Study of Correlation between Neuroimaging & EEG Changes in Seizure Disorder in Children (Six Months to Twelve Years)

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ABSTRACT

BACKGROUND

A seizure arises when a large number of neurons send out an electrical charge simultaneously, causing an abnormal intense wave of electricity. The present study aims to determine the frequency of abnormal neuroimaging in children with new onset seizures and to draw a correlation between clinical findings, electroencephalogram (EEG) findings and neuroimaging.

METHODS

This is a cross-sectional descriptive study conducted in the Department of Radiodiagnosis, Burdwan Medical College & Hospital. The entire study included recruitment of 160 subjects, data collection, data analysis, and reporting. An EEG was performed, using 18-channel EEG machine, within the first 48 hours of the first unprovoked epileptic seizure.

RESULTS

Partial seizure was seen in 54 (33.7%) children; complex febrile seizure in 18 (11.3%) children; and undetermined seizure in 6 (3.7%) children. Among cases of 6-12 years age group i.e. 94 (58.7%) cases, generalised seizure was found in 44 (27.5%) children; followed by partial seizure in 42 (26.2%); complex febrile seizure in 6 (3.8%); and undetermined seizure in 2 (1.2%) cases. Abnormal MRI was found in 120 (75%) cases; among them 64 (40%) cases were of generalised seizure; 44 (27.5%) partial seizures; followed by 9 (5.6%) and 3 (1.9%) cases of complex febrile seizure and undetermined seizure respectively.

CONCLUSIONS

93 cases showed abnormalities in EEG findings, 111 in Computed Tomography (CT) findings, and 120 cases showed abnormality in Magnetic Resonance Imaging (MRI) findings, highlighting the superiority of MRI over CT and EEG.

KEYWORDS

Seizure**,** Electroencephalography (EEG), Paediatric, CT, MRI

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DOI: 10.18410/jebmh/2020/262

Financial or Other Competing Interests: None.

How to Cite This Article:
Das R, Mondal A, Islam MA, et al. Study of correlation between neuroimaging & EEG changes in seizure disorder in children (six months to twelve years). J. Evid. Based Med. Healthc. 2020; 7(26), 1228-1233. DOI: 10.18410/jebmh/2020/262

Submission 04-04-2020,
Peer Review 19-05-2020,
Acceptance 30-05-2020,
Published 25-06-2020.

BACKGROUND

Excessive neuronal activity occurring in the brain simultaneously causes an episode of seizure.[1] The phenotypic appearance of a seizure episode involves varying degrees of involvement of body parts with a range of occurrence of loss of consciousness, starting from a temporary loss of awareness to a complete loss of consciousness. Motor activities range from complete violent shaking of all body parts during the seizure to involvement of only a limb or a portion of the face.[2] Generally, an episode of seizure lasts for 1-2 minutes with the patient making an effort to acclimatise to the normal surroundings again.[3]

Status epilepticus is a medical emergency condition where an episode of seizure lasts for more than 5 minutes.[3] An isolated episode of seizure does not necessitate the prescription of continual anti-seizure medication unless a major abnormality is detected on the electroencephalogram of the patient, in which case successive follow-up visits are needed to determine the aetiology and derive a possible treatment schedule.[4]

When a wave of activity passes across the neurons through synapse connections, some voltage fluctuations occur with regard to this electrical activity, which is measured on an electroencephalogram.[5,6] Multiple electrodes are placed on the scalp, which record the spontaneous electrical environment of the brain by way of voltage measurements, and produce a reading which often shows anomalies in epilepsy syndromes or specific metabolic disorders which affect the neuronal environment significantly.[7]

The first-line emergency imaging tool in most acute care settings, due to its ability to rapidly rule out intracranial haemorrhage or a mass lesion, is non-contrast CT. Non-contrast CT is perfectly adequate for the detection of epileptogenic foci of gliosis/encephalomalacia. The most common conditions in day-to-day practice which produce first-onset seizures are acute head trauma, infection and cerebrovascular accidents. Being less motion-sensitive,[8] CT can contribute to prognosis as well as diagnosis, with chances of recurrence in the six months following the first seizure.[9] A relatively cheap quick non-invasive tool, CT remains the primary modality of imaging in emergency settings and first-line modality in tertiary health care centres around the globe, predominantly in developing countries, owing to the availability of resources or lack of such.[10]

Direct comparisons of CT and MRI have shown that MRI has the higher diagnostic yield for epileptogenic lesions.[11,12]

Objectives

- To determine the pattern of involvement and proportion of abnormalities detected on neuroimaging in children who experience first-onset unprovoked seizure.
- To draw an inference regarding the correlation between findings detected on electroencephalogram (EEG) and neuroimaging, namely CT and MRI.

