Role of Magnetic Resonance Imaging of Brain in Evaluation of Pediatric Seizure Disorder

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Abstract- Seizure disorder in children is commonly seen in clinical practice and in the assessment of these patients. Magnetic Resonance Imaging (MRI) is found to be the ideal and first imaging modality of choice for pediatric seizure disorder because of lack of radiation exposure. This work aims to assess the role of MRI of the brain in the evaluation of pediatric seizure disorder. Before undergoing MRI, all of the patients received EEG to detect the epileptogenic center. On the superconductive 1.5-Tesla Siemens Avanto Magnetom MR system, patients underwent a brain MRI scan. Percentages and proportions were used in the statistical analysis. Around 70% of children with seizures were found to be controlled by the use of a single antiepileptic drug (AED). Electroencephalogram (EEG) findings were abnormal in 82% of patients. The MRI findings were normal in 45 patients (45%) and abnormal in 55 patients (55%). The common abnormalities were gliosis (45.4%), periventricular leukomalacia (12.7%), neurodegenerative changes in white/grey matter (7.3%), focal cortical dysplasia (FCD) (7.3%), arteriovenous malformations (AVM) (7.3%), polymicrogyria (5.5%), mesial temporal sclerosis (MTS) (5.5%), abnormal spectroscopy (3.6%), space-occupying lesion (SOL) (3.6%) and megalencephaly (1.8%). Our study showed about 55% of children with seizures had MRI abnormalities and common abnormalities were gliosis and periventricular leukomalacia. Improvements in perinatal care, hygiene, and socio-economic status can help in reducing the incidence and thus morbidity associated with a seizure disorder. Thus, MRI plays a pivotal role in the workup of pediatric patients with a seizure disorder.

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Keywords: Magnetic resonance imaging (MRI); Seizure disorder; Epilepsy; Gliosis; Electroencephalogram; Electroencephalogram (EEG)

Introduction

A seizure is a rapid, paroxysmal electrical discharge from the central nervous system (CNS) that causes involuntary motor, sensory, or autonomic abnormalities with or without sensorium changes (1). Seizures are a medical emergency in children and a common cause of hospitalisation, with high mortality and morbidity. Seizure disorder is a broad phrase that refers to a variety of conditions, including epilepsy, febrile seizures, and possibly single seizures and symptomatic seizures caused by metabolic, viral, or other causes, such as hypocalcemia and menin. The clinical appearance and kind of seizure disorder are determined by the patient's age and neurological maturity. Simple and complicated seizures, focal or partial seizures, and generalised seizures are all part of the clinical spectrum of seizures (2).

Approximately 5% of children are at risk of having a seizure, and half of these children have their first seizure while they are very young. In the newborn phase, prevalence is higher (almost 1 percent in term and 20 percent in preterm). The most common type of convulsion in children is febrile convulsions. When two or more unprovoked seizures occur within a 24-hour period, epilepsy is considered present. Epilepsy affects 3% of people at some point in their lives, with more than half of instances beginning in childhood. Epilepsy is the most common neurological disease treated by neurologists and the most prevalent chronic condition seen by paediatricians. In the paediatric age range, the incidence of epilepsy is 1% (1).

The electroencephalogram (EEG) is a

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straightforward, non-invasive, and low-cost test. When used wisely and in conjunction with clinical history and examination, it can provide important information about seizures. In EEG studies, roughly 40-50 percent of individuals with seizure disorders have a normal interictal EEG, whereas about 5% of people without seizures may have non-specific abnormalities. Computed tomography (CT) is a helpful investigation in diagnosing many causes of seizure disorder like intracranial hemorrhage, ventriculomegaly, calcifications, and major vascular malformations. It has approximately 30% of sensitivity in diagnosing the causes for a seizure disorder. It is one of the limitations of CT and also the risk of exposure to radiation in infants and children is of very high cost. Due to these factors, MRI has replaced CT in the elective workup of seizure disorder in children (3).

