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Original Research Article

Role of magnetic resonance imaging in the evaluation of seizures

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ABSTRACT

Background: A seizure is a clinical condition caused by a transitory event of unusual unrestrained or recurring neuronal activity in the brain. Repeated unprovoked seizures are described as epilepsy. Seizures and epilepsy are major public health problems in developing countries like India with a serious impact on patients and society. The objective of the present study is to evaluate the magnetic resonance imaging (MRI) findings in patients with seizures.
Methods: This cross-sectional observational study was conducted in the Department of Radiodiagnosis and Imaging, Government Medical College, Jammu on 125 patients referred with clinical features of seizures.
Results: In the present study, MRI findings were normal in 58 (46.4%) cases and revealed a spectrum of abnormalities in 67 (53.6%) cases. Out of 67 abnormal MRI findings, the common abnormalities noted were – neurocysticercosis (NCC) in 11 patients(8.8%), tuberculoma in 9 patients (7.2%), tumors in 7 patients (5.6%), hypoxic ischemic insult in 8 patients (6.4%), developmental cortical malformations in 6 patients (4.8%), encephalitis in 4 patients (3.2%), phakomatosis in 5 patients (4.0%), chronic infarct in 4 patients (3.2%), traumatic brain injury in 3 patients (3.2%), cavernoma in 2 patients (1.6%), mesial temporal sclerosis in 2 patients (1.6%), cerebral abscess in 2 patients (1.6%), and metabolic cause, multiple sclerosis, arterial infarct, and venous thrombosis, in one patient each respectively.
Conclusions: From our study, it could be concluded that MRI has an outstanding place in the evaluation of patients presenting with seizures. The findings of the present study will be valuable in epilepsy management in developing country like ours and MRI will emerge as a beam of light amidst a storm of myth for patients with seizures.

Keywords: Seizures, MRI, Neurocysticercosis, Tuberculoma, Hypoxic ischemic insult, Imaging protocols

INTRODUCTION

A seizure is a clinical condition caused by a transitory event of unusual unrestrained or recurring neuronal activity in the brain.[1] Repeated unprovoked seizures are described as epilepsy. The international league against epilepsy (ILAE) proposed that epilepsy be considered to be a disease of the brain defined by any of the following conditions: at least two unprovoked seizures occurring >24 hours apart; or one unprovoked seizure and a probability of further seizures similar to the general recurrence risk (at least 60%) after two unprovoked seizures, occurring over the next 10 years; or diagnosis of an epilepsy syndrome.

Seizures and epilepsy are crucial public health issues in developing countries like India causing a significant impact on patients and society. In India approximately 12 million people are suffering from epilepsy contributing to one-sixth of global burden. The prevalence of epilepsy in India is 3.0 to 11.9 per 1000 population and the incidence has reported to be 0.2 to 0.6 per 1000 population.[2] The foremost role of brain imaging in new-onset seizures is to find out whether an intracranial lesion is the source of seizure activity. In the emergency setting, computed tomography (CT) is suitable for evaluation of symptomatic patients with new-onset seizures. Magnetic resonance imaging (MRI) has surfaced as an invaluable diagnostic modality for preoperative localization of epileptogenic

focus because of its outstanding soft-tissue contrast, comprehensive portrayal of the anatomy, multiplanar imaging, lack of ionizing radiations, and absence of beam–hardening artifact in the basal brain that occur with CT.[3] MRI has been advocated as the primary imaging modality in evaluating patients with seizures and epilepsy by the National Institute of Health and Clinical Excellence (NICE) guidelines. The objective of present study is to determine the spectrum of findings in patients with seizures.

METHODS

This cross-sectional observational study was conducted in the Department of Radiodiagnosis and Imaging, Government Medical College, Jammu on 125 patients referred with clinical features of seizures from August 2020 to September 2021. Informed consent was taken from the patients. Patients with contraindication to MRI studies such as patients with pacemaker, metallic implants, aneurysmal clips and claustrophobia were excluded from the study.

MRI was performed using 1.5 Tesla (Siemens, Symphony) MR system using standard head coil and a dedicated epilepsy protocol with the following sequences: T_1 weighted imaging -sagittal, axial, coronal; T_2 weighted imaging -axial, coronal; fluid attenuated inversion recovery (FLAIR) - axial, coronal; three dimensional T_1 weighted GRE isotropic sequence (magnetization prepared rapid acquisition GRE); diffusion weighted images (DWI) and apparent diffusion coefficient (ADC) – axial; gradient echo images–axial; and post contrast T_1 weighted - axial, sagittal, coronal, when required. Intravenous contrast (gadolinium) in the dose of 0.1 mmol/kg body weight for contrast enhanced study was given, when indicated.

