Original Research Article

Role of Magnetic Resonance Imaging in Evaluation of Epilepsy

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Abstract

Introduction: Seizures have been classified in several ways, according to their etiology, i.e., idiopathic (primary) or symptomatic (secondary); their site of origin; their clinical form (generalized or focal); their frequency (isolated, cyclic, or repetitive, or the closely spaced sequence of status epilepticus); or their electrophysiologic correlates. Epileptic seizures are brief episodes of abnormal excessive or synchronous neuronal brain activity, characterized by typical ictal neurophysiological patterns and postictal and/or interictal abnormalities. Computed tomography introduced in 1973, with its widespread availability at emergent care facilities, rapid scan time, high sensitivity in detecting major abnormalities is widely used for screening patients with new-onset seizures. The present study is to evaluate the magnetic resonance imaging characteristics of epileptogenic substrates to identify the epileptogenic substrates based on imaging features, to assess the distribution of epileptogenic substrates, the diagnostic yield of magnetic resonance imaging and evaluate the role of magnetic resonance imaging in the pre-operative evaluation of patients with intractable epilepsy.

Material and methods: The present study was a prospective observational study, conducted in the Department of Radiodiagnosis and Imaging, GMC Srinagar J&K, MRI centre, Sheerin Bagh. Imaging was done with Magnetom Skyra, 3 Tesla Magnetic Resonance Imaging equipment from Siemens. All patients with magnetic resonance imaging reference for seizures at SMHS and Associated Hospitals between April 2017 to April 2018, irrespective of age and sex were included in the study. This was a type of purposive sampling.

Results: Majority of the patients were in the first two decades, the percentage of patients in the first decade being 29% and those in the second decade being 27%. Mesial temporal sclerosis was the most common abnormality identified in 29% of the study group. MRI was normal in 60 patients while abnormalities were identified in 90 patients of the study group. Among patients with partial seizures, 68 patients had lesions detected in magnetic resonance imaging. The diagnostic yield in the partial seizure group was 68%.

Conclusion: Magnetic resonance imaging should be considered in the initial evaluation of patients presenting with seizures, particularly with intractable partial seizures because of its high sensitivity for epileptogenic substrates, superior soft tissue contrast, multiplanar capability, lack of beam hardening artifact and lack of ionizing radiation.

Key words

MRI, Magnetic Resonance Imaging, Epilepsy, Evaluation.

Introduction

A seizure (from latin " to take possession of") is a paroxysmal alteration in neurologic function, resulting from abnormal excessive neuronal electrical activity arising in the gray matter of the cerebral cortex. Epilepsy is a chronic condition characterized by recurrent seizures unprovoked by an acute systemic or neurologic insult. Epilepsy usually requires long-term pharmacotherapy, or neurosurgical intervention in medically refractory cases [1]. Seizures have been classified in several ways, according to their etiology, i.e. ., idiopathic (primary) or symptomatic (secondary); their site of origin; their clinical form (generalized or focal); their frequency (isolated, cyclic, or repetitive, or the closely spaced sequence of status epilepticus); or their electrophysiologic correlates [2]. Seizures are symptoms of abnormal brain function and due to a diverse etiology. Western studies have shown about 4% of the population will have an unprovoked seizure by the age of 80 and treatment may reduce the chance of a second one by as much as 50% [3].

Epileptic seizures are brief episodes of abnormal excessive or synchronous neuronal brain activity, characterized by typical ictal neurophysiological patterns and postictal and/or interictal abnormalities [4]. The concept that brain lesions produce seizures is regarded to be true. The precise mechanism by which brain lesions produce seizures is not that clear. It is presumed that seizures arise from neurons that lie adjacent to a lesion that is rendered by several possible mechanisms susceptible to spontaneous coherent discharge [5, 6].

