

Study on patterns and prevalence of EEG abnormalities in children presenting with behavioural disturbances in psychiatry OPD, Gauhati Medical College and Hospital

Abstract

Background of the study: Children with behavioural abnormalities and developmental disorders are often advised electroencephalography (EEG) for evaluation of electrophysiological process of the brain to rule out any organic pathology. Various studies have reported abnormal EEG in these groups of children without history of clinical seizure on routine EEG and sleep EEG. **Aim of the study:** To study pattern and prevalence of EEG abnormalities in children with behavioural abnormalities without history of clinical seizure. **Materials and methods:** The study is a retrospective study. Ethical clearance has been obtained from institutional ethical committee for the study. To collect data, socio-demographic and clinical data proforma has been used. Data has been evaluated during the period from June 2011 to June 2014 as per selection criteria from the case history record of children with behavioural abnormalities attending child guidance clinic (CGC). Associations of abnormal EEG with various psychiatric diagnoses has been analysed and chi-square test has been used. p value <0.05 has been taken as test of significance. **Result:** Total 2011 children attended CGC from 2011 June to 2014 June. One hundred and ninety two children of various psychiatric diagnoses as per the tenth revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) criteria had fulfilled the selection criteria and 113 children had done EEG. Abnormal EEG was found in 26.54% of children with various psychiatric diagnoses. Association was statistically significant ($p < 0.05$). The EEG abnormalities were found more in male gender than female ($p < 0.05$) and more in younger age group (four to ten years, $p < 0.05$). **Conclusion:** Children with various psychiatric diagnoses have significant association with abnormal EEG without history of clinical seizure.

Keywords: Seizures. Mental Retardation. Minimal Brain Dysfunction.

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Introduction

Children with different developmental disorders like mental retardation (MR), pervasive developmental disorder (PDD), scholastic learning disorder (SLD), behavioural disorders like conduct disorder, hyperkinetic disorder are often seen to be associated with brain dysfunction in the form of abnormal electroencephalography (EEG) or comorbid seizure disorder or abnormal structural and functional neuroimaging findings. Children with dissociative disorder, PDD, and attention-deficit/hyperactivity (ADHD) require investigation of EEG during the process of evaluation. Children with intellectual disability (ID) are often advised for EEG to investigate abnormal neuronal discharge. Various studies have reported that children with developmental disorders show abnormal EEG without history of clinical seizure. EEG is an important tool for investigation of abnormal electrophysiological process in the brain. It has been introduced in the field of psychiatry by a psychiatrist Hans Berger of Germany in 1929.[1] One of

the earliest studies to identify EEG abnormalities in children with minimal brain dysfunction was Jasper *et al.* in 1938.[2] Over half of children had EEG abnormalities, in the form of increase in slow wave in the frontal region.[2] In healthy individuals, epileptiform EEG patterns are more common in children than adult. Only one community-based study has reported that prevalence of epileptiform EEG pattern in healthy children is 3.5%.[3] EEG changes in autism spectrum disorder (ASD) has been documented recently by Wang *et al.*[4]. Frank epileptiform EEG abnormality also has been reported in some subgroup of children with ADHD although they do not develop seizure clinically. Children with ADHD of this subgroup develops seizure after stimulant therapy.[5] EEG is an important tool for clinicians for evaluation while treating children with ADHD. Children with ID have comorbid conditions like cerebral palsy and epilepsy, and these comorbid conditions are three to four times more common in them.[6] So, this subgroup of children may show changes in EEG. Children with dissociative disorder, which

mimic seizure disorder, often require EEG to differentiate it from true seizure. Children presenting with behavioural abnormality or psychosis are advised for EEG to rule out brain dysfunction. Epilepsy and epileptiform EEG without seizure have been found to be also associated with autism and language disorders.[7] Recently, various research work has been done on EEG of children with psychiatric diagnosis and results lead to new insight in this field. Although it is well-known that normal EEG does not rule out diagnosis of seizure disorder and abnormal EEG without history of seizure do not diagnose seizure disorder. So, aim of our study is to look into the prevalence and pattern of abnormal EEG in children with problems of MR, ASD, SLD, ADHD, and conduct disorder, or any other behavioural disturbances without history of clinical seizure disorder.

Materials and methods

Place of the study: The study was conducted in the psychiatry department of Gauhati Medical College and Hospital (GMCH), Guwahati, a tertiary care institute receiving patients from Assam and entire North East India.