Because of its capacity to portray neuroanatomy, great gray-white matter distinction, the condition of myelination, and the detection of focal structural brain lesions, MRI is the imaging technique of choice. For children with partial seizures, MRI is an approved technique of neuroimaging (4). The use of magnetic resonance imaging (MRI) has improved our understanding of the underlying illness process, as well as the evaluation and therapy of seizure disorders. In roughly 12-14 percent of individuals with newly diagnosed epilepsy, MRI can detect the seizure-causing lesion (5).

Some indications for MRI in epileptic children have been provided by the International League against Epilepsy. Children with focal onset of seizures, a focal deficit on neurological or neuropsychological examination, onset of generalised or unclassified seizures in the first year of life or adulthood, failure to control seizures with first-line antiepileptic drugs, seizure loss, or a change in seizure pattern (4). Diffusion tensor imaging (DTI), MR image coupled with 18 fluorodeoxyglucose (FDG), positron emission tomographic (PET) images, and magnetoencephalography have all enhanced substrate detection and localization recently. In the diagnosis, treatment, and follow-up of patients with infectious and inflammatory lesions of the brain, such as neurocysticercosis, brain abscess, tuberculoma, demyelinating diseases, and encephalitis, MRI is the most appropriate investigation. On follow-up imaging, postoperative MR can uncover reasons for failure, such as insufficient resection, and can monitor tumour recurrence (6).

The goal of this study was to look at the range of MRI findings in paediatric epilepsy patients and determine the proportional distribution of various causes. There are very few studies related to this field in India. In addition, researchers looked at the range of MRI results in children having seizures. This, in turn, helps in early intervention and prevention of complications in the patient, resulting in a favorable prognosis.

Materials and Methods

A prospective cross-sectional study of 100 patients in the age group of 3 months-18 years with a clinical history of seizure disorder was subjected to MRI examination of the brain at Justice K. S. Hegde Charitable Hospital, Nitte University (Deemed to be University). The study includes inclusion criteria like children in the age group of 3 months to 18 years with first seizure based on clinical data, children in the age group of 3 months to18 years with recurrent seizures, those who are not investigated earlier with MRI, and parents/guardians willing to give consent for MRI and study. Contraindications to the use of contrast agents, contraindications to MRIs such as pacemakers, aneurysmal clips, cochlear implants, and patients with claustrophobia, as well as parents/guardians unwilling to give consent for the MRI and research, are all exclusion factors.

Method of collection of data

After initial resuscitation and stabilization of the child, detailed history and the variables like age, sex, the number of seizures, risk factor, and development of the child was taken. Clinical examination was done to rule out neurological deficits. The method was described to the parents/guardians and the patient, and signed informed consent was obtained from everyone who agreed to participate in the study. EEG and MRI of the brain were performed as part of regular management care at the request of the clinician.

Methodology of examination

A 1.5-Tesla Siemens Avanto Magnetom MR equipment was used for all MRI imaging studies. Before entering the MRI scanning room, patients were examined for cardiac pacemakers, aneurysmal clips, ferromagnetic objects, and so on. Patients were positioned supinely over the MRI machine board and examined properly. The patient was asked to immobilize the head, and supports were used to immobilize. For the scan, the head coil was utilised. Sequences were planned using the MRI seizure methodology and a first head programme was acquired. All patients had an MRI with T1 and T2-weighting, as well as inversion recovery and diffusion-weighted

imaging sequences, using a standardised paediatric seizure protocol with 5 mm thickness slices and 0.5 mm interslice gaps in the axial, coronal, and sagittal planes. For diffusion-weighted pictures, B values of 0 and 1000 sec/mm2 were utilised (DWI).