METHODS

This is a cross sectional descriptive study conducted in the Department of Radiodiagnosis, Burdwan Medical College & Hospital in 12 months. Verbal informed consent was obtained from each of the 160 participants at the time of sample collection. Socio-demographic data was obtained by means of personal interviews.

Sampling Technique

The patients attending the Emergency, In-patient and Out-patient Departments of Paediatrics Division of Burdwan Medical College were chosen for the study. A detailed clinico-developmental history was taken and physical and neurological examination were carried out. Blood samples of all subjects were drawn on admission and routine laboratory studies were performed. The International League Against Epilepsy classification was used to define seizure types.

An EEG was performed in all the subjects in the study, using 18-channel EEG machine. EEG, with a total of 22 electrodes, was performed within the first 48 hours of the first unprovoked epileptic seizure.

NCCT scan of head was performed in all the subjects on CT Machine (Scenaria 128 Hitachi). MRI was performed in those patients where the seizure episodes were accompanied by abnormalities on EEG. Also, MRI was needed where the CT findings needed to be investigated further for proper evaluation. The abnormal findings on CT included cortical atrophy with ventricular enlargement disproportionate to age, focal hypodensities, focal hypodense lesions on white matter and findings associated with lissencephaly-polymicrogyria spectrum. Similarly, abnormalities on MRI were grouped into focal encephalomalacic-gliotic changes, focal cortical lesions, abnormal white matter intensity changes and volumetric cranial atrophy disproportionate to age.

After recording the date as percentages, the proportional differences were measured by Chi-square analysis and Fisher's exact test.

Inclusion Criteria

Patients with age between 6 months and 12 years attending OPD & IPD, in the Department of Radio-diagnosis, Burdwan Medical College & Hospital.

Exclusion Criteria

1) Patients with other co-morbidities.
2) Whose guardians did not give valid consent.
3) Seizures resulting from other aetiology viz. toxins, trauma
4) Chronic neurological illness
5) Simple febrile seizures

RESULTS

Abnormal EEG Changes	Partial		Generalised		Complex Febrile		Undetermined	
	No.	%	No.	%	No.	%	No.	%
Sharp Waves	04	2.5	16	10.0	00	00	00	00
Spike Waves	08	5.0	05	3.1	00	00	00	00
Sharp Waves & Spike Waves	10	6.2	14	8.7	00	00	00	00
Asymmetry	04	2.5	06	3.7	00	00	00	00
Asymmetry with Sharp Waves	03	1.9	05	3.1	01	0.6	01	0.6
Asymmetry with Sharp & Spike Waves	02	1.2	02	1.2	02	1.2	01	0.6
Abnormal Background of Sharp Waves	03	1.9	02	1.2	00	00	00	00
Abnormal Background of Sharp & Spike Waves	02	1.2	01	0.6	01	0.6	00	00
Normal	18	11.3	31	19.4	14	8.7	4	2.5

Table 1. Abnormal Electroencephalographic Findings in Participants (n=160)

Chi- Square value- 35.782 p Value- 0.05

Type of Disorder	Abnormal MRI No. of Patients	%	Normal MRI No. of Patients	%	P Value
Partial	44	27.5	10	6.2	<0.05
Generalised	64	40.0	18	11.3	
Complex Febrile	09	5.6	9	5.6	
Undetermined	03	1.9	03	1.9	
Total	120	75	40	25.0	

Table 2. MRI Findings in Participants (n=160)