Data was analysed using Microsoft Excel 2007.

RESULTS

We studied 125 patients who presented with the clinical diagnosis of seizures as per criteria laid down by the International League Against Epilepsy (ILAE) 1981. Maximum number of patients presented with generalized tonic clonic seizures (GTCS), followed by focal seizures, myoclonic seizures, temporal lobe seizures, absence seizures, febrile seizures, tonic-clonic seizures, and tonic seizures in descending order (Table 1). Out of the total patients included 71 were males and 54 were females (Figure 1). The age range of patients was from neonate to 80 years (Figure 2). In the present study, the common etiologies of seizures were – neurocysticercosis (NCC), tuberculoma tumors, hypoxic-ischemic insult, developmental cortical malformations, encephalitis, phakomatosis, chronic infarct, traumatic brain injury, cavernoma, mesial temporal sclerosis, cerebral abscess, metabolic cause, multiple sclerosis, arterial infarct, and venous thrombosis (Table 2).

Table 1: Distribution of patients based on clinical diagnosis of seizures.

Clinical diagnosis	Number of patients	Percentage
Generalized tonic-clonic seizures	95	76
Focal seizures	11	8.8
Absence seizures	3	2.4
Myoclonic seizures	6	4.8
Temporal lobe seizures	4	3.2
Febrile seizures	3	2.4
Tonic-clonic seizures	2	1.6
Tonic seizures	1	0.8

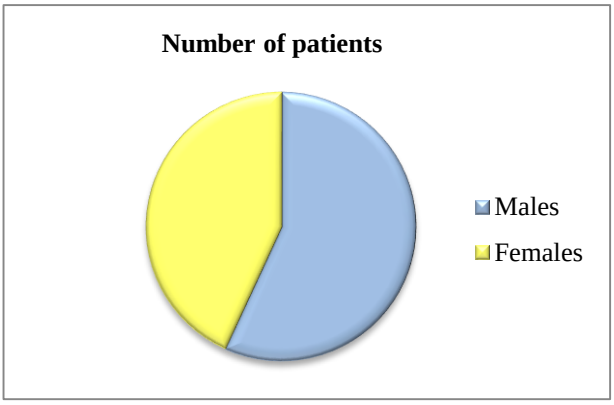

Figure 1: Sex-wise distribution of patients presenting with seizures.

Table 2: Distribution of patients based on MR findings.

MR findings	Number of patients	Percentage
Normal	58	46.4
Neurocysticercosis	11	8.8
Tuberculoma	9	7.2
Hypoxic-ischemic injury and its sequelae	8	6.4
Tumors	7	5.6
Developmental malformations	6	4.8
Phakomatoses	5	4.0
Encephalitis	4	3.2
Chronic infarct	4	3.2
Traumatic brain injury	3	2.4
Cavernoma	2	1.6
Cerebral abscess	2	1.6
Mesial temporal sclerosis	2	1.6
Arterial infarct	1	0.8
Multiple sclerosis	1	0.8
Venous thrombosis	1	0.8
Metabolic	1	0.8

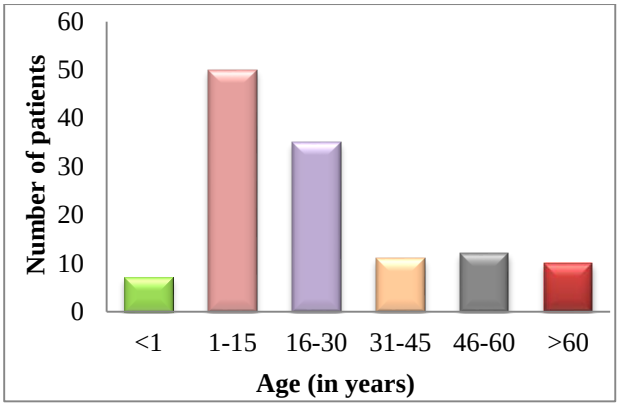

Figure 2: Age-wise distribution of patients presenting with seizures.