Study design: This is a retrospective study. Data were obtained during the period from 2011 Jun to 2014 June from the case history sheets available in child guidance clinic (CGC) of psychiatry outpatient department (OPD), GMCH as per selection criteria. The case history sheet of CGC clinic have the records of children's socio-demographic data, psychiatric diagnosis, investigation findings (EEG, neuroimaging), and birth history. The psychiatric diagnosis was established by consultant in CGC. Digital EEG was done in the EEG laboratory in the Department of Psychiatry by EEG technician using 10-12 electrode placement system with referential and bipolar montages. Activation method used was hyperventilation and photic stimulation, paper speed was 30 mm/sec. EEG records were sent to the Department of Neurology of GMCH for reporting and the neurologist who reported the EEG was blinded to the psychiatric diagnosis. To test our hypothesis, we included the data for analysis of those children with various psychiatric diagnoses as per the tenth revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10)[8] criteria who had done EEG without history of clinical seizure.

Objectives of the study

1. To assess the prevalence of EEG abnormalities in children with behavioural abnormality attending CGC, Department of Psychiatry, GMCH.
2. To see the pattern of EEG abnormality in children with behavioural abnormality attending CGC.
3. To assess the association of EEG abnormalities with different psychiatric diagnoses.
4. To see the association of prenatal, perinatal, and postnatal complications in children with behavioural disturbances and EEG abnormality.

Inclusion criteria: Both male and female children diagnosed with different behavioural abnormalities like MR, hyperkinetic disorder, psychotic disorders, ASD, dissociative disorder etc. as per ICD-10 criteria[8] and had been referred for EEG.

Exclusion criteria: Children with history of seizure, diagnosed case of epilepsy, brain tumour cases were excluded.

Assessment tool: To collect data, we have prepared a socio-demographic and clinical data proforma. In the proforma, we have included psychiatric diagnosis as per ICD-10 criteria, normal EEG record, patterns of abnormal EEG record, birth history, psychiatric comorbidity, and neuroimaging finding.

Ethical clearance: Ethical clearance was obtained from the Institutional Ethical Board, GMCH.

Statistical analysis of data: Data was analysed to test the hypothesis and to compare the variables, chi-square test has been used; a value of $p < 0.05$ was considered in this study.

Result

Data of 2011 children with behavioural abnormalities attending CGC at GMCH Psychiatry OPD from 2011 June to 2014 June was obtained. On evaluation, we found that 413 children were advised EEG and 192 children of them fulfilled the selection criteria. But, out of 192 children, only 113 (58.9%) with various psychiatric diagnoses had done EEG and in rest 79 (41.1%), EEG was not done or did not return for follow-up. So, in our study, we have done statistical evaluation on 113 children. Out of 113 children, abnormal EEG has been found in 30 (26.55%) children with behavioural abnormalities and normal EEG in 83 (73.45%) children with behavioural abnormalities (Figure 1).

Table 1 shows the age and sex differences with respect to normal and abnormal EEG. Abnormal EEG was found in 23 (33.82%) cases of male children and normal EEG was found in 45 (66.18%) cases of male children. Total 68 (60.18%) male children had done EEG. Only 7 (15.55%) cases of female children had abnormal EEG and 38 (84.45%) female children had normal EEG. Total 45 (39.82%) of female children had done EEG. The difference was found to be statistically significant; p value was 0.031.

The age of the study sample was divided into two groups: from four to ten years and from 11 to 18 years. Abnormal EEG was found in 19 (46.34%) children and normal EEG was in 22 (53.66%) children between four to ten years of age. Total 41 (36.28%) children were in this age group. Between 11 to 18 years, 11 (15.28%) children had abnormal EEG and 61 (84.72%) children had normal EEG. Total 72 (63.72%) children were in this age group. Difference in EEG findings

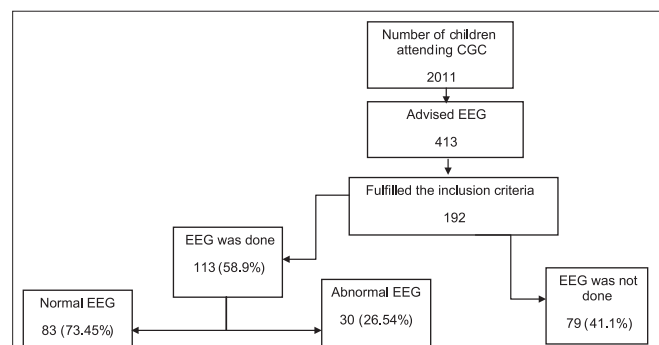


Figure 1: Study population. CGC=Child Guidance Clinic, EEG=Electroencephalography