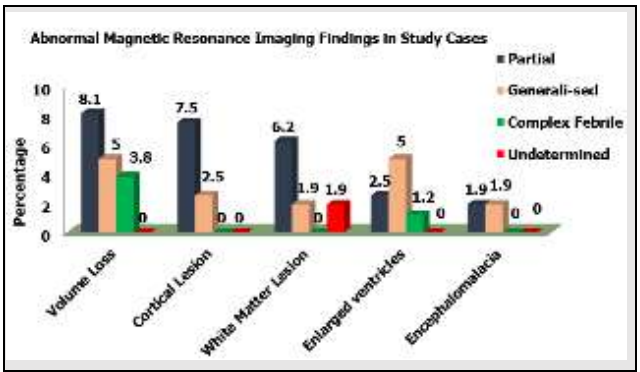
Normal & Abnormal findings	Partial		Generali-sed		Complex Febrile		Undetermined	
	No.	%	No.	%	No.	%	No.	%
EEG								
Abnormal	36	22.5	51	31.9	04	2.5	02	1.2
Normal	18	11.3	31	19.4	14	8.7	04	2.5
Chi-Square value- 13.224 p Value – 0.004								
CT Scan								
Abnormal	41	25.6	59	36.9	08	5.0	03	1.9
Normal	13	8.1	23	14.4	10	6.2	03	1.9
Chi-Square value- 7.67 p Value – 0.05								
MRI								
Abnormal	44	27.5	64	40.0	09	5.6	03	1.9
Normal	10	6.2	18	11.3	09	5.6	03	1.9

Table 3. Summary of Findings of EEG, CT & MRI in Participants

Chi-Square value- 9.616 p Value – 0.02

MRI	Electro encephalography Abnormal	Normal	Total	P-Value
Abnormal	93 (58.1%)	27 (16.9%)	120 (75.0%)	<0.001
Normal	40 (25.0%)	0 (0%)	40 (25.0%)	
Total	133 (83.1%)	27 (16.9%)	160 (100%)	

Table 4. Correlation between EEG & MRI Findings in Participants



Graph 1. Abnormal MRI Findings in Participants (n=160)

In all the case, the p value was statistically significant. Here, 93 cases showed abnormalities in EEG findings, but MRI findings were abnormal in 120 cases. Hence, 27 seizure cases were not properly diagnosed through EEG. Therefore, it may be inferred that MRI is more authentic in the diagnosis of seizure than EEG or CT.

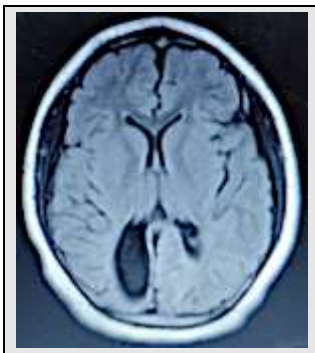


Figure 1. Axial Flair Image from MRI of Brain of a 10-Year-Old Child Showing Gliotic Change in Right Posterior Parietal and Occipital Region with Formation of a Porencephalic Cyst

Figure 2. Axial Flair Image from MRI of Brain of a 6-Year-Old Child Showing Focal Cortical Thickening with Gray Matter within the White Matter at the Right High Posterior Frontal Region with Adjacent Paucity of Sulcation, Likely Resulting in Focal Cortical Dysplasia

Figure 3. Axial Flair Image from MRI of Brain of a 6-Month Old Child Showing Prominence of Extra-Axial CSF Spaces with Paucity of Grey and White Matter, Likely Due to Hypoxic-Ischemic Encephalopathy Related Changes

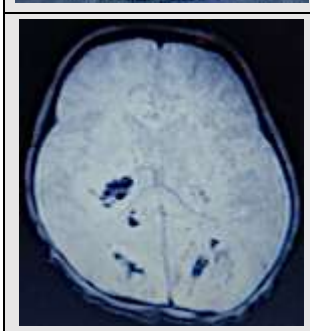


Figure 4. Axial GRE Image from MRI of Brain of a 6-Month Old Child Showing Multifocal Blooming in Right Thalamus and Bilateral Posterior Parietal Regions, Suggestive of Multifocal Haemorrhages Due to Hypoxic-Ischemic Encephalopathy Related Changes

Figure 5. Axial T1 Image from MRI of Brain of a 6-Month Old Child Showing Hyperintensity in Both Basal Ganglia and Thalamic Regions, Likely Due to Metabolic Disorder

Figure 6. Altered Intensity, Hyper on T1-W Image, of a 6-Month Old Child Noted, in Both Basal Ganglia and Thalamic Regions, Likely Due to a Metabolic Deposition Disorder. There Were Gliotic Changes in Both Fronto-Parietal Regions (Not Shown)

