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Original Research Article

Assessment of Paediatric Seizure Disorder using Magnetic Resonance Imaging of Brain

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Abstract:

Introduction: The clinical presentation and type of seizure disorder vary significantly with age and neurodevelopmental maturity. Magnetic resonance imaging (MRI) is the preferred modality for identifying underlying causes, particularly in partial seizures. It enhances the detection of intracranial lesions, especially vascular and meningeal abnormalities. This study aims to assess the role of MRI in evaluating paediatric seizure disorders.

Methodology: Seventy-five paediatric patients under 12 years presenting with generalized, partial, or absent seizures underwent MRI. Diagnosis relied on radiological features, supplemented by follow-up MRI and treatment response in inconclusive cases.

Result: Generalized seizures predominated (68%), compared to focal seizures (24%). MRI revealed abnormalities in the majority of cases (73.3%). Anoxia and hypoxic-ischemic encephalopathy (41.8%) were the most common aetiologies. Neoplasms were identified in 3 patients: 2 with unspecified types and 1 each with DNET and Pilocytic astrocytoma.

Conclusion: MRI plays a crucial role in diagnosing paediatric seizure disorders, facilitating accurate treatment decisions by identifying underlying causes.

Keywords: MRI, Paediatric, Seizures.

Introduction

A seizure is defined as a sudden, paroxysmal electrical discharge from the central nervous system (CNS) that results in involuntary motor, sensory, or autonomic disturbances, with or without changes in consciousness.

The clinical presentation and type of seizure disorder vary based on age and neurodevelopmental maturity. Approximately 5% of children are at risk of experiencing a seizure, with half of these cases occurring during infancy [1]. Given the concern over radiation exposure in infants and young children, computed tomography (CT) has largely been replaced by magnetic resonance imaging (MRI) in the evaluation of childhood epilepsy.

MRI is the preferred imaging modality due to its superior ability to visualize neuroanatomy, provide excellent grey-white matter differentiation, assess myelination status, and detect focal structural brain lesions. It is particularly effective in identifying the underlying causes of partial seizures, with increased sensitivity for detecting intracranial lesions, especially those of vascular origin or involving the meninges [2]. This study aims to evaluate the role of brain MRI in the assessment of paediatric seizure disorders.

Methodology

This study was conducted among children with seizures who were referred for MRI brain scans at the Radiology Department of a tertiary care hospital, Chengalpattu district, Tamilnadu. A total of 50 patients were evaluated, with appointments scheduled for non-emergency cases. Ethical clearance was obtained from both the Research and Ethical Committees of the institution.

Children under 12 years of age presenting with generalized, partial, or absent seizures were included in the study. And Patients unwilling to undergo MRI, unfit for MRI due to contraindications related to anaesthesia, Patients in poor general health requiring life support were excluded from the study.

Informed written consent was obtained from the parents or accompanying relatives. Prior to the MRI, patients were screened for the presence of any ferromagnetic objects. A thorough clinical history, including birth and vaccination history, family history, and past medical history, was recorded.

Important details such as the type and duration of seizures, associated symptoms, and physical examination findings, including neurocutaneous markers and a complete CNS examination, were noted. Relevant biochemical investigations were conducted, including a complete blood profile, liver and renal function tests, blood glucose, and electrolyte levels.

Additional laboratory tests for specific conditions such as leukodystrophies, serological studies for infections, and cerebrospinal fluid (CSF) analysis were performed when indicated. EEG and CT scan findings, if available, were also documented, and in some cases, EEG findings were correlated with MRI results.

All patients underwent MRI scanning using a Philips Achieva 1.5 Tesla scanner. Sedation was administered by an anaesthetist when necessary. Conventional MRI sequences were obtained in various planes.

Pulse sequences and imaging planes:

- T1 sagittal, axial pre- and post-contrast, and coronal post-contrast.
- T2 axial and coronal.
- FLAIR axial and coronal.
- DWI axial.
- GRE axial.
- T1 inversion recovery sequence.
- MR spectroscopy, MR venography, and MR angiography (TOF) when necessary.

The final diagnosis was based on radiological features. In inconclusive cases, a follow-up MRI and response to treatment were used to confirm the diagnosis. All MRI brain findings were recorded and analyzed for the study.