Table 1: Sex and age difference with respect to EEG record

	Abnormal EEG (%)	Normal EEG (%)	Total (%)	χ^2	df	p-value
Sex						
Male	23 (33.82)	45 (66.18)	68 (60.18)	4.6343	1	0.031339
Female	7 (15.55)	38 (84.45)	45 (39.82)			
Age (years)						
4-10	19 (46.34)	22 (53.66)	41 (36.28)	12.9271	1	0.000324
11-18	11 (15.28)	61 (84.72)	72 (63.72)			

EEG=Electroencephalography, df=Degree of freedom

in between the age groups has been found to be statistically significant; p value was 0.00032.

Different patterns of abnormal EEG record were shown in Table 2. Out of 30 abnormal records, EEG slowing of background was seen in eight (26.67%), generalised spikes and waves in five (16.67%), diffuse cortical dysrhythmia in three (ten per cent), temporal lobe discharge in three (ten per cent), frontal lobe discharge in three (ten per cent), increased theta waves in three (ten per cent), drug-induced sleep record in two (6.67%), high amplitude wave in two (6.67%), and centro-parietal discharge in one (3.33%) children.

Table 3 represents the various psychiatric diagnoses of children with behavioural abnormalities with respect to different patterns of abnormal EEG. Various patterns of EEG findings were highest with MR.

Percentage of different psychiatric diagnoses has been shown in Table 4. Out of 113 children with various psychiatric diagnoses, MR constituted 44.25%, hyperkinetic disorder 5.31%, PDD 3.54%, psychotic disorder 6.19%, dissociative disorder 21.24%, and other psychiatric diagnoses 19.47%. In the MR group, mild, moderate, severe, and profound MR were grouped together. In other psychiatric diagnoses group, out of 22 children, only one child with diagnosis of panic disorder had abnormal EEG record in the form of slowing of background and others had normal EEG. The other psychiatric diagnoses who had normal EEG were panic disorder (two), substance abuse (three), obsessive-compulsive disorder (OCD, four), conduct disorder (four), depressive disorder (four), anxiety disorder (two), and somatoform disorder (two).

EEG abnormalities and various psychiatric diagnoses have been compared in Table 5. Associations of abnormal EEG have been found to be statistically significant with various psychiatric diagnoses. The various psychiatric diagnoses included in statistical evaluation were MR, hyperkinetic disorder, PDD, dissociative disorder, and psychotic disorder; p value was 0.01 after Yates correction.

The demographic and clinical data of 30 children with abnormal EEG has been shown in Table 6. Mean age of children with abnormal EEG was 9.3 ± 3.9 years.

Abnormal neuroimaging finding has been found in three children with mental retardation, hyperkinetic disorder, and autism respectively. None of the children with abnormal EEG had reported abnormal prenatal history. Only one case of mental retardation had history of perinatal complication with history of preterm delivery and low birth weight (LBW),

Table 2: Pattern of abnormal record of EEG

Abnormal record	Total number	Percentage
Slowing of background	8	26.67
Generalised spikes and waves	5	16.67
Diffuse cortical dysrhythmia	3	10
Temporal lobe discharge	3	10
Frontal lobe discharge	3	10
Increased theta waves	3	10
Drug-induced sleep record	2	6.67
High amplitude waves	2	6.67
Centro-parietal discharge	1	3.33

EEG=Electroencephalography

and admitted to neonatal intensive care unit for nine days. Other psychiatric comorbidities like OCD, impulse control disorder, and learning disability have been found with MR and hyperkinetic disorder.

Discussion

Our study found that 26.54% of children with behavioural abnormalities had abnormal EEG without history of seizure disorder. Majority of them were diagnosed case of MR with significant impairment of behaviour followed by hyperkinetic disorder, PDD, psychotic disorder, and dissociative disorder. The abnormal EEG findings in children with behavioural abnormality also had been reported by Jasper *et al.*[2]. Harris in 1977 reported high incidence of EEG abnormalities in children with psychiatric disorders.[9] In our study, 60.18% of children were male and 39.82% were female of those who had done EEG. The prevalence of male gender has been reported to be greater than female in MR, hyperkinetic disorder, and autism.[10-12] In our study, sex difference was found to be statistically significant. Abnormal EEG was more in male (33.82%) children than females (15.55%).