DISCUSSION

MRI has revolutionized neuroimaging and has emerged as the premier imaging modality in patients with seizures. The diagnostic yield of the present study was high, detecting epileptogenic lesions in approximately half of the patients with seizures. Similar diagnostic yield of 48% and 43% was reported in studies by Forsgren et al and Pohlmann-Eden and Schreiner.[4,5]

Our study correlates with the study done by Hirani and Shrivastva, and Kaur et al in which generalized seizures constituted the major seizure group, being present in as many as 50% and 59% of patients respectively.[6,7] Slight male preponderance was noted with male to female ratio of 1.3:1. Literature also reported mild to moderate preponderance of males, as seen in studies by Hirani and Shrivastva, (1.17:1), Muralidhar and Venugopal, (2.12:1).[6,8] The maximum number of patients in this study i.e., 50 (40%) were in the age group of 1-15 years, followed by 35 (28%) in the age group of 16 to 30 years. Similarly in studies by Hirani and Shrivastva, (54%) Murlidhara and Venugopal, (64%), the highest proportion of patients were also aged <40 years.[6,8]

In the current study, the collective prevalence of infective etiology was observed as 20.8%, among which NCC was observed in 8.8%, tuberculoma in 7.2%, encephalitis in 3.2%, and cerebral abscess in 1.6%. Our study revealed more incidence of neurocysticercosis than tuberculoma. Quraishi et al reported that among neuro-infections causing seizures, tuberculoma was the most common (36.8%), followed by neurocysticercosis (31.5%), meningitis (15.8%).[9] Similarly, the incidence shown for tuberculoma and neurocysticercosis in studies done by Pannag and Ravi, was (9.7%) and (2.4%), Kaur et al (6.9%) and (4.5%) and Sinha et al (7%) and (4.6%) respectively.[7,10,11] The studies conducted by other developing countries such as Nigeria and Africa also demonstrated similar findings. Such findings could be attributed to the low socio-economic status of people, poor hygiene and lack of proper sanitation facilities, still on the loose in developing countries.

In the present investigation eleven patients (8.8%) showed evidence of NCC. Four patients had parenchymal form of NCC with ring-enhancing lesions in cerebral hemispheres, six patients had subarachnoid form of NCC, while one patient had both parenchymal and subarachnoid forms. The lesions showed T1W hypointense and T2W hyperintense contents. Few lesions showed perilesional edema evident on T2W and FLAIR sequences as surrounding hyperintense signal, suggestive of active disease, and few were calcified as seen on SWI images as blooming with negative signal on reverse phase images, suggesting inactive lesions (Figure 3) Most of the lesions were seen in parietal lobe, followed by frontal lobe. Seven patients had single ring-enhancing lesion and five patients had multiple lesions. Similar findings were noted by Tushar and Patil, who studied 40 patients with probable diagnosis of NCC and revealed that 72% of patients showed one lesion and multiple lesions were seen in 27% patients, and the common site was parietal lobe (4%).[12] Pannag and Ravi, and Sinha et al found that isolated NCC was found in 2.4% and 4.6% patients respectively in their studies which was less than that seen in our study.[10,11]

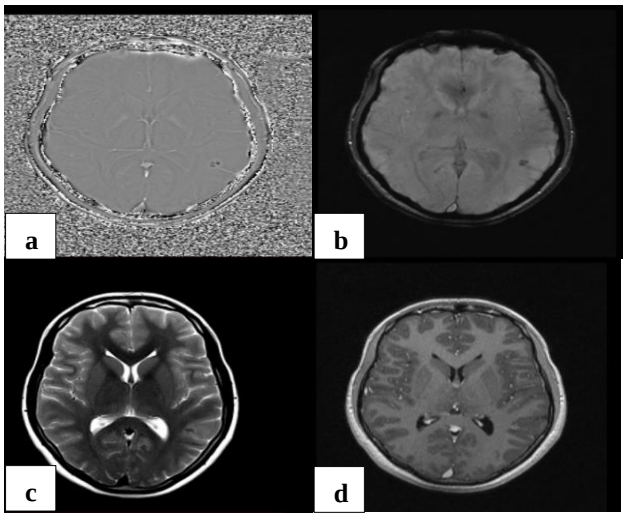

Figure 3: (a) and (b) SWI axial images show calcification in left parietal region, (c) T2W axial image shows no perilesional edema, and (d) MPRAGE axial image shows ring enhancement, findings consistent with calcified stage of NCC

In this study, 7.2% patients were diagnosed as having tuberculoma on MRI. Four patients had two to four lesions, whereas multiple lesions were also seen in four patients and one patient had a single lesion. Some lesions were hypointense to isointense on T1W and hyperintense on T2W images suggestive of noncaseating granulomas; and some lesions were iso to hypointense on both T1W and T2W images suggesting caseating granulomas. The lesions were well defined, rim enhancing, conglomerate with thick wall of different sizes. The lesions showed perilesional edema on T2W and FLAIR images and on MRS revealed elevated lactate, lipid peak (Figure 4). Similar findings were seen by Kanitkar et al and Quraishi et al who reported that among neurogenic infections

causing seizures, tuberculoma was found in 60% and 36.8% respectively.[9,13]