Prior to the advent of cross-sectional imaging, evaluation and classification of seizure patients was based on electroencephalography (electroencephalography) data and clinical findings. Although detection by electroencephalography of abnormal electrical activity remains the definitive means to document the presence of epilepsy, classification of seizures based solely on electroencephalography and clinical findings can result in the misclassification of some patients, particularly those with partial seizures that rapidly generalize. With surgical cure rates as high as 65% to 70% in patients with partial seizures that can be attributed to morphologic abnormality, such misclassification is not acceptable [7].

Computed tomography introduced in 1973, with its widespread availability at emergent care facilities, rapid scan time, high sensitivity in detecting major abnormalities is widely used for screening patients with new-onset seizures [8]. In a meta-analysis of epilepsy literature spanning 1988 to 1993, Greenberg and colleagues, found that 26% of patients with new-onset seizures have abnormal computed tomographic scans and those with a cancer history, age greater than 40, current treatment with anticoagulants, head trauma, a focal neurologic deficit, or persistent alteration in mental status would benefit from computed tomographic imaging [9]. Despite its utility in the acute setting, computed tomography has several drawbacks such as significant beam-hardening artifacts at the skull base, imaging only in the axial or oblique axial plane, poor sensitivity for subtle cortical and hippocampal abnormalities, which significantly limits its ability to characterize lesions. Hence, computed tomography has little role in the evaluation of chronic epilepsy [10].

Magnetic resonance imaging, the concept of which was introduced in 1936, and was initially used in basic science research, came into clinical practice with Lauterber's suggestion (1973), that position dependent encoding of magnetic resonance signal using gradients, can be used to generate images. With this the first magnetic imaging of human anatomy was done in 1976 and 1977 by two separate groups at Nottingham University. Since magnetic resonance imaging came into clinical practice in 1980s, it has been the preferred platform for evaluating diseases of the brain and spinal cord. [11]. Its advantages over computed tomography include superior contrast resolution, multiplanar imaging, absence of beam hardening artifacts and lack of ionizing radiation. These advantages result in better detection of small lesions, improved differentiation between gray and white matter structures and better visualization of hippocampus, all of which are critically important in epilepsy imaging [12].

Overall, magnetic resonance imaging is the preferred imaging tool for detecting the structural abnormalities that can result in seizure activity. The present study is to evaluate the magnetic resonance imaging characteristics of epileptogenic substrates to identify the epileptogenic substrates based on imaging features, to assess the distribution of epileptogenic substrates, the diagnostic yield of magnetic resonance imaging and evaluate the role of magnetic resonance imaging in the pre-operative evaluation of patients with intractable epilepsy.

Materials and methods

The present study was a prospective observational study, conducted in the Department of Radiodiagnosis and Imaging, GMC Srinagar J&K, MRI centre Sheerin Bagh. Imaging was done with Magnetom Skyra, 3Tesla Magnetic Resonance Imaging equipment from Siemens.

All patients with magnetic resonance imaging reference for seizures at SMHS and Associated Hospitals between April 2017 to April 2018, irrespective of age and sex were included in the study. This was a type of purposive sampling. Patients with history of metabolic disturbances (hepatic / renal failure etc.), pediatric patients with febrile seizures, were excluded from the study.

As per the "International League against Epilepsy Guidelines for Neuro-imaging in the Epilepsy patients (1997)" which recommends a dedicated epilepsy protocol magnetic resonance imaging for all patients with new onset seizure or newly diagnosed epilepsy in the non-emergent setting, the study group was imaged using EPILEPSY PROTOCOL, which consists of the following sequences: T2 Axial Fast Spin Echo (Fse), Fluid Attenuated Inversion Recovery Sequence(Flair) – Axial, Diffusion Weighted Sequence (Dwi), T1 Inversion Recovery (Ir) Sequence – Axial, T1 Inversion Recovery (Ir) Coronal Oblique – 3 Mm Slices, T2 Coronal Oblique – 3 mm Slices, T1 Spoiled Gradient Recalled Echo – Sagittal and [3d Magnetization Prepared Rapid Gradient Echo (Mprage)]. Gadolinium was used when a focal lesion/ tumor/ Sturge-Weber syndrome was detected. The magnetic resonance scans were reviewed and the findings were recorded in a preformed proforma.