This is the first study in this region to investigate EEG findings of children with behavioural abnormalities attending CGC clinic at tertiary care institute. This study gives us a brief idea about the important role of EEG in children with different psychiatric diagnoses, though they do not have seizure disorder clinically. Abnormal EEG was also found more in younger age group of children. The age difference was found to be statistically significant. Previous study also revealed that EEG abnormalities gradually disappear or diminish as the children reach later childhood or adolescence.[9] More abnormal EEG

Table 3: Psychiatric diagnoses of children with behavioral abnormalities with respect to different patterns of abnormal EEG

Abnormal record	MR	Hyperkinetic disorder	PDD	Psychotic disorder	Dissociative disorder	Others
Slowing of background	4	1	1	1	0	1
Generalised spikes and waves	3	0	1	0	1	0
Diffuse cortical dysrhythmia	3	0	0	0	0	0
Temporal lobe discharge	3	0	0	0	0	0
Frontal lobe discharge	2	1	0	0	0	0
Increased theta waves	1	2	0	0	0	0
Centro-parietal discharge	1	0	0	0	0	0
Drug-induced sleep record	2	0	0	0	0	0
High amplitude waves	1	0	1	0	0	0

EEG=Electroencephalography, MR=Mental retardation, PDD=Pervasive developmental disorder

Table 4: Percentage of different psychiatric diagnoses

Psychiatric diagnosis	Normal EEG	Abnormal EEG	EEG done
MR	30	20	50
Hyperkinetic disorder	2	4	6
PDD	1	3	4
Psychotic disorder	6	1	7
Dissociative disorder	23	1	24
Others (somatoform disorder, conduct disorder, OCD, anxiety disorder, depressive disorder, substance abuse, panic disorder)	21	1	22
Total	83	30	113

EEG=Electroencephalography, MR=Mental retardation, PDD=Pervasive developmental disorder, OCD=Obsessive-compulsive disorder

in younger age group may indicate the possibilities of delayed or abnormal maturation process of the developing brain. A somewhat similar study from this part of the globe among the intellectually disabled population reported prevalence of seizure disorder to be 22%.[13] Moreover, among all age groups in rural population with low socioeconomic status, the prevalence of seizures and encephalitis is common as found by Yadav *et al.*[14] This group of patients who has post-encephalitis seizure and sequelae tolerates less to higher doses of antiepileptic drugs and their combinations. Therefore, these kinds of study have a therapeutic implication too.

Different patterns of abnormal record have been found in 40% children with MR. Our study has found statistically significant association of psychiatric diagnosis with abnormal EEG. Similarly, EEG abnormalities in MR without seizure had been reported by Shibagaki *et al.*[15] In our study, out of six hyperkinetic disorder children, four of them had abnormal EEG in the form of increased theta wave, slowing of background, and frontal lobe discharge. Anderson in 1963 reported that out of 30 children with hyperkinetic behaviour, aged between 8-12 years, 26 had EEG abnormalities.[16]. Clarke *et al.*[17] also reported EEG abnormality in the form of more theta activity in ADHD group in comparison to control group. EEG differences in ADHD children in comparison to normal children had been reported by Chabot

and Serfontein.[18] ADHD children had increase in absolute and relative theta in the frontal region.[18] In our study, out of four cases of autism, three children showed abnormal EEG in the form of high amplitude wave, generalized spikes and waves, and slowing of back ground. Akshoomoff *et al.*[19] also reported abnormal EEG or epileptiform EEG in 30% children with ASD without history of epilepsy on routine EEG. Hrdlicka *et al.*[20] reported 30% of children (mean age 9.1 years) with ASD had epileptiform EEG. Different patterns of EEG abnormalities found in this study with autism is consistent with previous studies.[21-24] EEG abnormality in the form of slowing of background also has been observed in one child with hebephrenic schizophrenia, in the psychotic disorder group. Abnormal EEG in psychosis has been reported by Inui *et al.*[25] and observed that abnormal EEG in a subgroup of functional psychosis as per the fourth edition of DSM (DSM-IV)[26] criteria. Abnormal EEG was found in schizoaffective disorder (33%), schizophreniform disorder (30%), and in mood incongruent psychotic mood disorder (33%).[25] EEG screening of psychiatric inpatients without history of epilepsy was done by Bridgers[27] and reported that 2.6% patients had interictal epileptiform discharge. In our study, one child with dissociative disorder had abnormal EEG in the form of generalised spikes and waves. Krumholz and Hopp[28] reported that ten to 40% of psychogenic seizures' patients had epileptiform discharge on EEG.