Contrast agents and spectroscopy were utilized in specific conditions if required. Gadopentetate dimeglumine is the paramagnetic contrast agent used in MRI in specific cases. MRI findings will be recorded by senior radiologists in all the patients and according to the MRI seizure protocol, which was then entered in an MS excel sheet as per the proforma. We see the following things on T1 weighted (T1WI) superior for cortical thickness and the interface between grey and white matter in MRI seizure protocol: Look for grey matter in an abnormal place on T1WI, as in grey matter heterotopia. Look for cortical and subcortical hyperintensities, which might be modest, during fluid attenuation inversion recovery (FLAIR). Because artefacts in FLAIR can cause false-positive results, T2WI should be used to confirm the abnormalities. When looking for haemoglobin breakdown products, such as in posttraumatic alterations and cavernomas, or calcifications in tuberous sclerosis, Sturge-Weber syndrome, cavernomas, and gangliogliomas, T2WI or susceptibility-weighted imaging (SWI) can aid (Table 1).

Table 1. MRI seizure protocol

T1WI	Isotropic 3D-sequence
FLAIR	Axial Coronal=perpendicular to temporal lobe
T2* or SWI	Susceptibility artifacts
CE T1WI	Brain tumor-Sturge Weber

Statistical analysis

The statistical package for social sciences (version 18 SPSS Inc., Chicago, IL, USA) software was used to evaluate the collected data using descriptive statistics (percentages and proportions). Before the study began, the K. S. Hegde Medical Academy, Nitte (Deemed to be University) gained ethical permission from the institutional ethics council.

Results

A total of 100 patients with the diagnosis of seizures underwent MRI examination for one year and six months of diagnosis. The age distribution of the subjects was: 19 children between the age group of 3 months-1 years, 42 cases between 2-6 years, 27 of 7-12 years, and 12 of 13-18 years. This distribution shows that the maximum number of patients (42.0%) were in the age group 2-6 years, followed by 27.0% patients in the age group of 2-12 years. Out of the total patient population, 59 males and 41 females were observed showing slight male predominance. Table 2 illustrates the patient distribution based on the clinical diagnosis of seizures. According to this data, 82 patients had generalised seizures, with 74 of them having tonic-clonic seizures, which is the most common type. It's also worth noting that just 18% of the patients had partial seizures.

Table 2. Distribution of patients on the basis of clinical diagnosis of seizures

Clinical Diagnosis	No. of Patients	Percentage
Generalized seizures	82	82
Tonic clonic	74	74
Myoclonic	4	4
Absence	3	3
Atonic	1	1
Partial	18	18
Total	100	100

On the basis of the patient's history and clinical examination, here, a majority of patients were found to be presented with a history of multiple episodes of seizure, *i.e.*, 96% of patients are presented with the first episode of seizure. Additionally, 20% of children are with a history of birth asphyxia, 24% with neonatal seizures, and 35% with developmental delay. Moreover, our analysis shows that the majority of patients (70%) with seizures were treated with single anti-epileptic drugs and found to be controlled. About 46% of children with seizures presented neurological deficits on examination, 6% reported neuro-regression, and 3% were syndromic

(Table 3). (Figure 1-6) shows MRI findings, which are used for diagnosis of neuronal migration defect, complex partial seizure, intracranial space-occupying lesion, hypotonic cerebral palsy with seizures disorder and secondary to neonatal hypoglycemia, and intracerebral bleed secondary to vascular malformation, respectively.

Table 3. Distribution of cases on the basis of history and clinical examination

History and Clinical examination	Number of patients
Number of episodes	96-Multiple episodes
Birth asphyxia	20
Neonatal seizures	24
Developmental delay	35
Anti-epileptic drug	70-Single AED 30-Multiple AED
Neurological deficit	46
Neuro regression	6
Syndromic	3

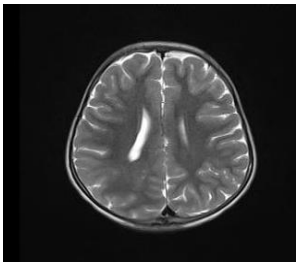

Figure 1. Asymmetric enlargement of right cerebrum, cerebellum, right-sided ventricle, patchy gyria in the right parieto occipital lobe–right hemimegaloencephaly