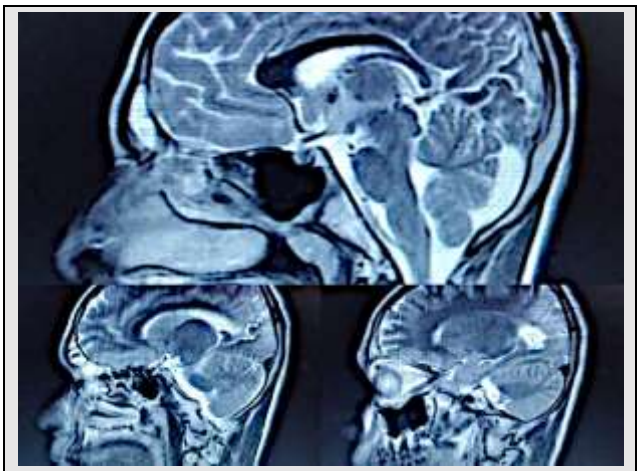


Figure 7. Hyperintensity Noted on Sagittal T2-W Image of a 12 -Year old Child in Posterior Parietal and Occipital Region with Thinned Out Posterior Body and Splenium of Corpus Callosum- Likely Sequalae of Hypoxic-Ischemic Encephalopathy Changes

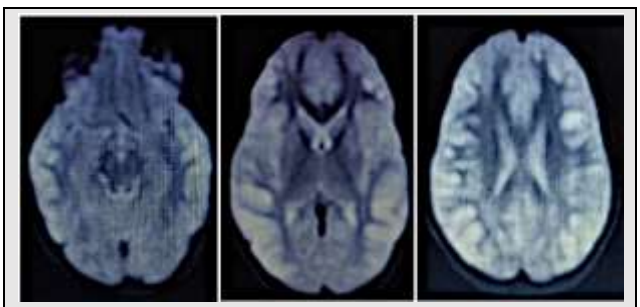


Figure 8. DWI Image of a 5-year Old Child Reveals Areas of Diffusion Restriction in Bilateral Fronto-Parieto-Temporal Regions Involving the Cortex- Synchronous with Encephalitis Changes According to the Clinical Picture of Pyrexia, Leucocytosis and Seizures

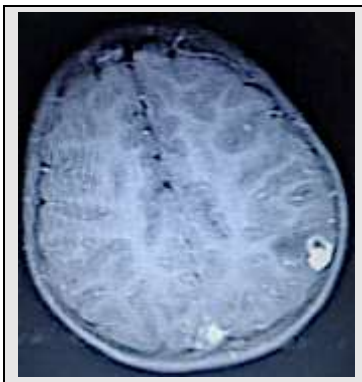


Figure 9. T1FS + C Image of a 4-Year Old Child Reveals a Lesion with Thick Ring of Peripheral Enhancement and Features of Conglomeration in Left Posterior Parietal Region, with Surrounding Focal Hypointensity – Likely Granuloma with Perilesional Oedema

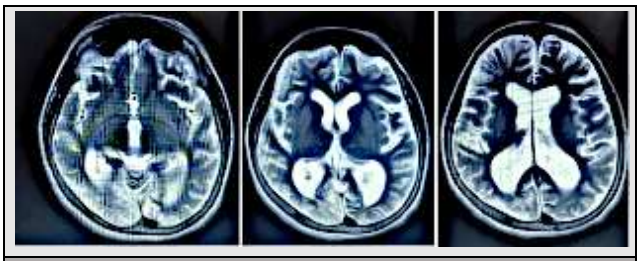


Figure 10. Hyperintensity Noted, On a T2-W Image of a 12-Year-Old Child, in Right Fronto-Parieto-Occipital Cortex and Left Fronto-Parietal Cortex with Cortical Atrophy and Prominent Extra Axial CSF Spaces - Likely Due to Focal Demyelination Changes

DISCUSSION

There are very few studies that correlate neuroimaging findings with EEG data in children who present with new-onset seizures. In this background, the proposed study was conducted in Burdwan Medical College &Hospital with 160 children. The diagnostic correlation was assessed properly.

Generalised seizure was the commonest type in this study, found in 82 (51.3%) children. This was followed by partial seizure found in 54 (33.7%), complex febrile seizure in 18 (11.3%) and undetermined seizure found in 6 (3.7%) children. Seizures were more common in males than females.