Results

The present study was conducted in a study population of 150 patients, who presented with history of seizures and underwent magnetic resonance imaging.

Table – 1: Age and gender distribution of subjects.

Age-Group (Years)	No. of Patients	Percentage Distribution
0-10	44	29%
11-20	40	27%
21-30	31	21%
31-40	19	13%
41-50	9	6%
51-60	5	3%
61-70	2	1%
Male	**91**	**60.67%**
Female	**59**	**39.33%**
Total	**150**	

Table - 1 presents the age distribution of all study subjects with male and female distribution.

In present study, majority of the patients were in the first two decades, the percentage of patients in the first decade being 29% and those in the second decade being 27%. **Table - 2** presents the MRI findings associated with epileptogenic substrates. The epileptogenic substrates were identified on the basis of the signal intensities and morphological abnormalities seen on magnetic resonance imaging**.**

Figure - 1 presents the percentage distribution of epileptogenic substrates. In our study, mesial temporal sclerosis was the most common abnormality identified in 29% of the study group, followed by gliosis seen in 27% of the seizure patients.

Table - 2: MRI findings associated with epileptogenic substrates.

T1- W image	T2- W image	FLAIR	IR	SPGR	Post contrast	Epileptogenic substrate
Hypointense signal in hippocampus Volume loss in hippocampus	Hyperintense signal in hippocampus Volume loss in hippocampus	Hyperintense signal in hippocampus	Loss of architecture in hippocampus	---	---	Hippocampal sclerosis
Hypointense	Hyperinense	Hypointense	---	---	---	Gliosis
Hypo-to-isointense	Hypointense with edema	---	---	---	Ring enhancement	Tuberculoma
Hypo/ hyperintense	Hyperintense with edema	---	---	---	Ring enhancement, scolex seen	Neurocysticer cosis
Hypo-to-isointense	Homogenous high signal / variable signal	---	---	---	Variable/ irregular enhancement	Low grade glioma
---	---	---	---	Cleft dimple complex	---	Focal cortical dysplasia
Focal round, linear, serpentine flow voids seen	Focal round, linear, serpentine flow voids seen	---	---	---	Nidus/venous side of the lesion enhances	Arteriovenous malformation
Focal central heterogeneity with hypointense rim	Focal central heterogeneity with hypointense rim	---	---	---	Enhancement seen	Cavernous angioma

Table - 3: Epileptogenic substrates.

Epileptogenic substrate	**No. of patients**	**Percentage Distribution**
Mesial temporal sclerosis	26	29%
Gliosis	24	27%
Infectious etiology	19	21%
Tumors	12	13%
Malformations of cortical development	8	9%
Vascular malformation	1	0.01%
Total	**90**	---

Table – 4: Findings on magnetic resonance imaging.

MRI features	**No. of patients**	**Percentage distribution**
Normal magnetic resonance imaging	60	40%
Magnetic resonance imaging with findings	90	60%
Total	**150**	---

Table - 5: Findings in patients with partial and generalized seizures.

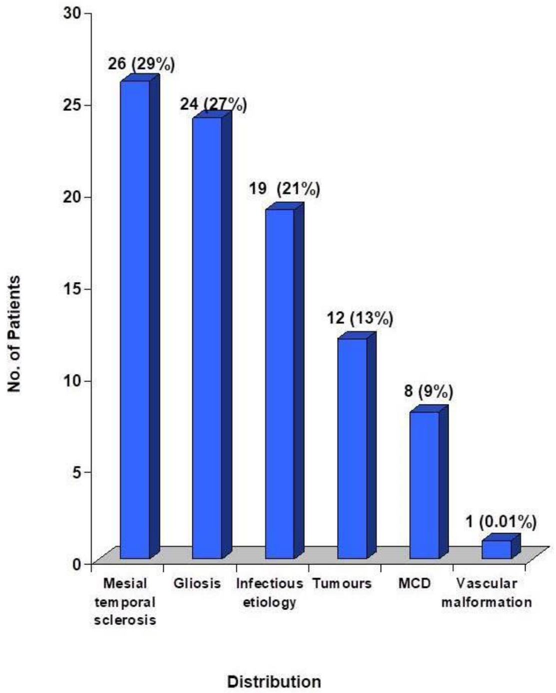
MRI features	**Partial seizure group**	**Generalized seizure group**
MRI with findings	68	23
Normal MRI	32	27
Total	**100**	50

Table – 6: Correlation of EEG and MRI findings in patients with partial seizures.