Results

This study prospectively evaluated the MRI brain scans of 50 paediatric patients, aged 0-12 years, who presented with seizure disorders. The study was conducted in the Radiology Department of a tertiary care hospital. Among the 50 patients, the largest group 27 patients (54%) were between 0-3 years of age. This was followed by 10 patients (20%) in the 4–6 year age group, 7 patients (14%) in the 7–9-year age group, and 6 patients (12%) in the 10–12 year age group. Thus, the majority of patients were infants and toddlers (0-3 years), followed by those in early childhood (4-6 years). The study population comprised 32 males (64%) and 18 females (36%), resulting in a male-to-female ratio of 2.2:1. Males were more commonly affected than females. Seizure disorders were classified based on the recommendations of the International League against Epilepsy (ILAE). Of the 50 patients, 30 (60%) presented with generalized seizures, making this the most common type. Additionally, 12 patients (24%) presented with focal seizures, while 8 patients (16%) had seizures of unknown onset. Generalized seizures were, therefore, the predominant presentation in this cohort.

MRI findings revealed abnormalities in 37 patients (74%), indicating the presence of detectable lesions or abnormalities associated with seizure activity. In contrast, 13 patients (26%) had normal MRI results, with no detectable brain lesions.

These results underscore the utility of MRI in identifying underlying causes or abnormalities in paediatric seizure disorders, although a normal MRI does not rule out the presence of a seizure disorder.

Table 1: Type of seizure and MRI abnormality

S.no	Seizure Type	Cases of seizure	MRI abnormality	%
1.	General	30	22	73%
2.	Focal	12	10	80%
3.	Unknown	8	5	63%

In this study, anoxia and hypoxic-ischemic encephalopathy (HIE) were the most common etiology, accounting for 43% of the cases. Malformations of cortical development (MCD) were observed in 22% of patients, followed by infections in 8%, phakomatoses in 7%, and mesial temporal sclerosis, inherited metabolic disorders, and neoplasms, each comprising 5% of the cases.

Vascular causes were rare, accounting for only 1% of patients. Thus, the most common cause of seizures in our cohort was anoxia and HIE, followed by malformations of cortical development. Mesial temporal sclerosis was found in 2 patients. Both exhibited hippocampal atrophy and secondary changes such as temporal horn dilatation. Additionally, both patients showed loss of hippocampal architecture and hyperintensity on T2 and FLAIR sequences. One of these patients also had persistent peritrigonal hyperintensities on T2W and FLAIR images, as well as chronic ischemic foci in the cerebellum, occipital regions, and periventricular white matter.

Malformations of cortical development were identified in 7 patients with seizures. Among these, focal cortical dysplasia (FCD) was the most common, present in 71% of patients. Other conditions included corpus callosal dysgenesis/agenesis (CCD/CCA), polymicrogyria, and heterotopia, each observed in 25% of patients. Pachygyria and hemimegaloencephaly (HMEG) accounted for 16%, while microcephaly was found in 5% of patients. Five patients had multiple pathologies. One case presented with unilateral perisylvian cortical dysplasia and polymicrogyria (Congenital Unilateral Perisylvian Syndrome), while another had Joubert syndrome, heterotopia, and pachygyria. Another patient displayed a combination of heterotopia, corpus callosum dysgenesis, focal cortical dysplasia, and HIE. One case involved hemimegaloencephaly, agyria-pachygyria, and polymicrogyria. Thus, focal cortical dysplasia was the most frequent pathology in patients with MCD. Among the 4 patients with phakomatoses, 60% were diagnosed with tuberous sclerosis (TS), making it the most common phakomatosis in this study. Three patients had inherited metabolic disorders, with one case each of neuronal ceroid lipofuscinosis and Zellweger syndrome.

Anoxia and HIE were responsible for seizures in 23 patients. Of these, 7 patients (30.4%) were preterm, while 16 (69.6%) were term based on clinical data. Neuroimaging findings in HIE primarily included periventricular leukomalacia, gliosis/ encephalomalacia with cystic changes, basal ganglia and thalamic lesions, and subcortical white matter involvement. Many patients had multiple findings, with periventricular leukomalacia being the most common, seen in 76% of cases. Gliosis/ encephalomalacia with cystic changes occurred in 51% of patients, and basal ganglia and thalamic lesions were noted in 40%.