Many studies show that seizures are more prevalent in a younger age group. In children with age less than 10 years, males suffered from episodes of seizure than females. But this was not true in children older than 10 years. In the latter age bracket, females outnumbered males in experiencing unprovoked first-onset seizures. There was history of fever preceding or accompanying the seizure episode in 53.5% of cases.[10]

Here, 160 cases were divided into two age groups: 6 months - 6 years and >6 years - 12 years. 94 cases belonged to >6 years-12 years age; among them generalised seizure was found in 44 (27.5%) cases, followed by partial seizure in 42 (26.2%), complex febrile seizure in 6 (3.8%) and undetermined seizure in 2 (1.2%) cases. Among 66 (41.3%) cases of 6 months- 6 years age group, generalised seizure was found in 38 (23.8%) cases, followed by partial seizure and complex febrile seizure in 12 (7.5%) cases each and undetermined seizure in 4 (2.5%) cases. Complex febrile seizure and undetermined seizure were found slightly more common in 6 months- 6 years age group.

Shakya et al stated, 82% of children had generalized tonic-clonic seizures, whereas the remaining 17.9% had partial seizures. Other types (absence and atonic seizures) were not seen in their study which aimed to study the relative frequencies of various epileptic seizures and the age at onset of different seizure types in Nepalese children in 2001-2002 on 50 children diagnosed with epilepsy.[12] Saravanan et al. showed that around two-thirds of children with seizure symptomatology were below 6 years of age.[13]

In the current study, head injury was the most common major complaint after headache (14 of the 120 patients, 11.5%). Among these cases, abnormal findings were detected in only one case (7.1%). Richard Lichtenstein et al. also conducted a prospective study between 2004 and 2006.[14] CT scan was performed for 15,907 of 43,398 children, reported to 25 emergency services affiliated to the Pediatric Emergency Care Research Network in USA with blunt head injury. Among these cases, intracranial injuries were found in CT scans of 1,156 cases (7.3%).

In the present study, abnormal MRI was found in majority of cases i.e. 120 (75%) cases among them 64 (40%) cases were of generalised seizure, 44 (27.5%) of partial seizure followed by 9 (5.6%) cases and 3 (1.9%) cases of complex febrile seizure and undetermined seizure respectively. Among 40 cases who showed normal MRI findings, 18 (11.3%) cases were of generalised seizure, 10 (6.2%) cases were of partial seizure followed by 9 (5.6%) cases and 3 (1.9%) cases of complex febrile seizure and undetermined seizure respectively. The p value (<0.05) was statistically significant.

Recent literature suggests that the presence of a specific intensity change in MRI predicts or suggests the occurrence of successive episodes of seizure in patient follow-up. In a case of a patient suffering from temporal lobe epilepsy, the MRI abnormality was the only successful independent determinant of patient condition and prognosis.[13,14] Likewise, in a study pertaining to partial seizures, MRI was successful in determining and correctly predicting patient prognosis on a long-term basis.[10] Hence, gathering from the findings obtained from the present study and previous literature, it may be inferred that multiple imaging abnormalities, subtle in a few cases, are likely to be present on neuroimaging during the first episode of unprovoked seizure which are associated with poor patient outcome on long-term follow-up. This is an important reason to extend outcome studies in childhood-onset seizures towards adulthood.

MRI findings were considered significant when they were reasonably associated with seizure disorder, consistent with other groups of epileptogenic lesions. These were defined as at least one of the following: leukomalacia, encephalomalacia, any grey matter intensity change (focal or otherwise), mass lesion, presence of haemorrhage, presence of any vascular lesion, hippocampal abnormality, ventricular enlargement with maximum diameter >1.5 cm, or prominence of extra-axial fluid spaces measuring >1.0 cm. A case-by-case basis approach was employed to assess structural abnormalities on brain.[15]

CONCLUSIONS

CT scan is more authentic in the diagnosis of seizure than EEG. MRI is more authentic in the diagnosis of seizure than EEG or CT scan. Although EEG may be practically feasible in the current scenario, neuroimaging is a mandatory intervention in new-onset seizures in children to follow them up to adulthood, especially in known epilepsy syndromes. The frequent occurrence of abnormalities on neuroimaging in epilepsy syndromes makes a radiological investigation a necessity in an episode of first-onset unprovoked seizure. A systematic approach to reporting imaging studies in the paediatric population might help the radiologist to detect subtle abnormalities that could contribute to predicting patient outcome and other comorbidities. Future studies, especially from other medical fields, correlating these abnormalities to patient prognosis and changes in treatment schedule, would be especially helpful in further defining significance of radiological investigations.

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