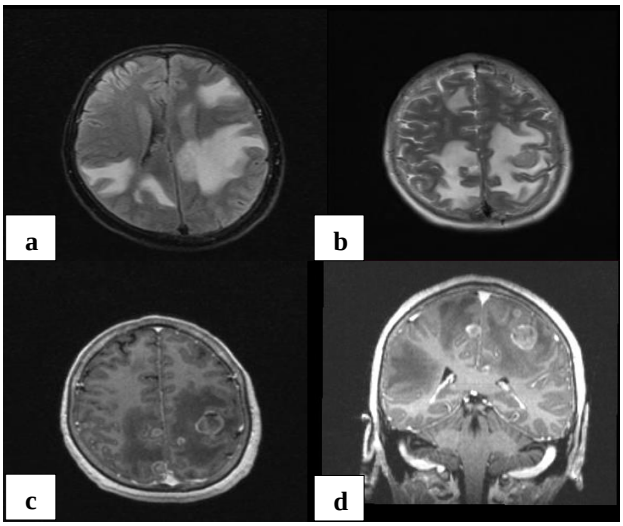

Figure 4: (a) IR axial, and (b) T2W axial images show multiple T2 hypointense lesions with surrounding edema in bilateral cerebral hemispheres, (c) and (d) post contrast images show ring enhancement in these lesions, MRS revealed lipid peak; with clinical and laboratory correlation, diagnosis of tuberculoma was made.

The most common cause of seizures in pediatric patients was perinatal hypoxic-ischemic brain injury and its sequelae, seen in 6.4% patients. Four patients had periventricular leukomalacia characterized by thinning of the periventricular white matter seen as increased signal on T2W and FLAIR sequences in the periventricular region suggesting periventricular gliosis. Thinning of corpus callosum and irregularity of margins of body and trigone of lateral ventricles was also noted. Two patients had features of cystic encephalomalacia characterized by cystic lesions within the cerebral white matter, showing signal intensity similar to CSF on all pulse sequences with ex –vacou dilation of the lateral ventricles (Figure 5). One patient showed areas of encephalomalacia with gliosis in bilateral occipital regions suggestive of ulegyria and one patient had T2W and FLAIR hyperintense lesions in MCA-PCA watershed territory. Similar findings were noted in a study conducted by Sahdev et al in which hypoxic ischemic encephalopathy (HIE) was noted in 4.7%, patients.[14] Similarly, in a study conducted by Umap et al in the age group of 0-12 years, the most common etiology of seizures was anoxia and hypoxic ischemic encephalopathy (31.5%).[15]

In the present study, tumors were seen in seven patients (5.6%). Oligodendroglioma (ODG) and low-grade glioma were seen in two patients each, while glioblastoma multiforme (GBM) was noted in one patient. Metastasis and meningioma were also noted in one patient each. Three patients showed a lesion in the right frontal region and three patients in the left frontal region. The lesions were hypointense on T1W and hyperintense on both T2W and FLAIR sequences. Oligodendrogliomas showed cortical-subcortical location with evidence of calcification and no significant peritumoral edema, no post-contrast enhancement but with choline peak on MRS. GBM showed significant perilesional edema and mass effect on T2W and FLAIR images with post-contrast ring enhancement and choline peak on MRS. Metastasis was noted in both cerebral hemispheres and revealed post-contrast ring enhancement and choline peak. Meningioma was seen as an extra-axial intensely homogeneously enhancing lesion in the right frontal lobe with a dural tail. In studies by Abud et al and Sachdev et al, the spectrum of epilepsy-associated tumors comprises gangliocytoma, dysembryoplastic neuroepithelial tumor (DNET), pleomorphic xanthoastrocytoma (PXA), pilocytic astrocytoma, and oligodendroglioma).[16,17]