Therefore, periventricular leukomalacia was the most prevalent neuroimaging finding in patients with anoxia and HIE. In patients with an infectious etiology, encephalitis was the most common pathology, followed by meningoencephalitis. Two patients were diagnosed with encephalitis, one of whom had basal ganglia and thalamic lesions. Temporal lobe lesions were observed in 60% of cases, while frontal, parietal, cerebellar, and brainstem lesions were seen in 31% of patients. The most frequent neuroimaging findings in encephalitis were basal ganglia/thalamic lesions and temporal lobe involvement. Among neoplasms, one patient each had dysembryoplastic neuroepithelial tumor (DNET) and pilocytic astrocytoma, making up 50% of neoplasm cases in this study. No cases of venous infarction, arteriovenous malformation, or cavernous angioma with developmental venous anomaly were detected. Leukoencephalopathy, cerebellar tonsil herniation through the foramen magnum, dilated Virchow-Robin spaces, and bilateral choroid plexus cysts were found in 22% of patients. Additionally, two patients exhibited multiple findings, including mild cerebellar atrophy, thinning of the corpus callosum, and bilateral choroid plexus cysts.

Discussion

This study prospectively evaluated MRI brain scans of 50 pediatric patients aged 0-12 years who presented with seizure disorders, highlighting the diverse etiologies and neuroimaging findings associated with this condition in a tertiary care setting. The demographic profile of our cohort showed a significant preponderance of males (64%) compared to females (36%), with a male-to-female ratio of 2.2:1, consistent with previous studies that indicate a higher incidence of seizure disorders in males during early childhood [3].

The age distribution of patients revealed that a majority were infants and toddlers (0-3 years), constituting 54% of the study population. This finding aligns with existing literature suggesting that the incidence of seizures is particularly high in the very young, likely due to the high prevalence of conditions such as neonatal seizures and developmental abnormalities during this critical period [4]. The classification of seizure types according to the International League against Epilepsy (ILAE) guidelines showed that generalized seizures were the most common, accounting for 60% of cases. This is consistent with other studies in the paediatric population where generalized seizures, including tonic-clonic seizures, are frequently observed [5,6].

Notably, MRI findings revealed abnormalities in 74% of patients, indicating a high diagnostic yield of neuroimaging in identifying underlying structural causes of seizures. The presence of detectable lesions emphasizes the importance of MRI in the evaluation of paediatric seizure disorders, although the 26% of patients with normal MRI results also suggests that a normal imaging study does not exclude the possibility of seizure disorders [7]. The most common etiology identified in this cohort was anoxia and hypoxic-ischemic encephalopathy (HIE), accounting for 43% of cases. This is consistent with the understanding that HIE remains a significant contributor to neurological deficits in the paediatric population, especially among infants [8]. Malformations of cortical development (MCD) were the second most common etiology, observed in 22% of patients, with focal cortical dysplasia being the most frequent subtype. This finding corroborates previous research indicating that MCDs are a prevalent cause of epilepsy in children [9]. The identification of mesial temporal sclerosis in two

patients further underscores the diversity of pathologies that can underlie seizure disorders in this age group [10].

In our study, neuroimaging findings in HIE primarily included periventricular leukomalacia, which was the most common finding (76%). This aligns with existing literature that recognizes periventricular leukomalacia as a frequent complication in infants with HIE [11]. The presence of gliosis and encephalomalacia with cystic changes in 51% of patients also reflects the typical sequelae associated with hypoxic injuries. In terms of infectious etiologies, encephalitis was the most common pathology, with temporal lobe lesions being prominently observed. This is consistent with findings from other studies that emphasize the role of viral infections, such as herpes simplex virus, in causing temporal lobe epilepsy. The absence of vascular anomalies such as arteriovenous malformations in our study supports the notion that structural brain abnormalities in the paediatric population are predominantly developmental or infectious in nature.

In conclusion, this study highlights the importance of MRI in evaluating paediatric seizure disorders, revealing a range of underlying etiologies with HIE and malformations of cortical development being the most common. The findings underscore the necessity for comprehensive imaging and clinical evaluation to guide appropriate management and intervention strategies for affected children.

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