EEG and MRI correlation	**No. of patients**	**Percentage distribution**
Non-lateralizing	**35**	**53%**
Concordant	**19**	**27%**
Multifocal	**12**	**17%**
Discordant	**2**	**5%**
Total	**68**	---

Table - 3 illustrates the epileptogenic substrates, in the present study, mesial temporal sclerosis was the most common abnormality identified in 29% of the study group, followed by gliosis seen in 27% of the seizure patients. **Table - 4** shows the findings on magnetic resonance imaging. MRI was normal in 60 patients while abnormalities were identified in 90 patients of the study group. **Table - 5** shows the findings in patients with partial and generalized seizures. Among patients with partial seizures, 68 patients had lesions detected in magnetic resonance imaging. The diagnostic yield in the partial seizure group is 68%. In the generalized seizure group, lesions were identified in 23(46%) patients. **Table - 6** shows the correlation of EEG and MRI findings in patients with partial seizures, most of the electroencephalographic data was concordant in patients with mesial temporal sclerosis.

Figure – 1: Epileptogenic substrates.



Discussion

Magnetic resonance imaging has become indispensable in the diagnostic work-up of epilepsy patients, who present with recurrent seizures, which is amenable to both medical and surgical treatment. About 15-30% of patients with partial seizures are refractory to pharmacotherapy, which mandates the need to evaluate these patients with imaging studies to identify possible structural abnormalities which may be responsible for seizures [13, 14, 15]. Identification of a structural substrate on magnetic resonance imaging, guides further management, as the chance of being considered for surgical treatment is greatly enhanced when a structural abnormality is found on magnetic resonance imaging [16, 17, 18].

In the present study which included one hundred and fifty epilepsy patients who underwent epilepsy protocol magnetic resonance imaging. Out of the 150 patients, the majority of patients belonged to the first two decades, the percentage being 29% in the first decade and 27% in the second decade [19]. Previously researchers have categorized the cause of epilepsy by the age of seizure onset, in which majority are in the first two decades, similar to our study. About 91(60.67%) were males and 59(39.33%) were female patients. The results of the present study included 100 patients with partial seizures and 50 patients with generalized seizures. Hippocampal sclerosis was diagnosed based on the principal findings of volume loss and abnormal signal in the hippocampus with identification of loss of hippocampal architecture on inversion recovery sequence [17, 20, 21, 22].

In the present study, hippocampal sclerosis was identified in 26(29%) patients. Similar, results were shown by Lefkopoulos, et al. in their study of 120 patients with refractory seizures [23]. In the partial seizure group, the incidence of hippocampal sclerosis is 38% similar to the incidence found by Hui, et al. in their study of 100 patients with refractory partial seizures. Minor findings such as atrophy of the ipsilateral fornix and mammillary body, ipsilateral dilatation of the temporal horns were also identified in our patients. [24]. Associated involvement of the anterior temporal cortex was seen in one of the patients. This is significant because seizure-free surgical outcome is significantly better in isolated hippocampal atrophy [25]. In the present study majority of patients with hippocampal sclerosis were in their second and third decades with few cases seen in the first decade, similar to the study done by Bronen [19].

