MRI scan abnormality (p-value = 0.04).

Conclusion: This study described the clinical, laboratory and imaging finding in children with seizure disorder from Eastern India. Future studies should follow up children with seizure disorder to see the change in profile, imaging abnormalities, and outcomes.

Keywords: Epilepsy, observational study, neuroimaging, prevalence, developing country.

Introduction

Seizures are the most common neurological disorder with 4-10% of children suffering at least one seizure in the first 16 years of life [1]. Seizure disorder is a broad term given to seizures of diverse etiologies until a definitive cause is established [2]. Epilepsy means presence of underlying risk factors or EEG abnormalities predicting future recurrence of seizures. The incidence of epilepsy in children ranges from 41-187/100,000 (ranging from 3.2-5.5/1,000 in developed countries and 3.6-44/1,000 in underdeveloped countries). The incidence is highest in children younger than 3 years of age with decreasing frequency in older children [3]. Less than one-third of seizures in children are caused by epilepsy.

Childhood seizures have been classified recently based on the onset – focal onset, generalised onset, unknown onset, and unclassified [2]. Excluding febrile seizure; birth asphyxia, anoxic episodes, head trauma or neoplasms are the common causes of seizures identified in developed country, but in developing countries, infections (acute or chronic or recurrent) are the major causes [4,5]. The etiologies mentioned here can present with either generalised or partial seizure. There are some other etiologies that need special mention here if we broaden the conditions under partial seizure (localization related epilepsy or LRE) in developing country and they include - idiopathic (3%), symptomatic (48%), and cryptogenic (49%). Single CT enhancing lesion (SCTEL; solitary cysticercal granuloma), single small cerebral calcific CT lesion (SSCCCTL), and multiple small cerebral calcific CT lesions together accounted for 51% of symptomatic LRE [6].

The evaluation of seizure disorders is based on a detailed history and clinical examination directing the appropriate investigations. These include screening for an underlying infection, metabolic screening of blood and urine, examinations of the CSF, radiology (ultrasonography, CT or MRI), EEG, and genetic studies. There is no recent data showing the clinical profile of seizure disorders in children from the Eastern part of India. That's why the present study was designed to study the etiology, profile, EEG and imaging abnormalities of seizure disorders in children presenting to our centre.

Materials and Methods

This cross-sectional study was conducted in a tertiary care teaching hospital from Eastern part of India. Children of 1 to 14 yrs with seizure disorders attending the outpatient and inpatient were included over two-year period from December 2020 to 2022. Exclusion criteria were: neonatal seizures, typical febrile seizures, post-traumatic seizures, and pseudo-seizures. The study was approved by Hospital ethics committee. After getting informed consent, patients were subjected to detailed history and clinical examination. A pre-designed proforma was used to collect data regarding age, sex, socio-demographic profile, presenting complaints, seizure semiology, developmental milestones, and relevant peri-natal, past & family history. Clinical examinations including general physical examination, systemic examinations were done. In case of inpatients, hospitalization details including indication, duration of stay, development of any complications, treatment given and final outcome were recorded in the proforma. Relevant investigations included complete blood count, liver and renal function tests, urine examination, work up for underlying infection, metabolic profile (glucose, electrolytes), CSF study, autoimmune encephalitis panel, TORCH profile, EEG, CT scan or MRI brain.

Statistical Analysis

Patients were recruited during the study period by convenient sampling method. Data were collected on a pre-designed proforma and entered into worksheets of Microsoft office Excel (version 2013). Data were analyzed using simple descriptive statistics. Categorical variables are expressed as number (percentage) of patients, and compared across the groups using Pearson's Chi-square test or Fisher's test as appropriate. The statistical software SPSS (version 22, IBM Corporation) was used for the analysis. A p-value of <0.05 was considered as significant.

Results

A total of 210 cases were included. The most common age group was 5-10 years (40%) followed by 1-5 years age group (30.5%). The least common age group was infants (<1 year, 8.6%). Males were more commonly affected (53%) as compared to females (47%) with a male to female ratio of 1:1.2.

The distribution of different types of seizures is provided in **Table 1**.