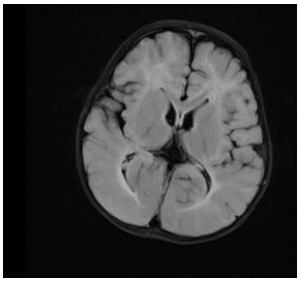

Figure 2. Bilateral frontoparietal thickened cortex and multiple small irregular gyrations and decreased sulcations. Features suggestive of frontoparietal polymicrogyria and pachygyria

Figure 3. Flair hyperintense signal changes in bilateral medial temporal lobes in the region of the hippocampus, which shows the reduced volume and thinning of the fornix on the right and atrophy of the mamillary body dilatation of the temporal horn of the right lateral ventricle. Features suggestive of mesial temporal sclerosis

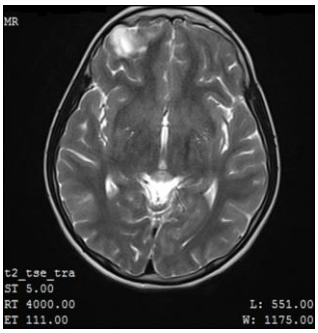

Figure 4. Altered signal intensity lesion with lobulated margins in the cortical and subcortical region of the right frontal lobe appearing hypointense on t1, hyperintense on t2 with the hyperintense rim on flair with no obvious post-contrast enhancement. Features suggestive of dysembryoplastic neuroepithelial tumor (dnet)

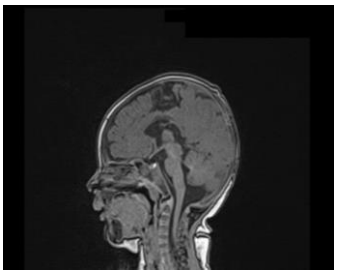

Figure 5. Gliosis of bilateral basal ganglia likely secondary to the old ischemic event with atrophy of cerebral cortex around Sylvian fissure and frontoparietal region

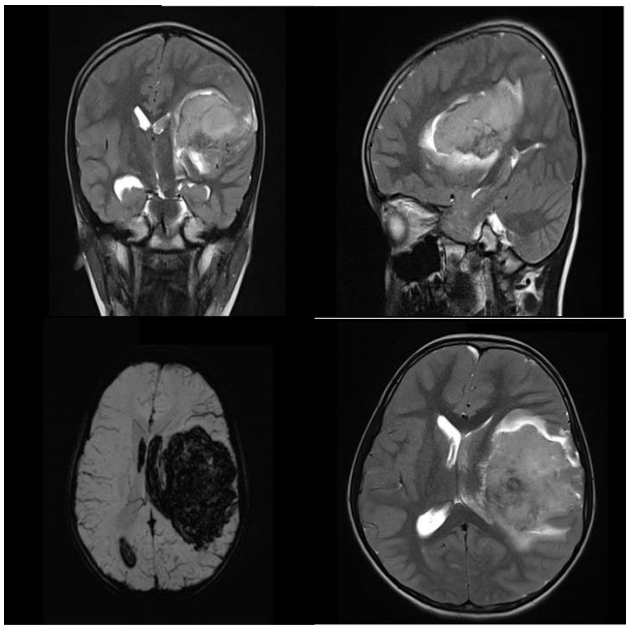

Figure 6. Altered signal intensity noted in the left temporoparietal lobe causing mass effect on ipsilateral lateral ventricle with minimal midline shift- suggestive of left temporoparietal hyper-acute hematoma with intraventricular extension. Enhancing vessels within the hematoma noted- vascular malformation

Nearly 82 patients with seizures out of 100 were characterized by abnormal EEG findings and 55 patients with abnormal MRI findings. It was seen that EEG and MRI have a positive association, *i.e.*, children who had EEG abnormality on seizure have also found abnormal MRI. About 58% of children with EEG abnormality had also found MRI abnormality. The distribution of patients based on MRI findings is represented in Figure 7. This distribution plot illustrates that all the children with abnormality were characterized by gliosis as a common

MRI finding (45.4%), followed by periventricular leukomalacia (12.7%), FCD, and Neurodegenerative changes in white/ grey matter with 7.3% each.