Associations of abnormal EEG with abnormal neuroimaging findings were found in three children with autism, hyperkinetic disorder, and MR respectively. Pandey *et al.*[29] reported abnormal neuroimaging findings in 63.82% cases with MR. Abnormal neuroimaging finding in hyperkinetic disorder has been consistent with findings of Castellanos and Acosta.[30]. Regarding our fourth objective regarding association of abnormal EEG with birth history, we could not go for further analysis because only one child with MR had perinatal and postnatal complications with LBW. LBW and preterm delivery children are vulnerable for any form of psychiatric disorder as per various research findings.

Our study has some limitations: The study is of retrospective design. Hence, when EEG was advised the suspicion of seizure by the consultant cannot be ruled out. The abnormal EEG has been found in small group of children because of high dropout rate; 41.1% of children had not

Table 5: Comparison of EEG abnormalities with various psychiatric diagnoses

Diagnosis	Normal EEG record	Abnormal EEG record	Total	χ^2	df	p-value
MR	30	20	50	12.441	4	*0.01435617
Hyperkinetic disorder	2	4	6			
PDD	1	3	4			
Psychotic disorder	6	1	7			
Dissociative disorder	23	1	24			

*p-value is calculated after Yates' correction, EEG=Electroencephalography, df=Degree of freedom, MR=Mental retardation, PDD=Pervasive developmental disorder

Table 6: Demographic and clinical data of 30 children with abnormal EEG

Age (years)	Mean±SD	9.3±3.9
	Range	4-18
Sex	Male	23
	Female	7
Psychiatric diagnosis	MR	20
	PDD	3
	Hyperkinetic disorder	4
	Psychotic disorder	1
	Dissociative disorder	1
	Panic disorder	1
Neuroimaging finding (CT/MRI)	Advised	
	Normal	5
	Abnormal	3
	Not done	18
	Not advised	4
Prenatal complication	Not reported/inadequate information	30
Perinatal complication	Reported	1
	Not reported/inadequate information	29
Postnatal complication	Reported	1
	Not reported/inadequate information	29
Psychiatric comorbidity	OCD	1 (in MR)
	Impulse control disorder	1 (in MR)
	Learning disability	1 (in hyperkinetic disorder)

EEG=Electroencephalography, SD=Standard deviation, MR=Mental retardation, PDD=Pervasive developmental disorder, CT=Computed tomography, MRI=Magnetic resonance imaging, OCD=Obsessive-compulsive disorder

done EEG. Therefore, the abnormal EEG findings cannot be generalised. Activation method like sleep deprivation was not used during EEG. Other method of EEG recording may detect more abnormality. Regarding history of prenatal, perinatal, and postnatal complications, majority of them were found to be not reported; being a retrospective study, we could not explore this part of the history and we considered them as inadequate information. A prospective follow-up study will be more informative.

Strength of our study: EEG reporting was done by a neurologist who was blinded to the psychiatric diagnosis.

Clinical implication of the study: Our study investigated the prevalence of EEG abnormality and its associations with various psychiatric disorders, and the findings will help for the management of this group of children. Propensity to develop provoked seizure in this group of children during pharmacological treatment may be an important area of concern. Association of the abnormal EEG with the symptoms reduction or any disappearance of abnormal wave as the age progresses may require treating clinician to periodically follow-up the EEG study. Appropriate measures will be required to reduce dropout rate.

Conclusion

Children with behavioural abnormalities or developmental disorders may have an ongoing cerebral dysfunction during the maturation process and was reflected on EEG in this study. So, irrespective of presence or absence history of seizure disorder, EEG should be always preferred in these children along with routine investigations. The abnormal EEG may be a predictor of high-risk children for future seizure disorder or whether there is disappearance of abnormal wave as the maturation of brain progresses or with treatment requires further research in these children.

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