Table 1: Distribution of seizure frequency among various seizure subtypes

Seizure type	Frequency (%)
Generalised seizure	
• Tonic-clonic	94 (44.7)
• Atonic	14 (6.7)
• Tonic	11 (5.2)
• Myoclonic	7 (3.3)
• Infantile spasm	2 (1)
Partial (focal) seizure	
• Simple	55 (26.1)
• Complex	22 (10.5)
Complex febrile seizures	19 (9)
Undiagnosed	6 (2.8)

The prevalence of generalized across all age groups were as follows: <1 yr (66.7%), 1-5 yr (57.8%), 5-10 yr (64.3%), and >10 yr (56.8%). The prevalence of GTCS across all age groups were as follows: <1 yr (38.9%), 1-5 yr (67.2%), 5-10 yr (57.1%), and >10 yr (47.7%). The prevalence of complex partial seizures (CPS) across all age groups were as follows: <1 yr (11.1 %), 1-5 yr (18.8%), 5-10 yr (13.5%), and >10 yr (22.7%). There was no significant correlation between the type or subtype of seizure and the age group (p-value =0.61). There was also no significant association between the gender and the type of seizure they presented with.

Fever can be a sign of infection or it can be the reason for lowering of seizure threshold in children. About 48% had fever prior to seizure. Among patients who had fever and threw seizures most were generalised (47%) followed by partial seizures (31%). The most common underlying etiology was infective (29.5%) followed by epilepsy group (25.7%) and cerebral palsy (13.8%). Less common

causes were complex febrile seizures (9%) and intracranial space occupying lesion (ICSOL) (8.6%). Rare causes were cerebral vascular accident (3.3%), epilepsy syndromes (3.3%), demyelination (1%), congenital malformations (1%), and vascular malformations (1%). Patients who came with generalised seizures were predominantly seen to have epilepsy (48%) followed by infection (34%), followed by cerebral palsy (25%). Les commonly they had stroke (5%), ICSOL (5%) and epilepsy syndrome (7%). Rarely they had congenital malformations (1%) and demyelination (3%). Patients who came with partial seizures were predominantly seen to have infection (28%) followed by ICSOL (13%). Less commonly they had cerebral palsy (4%) and epilepsy (6%). Rarely, they had vascular malformations (n=2), congenital malformations (n=2), and stroke (n=2). Regarding the metabolic causes, 15.2% had hypocalcemia, 6.2% had hypoglycemia, 8.6% had hyponatremia. A minority showed leucocytosis (11.4%), and 82.4% cases showed lymphocytosis during post-ictal period.

EEG was done in 92% of the patients, of which 73% were abnormal (**Table 2**).

Table 2: Relation of EEG to different seizure types

Seizure type	EEG			P-value
	Abnormal	Normal	Not done	
Complex febrile seizure	12 (63.2%)	7 (36.8%)	0	<0.001
Generalised seizure	113 (88.3%)	12 (9.4%)	3 (2.3%)	
Partial seizure	29 (50.9%)	15 (26.3%)	13 (22.8%)	
Undiagnosed seizure	0	6 (100%)	0	

Among the various abnormalities seen in EEG, the two most common patterns were sharp wave and spike pattern (36.4%), and sharp wave pattern (30.5%). Details are provided in **Table 3**.

Table 3: Type of EEG abnormality and its relation to different seizure types

EEG abnormality	Diagnosis			P-value
	Complex febrile seizure	Generalised seizure	Partial seizure	
Abnormal background with sharp wave	0	3 (2.7%)	1 (3.4%)	0.16
Abnormal background with sharp wave and spike	1 (8.3%)	5 (4.4%)	5 (17.2%)	
Asymmetry with sharp wave	0	3 (2.7%)	0	
Asymmetry with sharp wave and spike	0	3 (2.7%)	1 (3.4%)	
Hypsarrhythmia	0	3 (2.7%)	0	
Sharp wave	3 (25%)	30 (26.5%)	14 (48.3%)	
Sharp wave and spike	5 (41.7%)	43 (38.1%)	8 (27.6%)	
Spike	3 (25%)	23 (20.4%)	0	

There was a statistically significant correlation between the type of seizure and the presence of EEG abnormality (p-value <0.0001). There was no statistically significant correlation between the type of EEG abnormality and the type of seizure seen.

CT scan was done in 189 patients (90%), of which 45% were abnormal. Details are provided in **Table 4**.