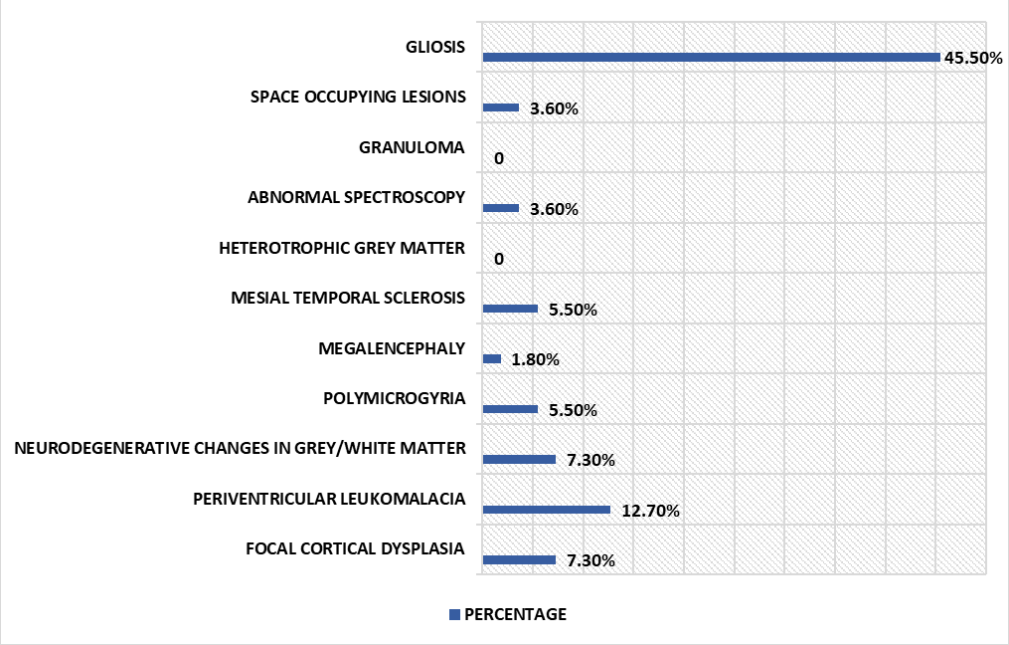

Figure 7. Distribution of patients based on MRI findings

Discussion

In India, seizure disorder, often known as epilepsy, is the second most frequent neurological illness after headache (7). There are no studies on the role of radio-imaging in seizure disorders in children in south India, particularly in the coastal region. MRI has been found to be efficient in the evaluation of brain structures and imaging the possible pathologies in the etiology of seizure disorder and other abnormalities in partial childhood epilepsy. MRI is highly sensitive and non-invasive neuroimaging, but it is expensive and not comfortably available. Because of the superior resolution, versatility, and lack of radiation, MRI is preferred over CT (4). This study was hospital-based, with a total of 100 patients who presented with seizures to the hospital. The clinical history of each patient was recorded, and as per the proforma, all underwent routine investigations. EEG was done on all patients. MRI scan was carried out using 1.5T Siemens Avanto Magnetom Scanner as per pediatric seizure protocol.

The average age of the children in our study was five years and nine months. The study conducted by Anand *et al*., (7) had a mean age group of four years and three months, which is comparable to our study when the age group is considered. Patients aged 2 to 6 years accounted for the greatest number of patients (42.0 percent), followed by those aged 7 to 12 years (27.0 percent). In India, seizure occurrence was higher in the first decade of life, according to incidence and prevalence studies (8,9). There were 59 men and 41 women among the 100 patients that took part in the study. In our investigation, there was a small male predominance. The maximum number of patients presented with generalized seizures i.e., 82 (82%) among which tonic-clonic type was a maximum of 74 (74%) patients. Only 18% of patients had partial seizures. Our findings are consistent with those of other studies from Africa (9) and India (10), which reveal a 60-90 percent prevalence of generalised tonic-clonic seizures (GTCS) (8). We found that majority of patients had a history of multiple episodes of seizure, i.e., 96%, patients presenting with the first episode of seizure. Among all the patients with seizure history, about 20% of children had a history of birth asphyxia; neonatal seizures history was present in 24% of children, developmental delay history was present in 35% of children. In our study, the seizure was controlled in the majority of patients with the use of a single anti-epileptic drug, *i.e.*, around 70% of children. About 46% of children presenting with seizures had a neurological deficit on examination, 6% had neuroregression, and 3% were syndromic.