In our study, gliotic changes which occur as a consequence of infarction, trauma, infection was the second most common lesion, identified in 24(27%) of the patients. In magnetic resonance imaging, gliotic areas follow cerebrospinal fluid signal intensity on all pulse sequences. Hui, et al. in their study of 100 patients with intractable epilepsy had found gliosis in 30% of patients, being the second most common finding next to hippocampal sclerosis, similar to our study [24]. Rajasekhar V. has reported increased frequency of neurocysticercosis than tuberculoma in our country in patients with seizures. In our study also, we found neurocysticercosis to be more common than tuberculoma [26]. In our study, among the 89 patients with positive magnetic resonance imaging, tumors were identified as the focal epileptogenic substrate in 12(13%) of the patients. Magnetic resonance has nearly 100% sensitivity for identifying neoplastic lesions [21]. Out of these 12 patients, 7(8%) had low grade glioma showing variable/irregular contrast enhancement. Malformations of cortical development were identified in 8(9%) patients of the study group in their first decade, with subependymal heterotopia detected in 2(2%), hypothalamic hamartoma in (2%) patients. Lissencephaly, pachygyria/ polymicrogyria, cortical dysplasia and tuberous sclerosis were each identified in one patient.

In our study, only one patient with cavernous angioma presenting with focal seizure was identified. Two children who had history of gelastic seizures had hypothalamic hamartoma. Vascular malformations most commonly presenting with seizures include cavernous angioma and arteriovenous malformations. Medial temporal lobe pathology was identified in 29% of patients and extra-hippocampal lesions in the rest 71%.The electroencephalography data was non-lateralising in 35, concordant in 19, multifocal in 12, and discordant in 2 patients. Concordance was seen in most patients with mesial temporal sclerosis. A study by Hui, et al.

on patients with refractory partial seizures has shown similar results [24]. Electroencephalography tells us that a seizure focus is present in the brain. It can also localize the focus as well as help to classify the seizures. However, it cannot characterize the underlying structural abnormality which may be responsible for seizure in patients with partial epilepsy. The diagnostic yield of magnetic resonance imaging depends on many factors, one being the patient population it is applied to. The highest yield (65-83%) in detecting epileptogenic lesions is observed in patient groups with intractable partial epilepsy who are considered candidates for surgery [23, 27].

In our study, the diagnostic yield of magnetic resonance imaging in the partial seizure group is 68% similar to the results obtained by Hui, et al. [24]. The most common lesion identified in patients with intractable epilepsy being hippocampal sclerosis followed by gliosis [24]. The localization of seizure focus can be made by clinical symptoms, electroencephalography, computed tomography, magnetic resonance imaging, functional magnetic resonance imaging, SPECT, and PET studies. No single modality among these can definitively identify the seizure focus, especially those who are planned for epilepsy surgery, and hence a combination of these should be used [16].

Computed tomography is widely available, very useful in the emergent setting, can detect major structural abnormalities and calcifications, but its sensitivity in the detection and characterization of subtle cortical abnormalities, hippocampal lesions which is important in epilepsy imaging , and detection of posterior fossa lesions is low. Magnetic resonance imaging with its superior soft tissue contrast, multiplanar imaging capability, lack of beam hardening artifact is more sensitive in picking up subtle cortical abnormalities, hippocampal lesions as well as characterizing lesions such as different types of tumors, infections with its advanced applications. Functional magnetic resonance imaging, SPECT and PET also help to localize the seizure focus. They are complementary to magnetic resonance imaging [19].

However, their availability restricts their routine usage, though they can be used in (1) patients with abnormal magnetic resonance imaging with non-localising electroencephalography or discordant clinical semiology and/or electroencephalography findings and/or electroencephalography findings, (2) multifocal magnetic resonance imaging (tuberous sclerosis), (3) normal magnetic resonance imaging with abnormal electroencephalography [5].

From our study, we found that magnetic resonance imaging along with clinical history and electroencephaography should be used in the initial assessment of patients who are considered surgical candidates, since the presence of focal and, in particular, medial temporal lobe pathology increases the chances of progression to successful surgical treatment.

Conclusion

The results of the present study concludes that Magnetic resonance imaging should be considered in the initial evaluation of patients presenting with seizures, particularly with intractable partial seizures because of its high sensitivity for epileptogenic substrates, superior soft tissue contrast, multiplanar capability, lack of beam hardening artifact and lack of ionizing radiation.

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