Table 4: CT scan abnormality in different seizure types

CT scan abnormality	Diagnosis		P-value
	Generalised seizure	Partial seizure	
Calcification	1 (2%)	3 (8.6%)	0.06
Cerebral atrophy	19 (37.3%)	8 (22.9%)	
Cerebral edema	8 (15.7%)	0	
Dilated ventricle	16 (31.4%)	17 (48.6%)	
Infarction	1 (2%)	0	
Neurocysticercosis	1 (2%)	0	
Ring enhanced lesion	0	1 (2.9%)	
Subdural effusion	1 (2%)	0	
Tuberculoma	0	1 (2.9%)	
Tumor	4 (7.6%)	5 (14.3%)	

There was no statistically significant relationship between the type of seizure and the CT scan abnormality (p-value = 0.06). MRI was done in 150 cases (71.4%), of which 70% were abnormal. Details are provided in **Table 5**.

Table 5: MRI abnormality in different seizure types

MRI abnormality	Diagnosis			P-value
	Complex febrile seizure	Generalised seizure	Partial seizure	
ADEM	0	3 (4.8%)	0	0.04
AES sequlae	0	1 (1.6%)	3 (7.3%)	
Aqueductal stenosis	0	1 (1.6%)	0	
AV malformation	0	0	2 (4.9%)	
Calcification	0	0	3 (7.3%)	
Cerebral atrophy	2 (100%)	17 (27.4%)	4 (9.8%)	
Cerebral edema	0	4 (6.5%)	0	
Dilated ventricle	0	11 (17.7%)	5 (12.2%)	
Obstructive hydrocephalus (basal exudates)	0	3 (4.8%)	0	
Encephalomalacia	0	3 (4.8%)	0	
Granulomatous lesion	0	0	6 (14.6%)	
Hippocampus atrophy	0	3 (4.8%)	0	
Infarction	0	5 (8.1%)	2 (4.9%)	
Neurocysticercosis	0	1 (1.6%)	0	
Periventricular leucomalacia	0	3 (4.8%)	2 (4.9%)	
Porencephalic cyst	0	2 (3.2%)	0	
Temporal lobe atrophy	0	0	1 (2.4%)	
Tuberculoma	0	0	1 (2.4%)	
Tumor	0	5 (8.1%)	12 (29.3%)	

The most common abnormality was cerebral atrophy (21.9%) followed by dilated ventricles (15.2%). There was a statistically significant relationship between the type of seizure and the MRI scan abnormality (p-value = 0.04).

Of the 137 patients who had abnormal EEG recording, only 47% had abnormal CT scan. Of 38 patients who had a normal EEG recording, 28% had an abnormal CT scan. There was a statistically significant relationship between EEG recording and CT scan findings (p-value = 0.04). Of the 120 patients who had abnormal EEG recording, majority (65%) had abnormal MRI. Of 17 patients who had a normal EEG recording, 82% had abnormal MRI scan. There was a statistically significant relationship between EEG recording and MRI scan findings (p-value <0.001). Of the 86 patients who had abnormal CT findings, majority (98.8%) had an abnormal MRI. Of 57 patients who had a normal CT scan, 17% had an abnormal MRI.

Discussion

In the present study, generalized seizures were most common across all age groups with 5-10 years age group being commonly affected (40%), and infants (<1 yr) being least affected (8.6%). Males predominated over females. As the age progresses the frequency of seizures decreases beyond 5 years of age. This is quiet similar to a study from Israel where 18% of seizures began in infancy, 64% in childhood (2-10 yr) and 18% in adolescent (11-15 yrs) [7]. In another study, the seizure prevalence in infancy was 32% [8]. A study including children up to 12 yrs found the overall prevalence of first seizure episode to be 68.5% [9]. In India, the higher incidence of convulsion during in late infancy may be due to poor socioeconomic conditions, unhygienic living conditions, overcrowding, and poor immunization with increase vulnerability for intracranial infections [10].

In the present study, males outnumbered females. This male predominance is quite similar to previously published studies [11,12]. Though the exact cause of higher male preponderance is not known, they postulated that genetically males were more prone to develop convulsions. Similar observations were also made by another study [13]. The authors attributed this male predilection to their greater liabilities to congenital cerebral defects and birth injuries, which lowers the seizure threshold of the brain.