Abnormal MRI findings varied between 28.5-55.86 %

in different studies done to evaluate neuroimaging findings in childhood seizure disorder (11,12,13). Resta *et al.*, (12) for example, found a 51.3 percent positive MRI. According to the above research, roughly 55% of children with seizure disorder exhibited aberrant MRI findings in our study. Here, among children who presented with seizures, 82% had EEG abnormalities, and 55% had MRI abnormalities which are in comparison to prior studies (12). In a study conducted by Fariba *et al*., (14), 71% of children had EEG abnormalities. It was seen that EEG and MRI had a positive association i.e., children who had EEG abnormalities on seizure have also had MRI abnormalities. MRI abnormalities were found in about 58.5 percent of children with EEG abnormalities, which was consistent with earlier research showing that MRI abnormalities are frequently related with abnormal EEG (15) EEG is useful in determining the cause of seizures, identifying syndromes, and predicting prognosis (16). Though the existence of an abnormal EEG in a patient may predict positive MRI findings, a normal EEG does not rule out brain abnormalities. This suggests that MRI has a better likelihood of detecting seizure focus than EEG alone, which is consistent with a previous study by Kuzniecky *et al*., (17). It's possible that EEG could be beneficial, but not by itself.

In various studies, there are considerable variances in the most common findings on MRI for various seizure disorders.In this study, among the children with abnormal finding gliosis was the most common MRI finding (45.4%), followed by periventricular leukomalacia (12.7%). Gliosis with or without encephalomalacia, periventricular leukomalacia (PVL), porencephaly, and atrophy are the brain's various responses to any form of damage, most commonly perinatal or infancy, but also later due to trauma, infection, infarct, or haemorrhage. The outcome of a perinatal brain injury is determined by the patient's gestational age, the duration and severity of the brain injury, as well as prenatal asphyxia, low birth weight (LBW), preterm, and pregnancy toxaemia as predisposing factors (18). Cerebral palsy, intractable seizures, and developmental delays are common symptoms of perinatal injury (20). Shinnars *et al*., (19) discovered abnormalities in 21 percent of children, with localised encephalomalacia being the most prevalent anomaly.Another study by Kalnin *et al*., found that ventricular enlargement was the most common aberration in 21 of 87 children with MRI abnormalities (51 percent). CNS tuberculosis was revealed to be the most common cause of epilepsy in a study by Rachna *et al.*, (Tuberculomas, 15.7 percent & TBM, 14.6 percent). Leukomalacia/gliosis was found to be in 23% of children in a study done by Kalnin *et al*., (20). In a study by Nathiya *et al*., (21), out of 42 children with abnormal MRI findings, 21.4% (n=9) had hypoxic-ischemic changes, and periventricular leucomalacia and is the commonest abnormality followed by other white matter lesions that constituted about 19%. This study was done on the south Indian population, mainly coming from the costal part. The most common abnormalities were gliosis and periventricular leukomalacia. Thus, improvements in perinatal care, hygiene, and socio-economic status can help in reducing the incidence and, thus, the morbidity associated with seizure in children.

Seizure disorder in children is the common disorder seen in clinical practice and in the assessment of these patients. MRI would be the ideal and first imaging modality of choice for pediatric seizure disorder because of lack of radiation exposure, excellent soft-tissue resolution, multi-planar imaging capabilities, and identification of subtle epileptogenic substrates. In detecting the underlying etiological component, MRI with adequate techniques is highly sensitive and specific. Not only for particular therapy and follow-up, but also for communicating the prognosis to the parents, determining the origin of seizure condition is critical. Hence we demonstrate the importance of MRI in the diagnosis of patients with pediatric seizure disorder.

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