Generalised seizures were the more common form of seizures (61%) as compared to other forms of seizures. This is in agreement with other study results [11-13], which made similar observations in that generalised tonic clonic seizures are the most common (58.3%) seizure type in all age groups and both sexes. Another study demonstrated that GTCS are the most frequent (49.5%) followed by atonic (23.3%), tonic seizures (21.6%); while myoclonic

seizures (2.6%) and absence seizures (1%) were the less frequent types [12]. In another study, the frequency of generalised seizures was higher (79%) [13]. The higher incidence of generalised seizures in the age group of 1-5 years in our study was due to the fact that 6 months to 5 years is the most common age group for febrile seizures. However there was no statistically significant correlation between the type of seizure seen and the age of patient. It could be due to the variation in the underlying etiologies for the seizure.

A study found EEG abnormality to be present in 62% of patients [14]. But in our study 73% of EEG was abnormal which could be due to more rampant use of EEG as a primary evaluation modality by pediatricians and neurologists. We found that 51% of patients with partial seizures and 88.3% of patients with generalised seizures were having abnormal EEG. Observation in our study was quite similar to other studies [15,16]. The authors reported abnormal EEG in 81% of patients with partial seizures and 78% of patients with generalised seizures, respectively. Another group of authors found that 70.9% of patients with partial seizures and 70.1% of patients with generalised seizures were having abnormal EEG [17]. The EEG abnormality of complex febrile seizure group in our study was 63.2%, which is similar to that found in other studies [18]. However, one study from India showed only 16.3% abnormal EEG in complex febrile seizure [17]. In the undiagnosed seizure group in our study, no patient had abnormal EEG. But a study showed that 20% of undetermined seizure patients had abnormal EEG [17]. This may be due to poor follow up and not repeating EEG in these groups of patients. In our study, sharp wave and spike were the most common EEG abnormality. Similar findings were observed by other authors [17,19]. However, in another study, focal slowing was the most common abnormality [20]. This deference may be due to varied opinion by different neurologist having experience in pediatric EEG.

It has been reported that CT scan abnormality may be present in 28 to 92% of patients with seizure disorders. In our study, CT scan was found to be abnormal in 61.4% of patients with partial seizures and 39.8% of patients with generalised seizures. A previous study reported abnormal CT scan in generalised seizure disorder, which was similar to ours [18]. In another study, abnormal CT scan was seen in a lesser number of patients (52%) with partial seizures compared to ours [21]. Yet another study reported a much higher proportion of abnormal CT scan in patients with partials seizures [19]. Since we had excluded patients with some known etiological factors (head trauma), it was anticipated that relatively fewer CT scan would reveal finding in our study. In the complex febrile seizure group no CT abnormality found in our study. This was in contrast to another study that showed abnormal CT scan in 1.6% of patients [17].

In our study, MRI brain was abnormal in 48.4% cases of generalised seizure and 80% cases of partial seizure. Like CT scan, in all the undiagnosed cases of seizure, MRI was also normal. A previous study reported MRI abnormality in 32.5% of children with newly diagnosed seizures [20]. The higher abnormality of MRI in our study could be due to higher picking power of 1.5 Tesla MRI machines in which we conducted our study.

Of 137 patients in our study who had abnormal EEG recording, only 47% had abnormal CT scan. Again, of 38 patients who had a normal EEG recording, 28% had abnormal CT scan. This result was similar to a previous study result where the authors found abnormal CT scan in 57.8% and 28.5% of cases with abnormal and normal EEG, respectively. Of the 120 patients who had abnormal EEG, 65% had abnormal MRI. Again, of 17 patients who had a normal EEG recording, 82% had abnormal MRI. This was in contrast to that observed by another study [21]. In the later study, the authors showed the accuracy of picking abnormality by MRI when EEG is abnormal is 24.8%.

Conclusions

Seizure disorder was most common in age group of 5-10 years followed by 1-5 years age group, and least common in infants. Males were more commonly affected, and majority were generalised seizures. The most common underlying etiology was infective followed by epilepsy. EEG was abnormal in 73%, MRI abnormal in 70%, and CT brain abnormal in 45%. Future studies should follow up children with seizure disorder to see the change in profile, imaging abnormalities, and outcomes.

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