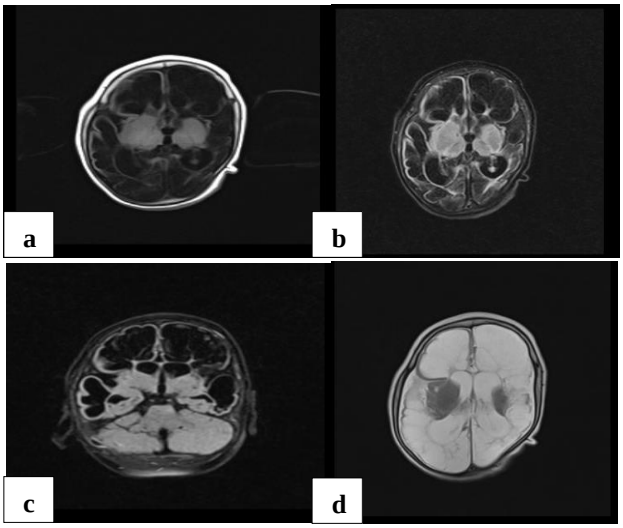

Figure 5: (a) T1W axial, (b) IR axial, (c) IR coronal, and (d) T2W axial images show areas of cystic encephalomalacia; with clinical correlation, findings were consistent with sequelae of hypoxic ischemic injury.

Developmental cortical malformations were noted in six patients (4.8%). Three patients revealed schizencephaly, two of which had grey matter lined cleft in the right frontal lobe and one had grey matter lined clefts in bilateral frontal lobes with absent septum pellucidum and small right optic chiasma suggestive of associated septo–optic dysplasia. Two patients revealed heterotopias, one of them showed a large subcotical nodular mass isointense to cortical grey matter in the right frontotemporal region, and the other had subependymal nodules isointense to grey matter with associated corpus callosum agenesis. One patient showed lobar holoprosencephaly characterized by the fusion of frontal horns of lateral ventricles. Similar results were seen in studies by Singh et al and Chabarwal et al in which cortical malformations were seen in 3.64% of cases in both studies.[18,19] Sanghvi et al studied 76 children with seizures and found that 19 cases revealed corpus callosal dysgenesis, 9 patients with lissencephaly, and 9 patients

with focal cortical dysplasia, 6 patients with pachygyria, 3 patients with polymicrogyria.[20]

In the present study, five patients (4.0%) had various phakomatosis. Out of the five patients, one patient revealed MRI features of Sturge-weber syndrome (SWS) showing leptomeningeal hyperintensity on T2W and FLAIR images in the right parietooccipital region with intense pial enhancement in these regions along with enlarged ipsilateral choroid plexus and dilated transependymal veins in this region. Another three patients out of the five had features of tuberous sclerosis showing cortical/subcortical tubers which had high T2W and low T1W signal, radial bands appearing as linear regions of T2W and FLAIR hyperintense signal from periventricular white matter to the subcortical region, and subependymal nodules showing calcification on SWI (Figure 6). Another one patient had neurofibromatosis type 1 showing focal areas of signal intensity (FASI) in deep white matter and basal ganglia.

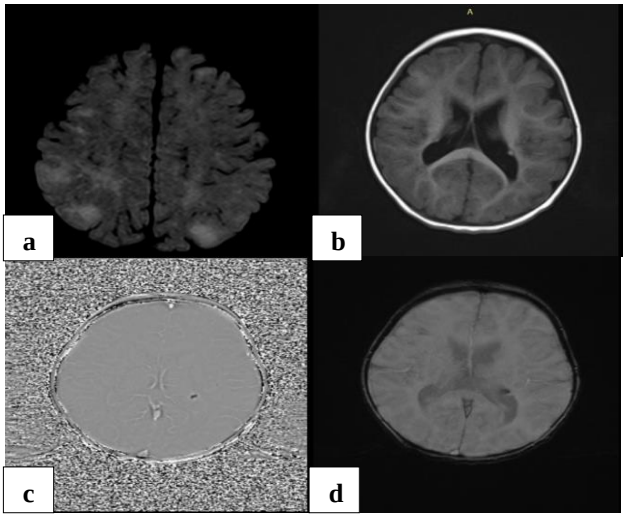

Figure 6: (a) IR axial image showing cortical/subcortical tubers and radial bands, (b) T1W axial, (c), and (d) SWI axial images show a small calcified subependymal nodule along left lateral ventricle, findings are consistent with tuberous sclerosis.

Mesial temporal sclerosis (MTS) was seen in two patients (1.6%). Both patients had features of unilateral MTS. Reduced hippocampal volume with secondary enlargement of the temporal horn of lateral ventricle and increased signal intensity in the hippocampus on T2W and FLAIR sequences was noted, reflecting gliosis (Figure 7). Atrophy of the ipsilateral fornix and mamillary body was also noted. The incidence of mesial temporal sclerosis in our study is less than the previous study by Sachdev et al in which the incidence was 46.7%, however the study was conducted on 3 tesla MRI.[17] In a study by Hakami et al, the prevalence of mesial temporal sclerosis was 9%, however, with a much bigger sample size.[21]

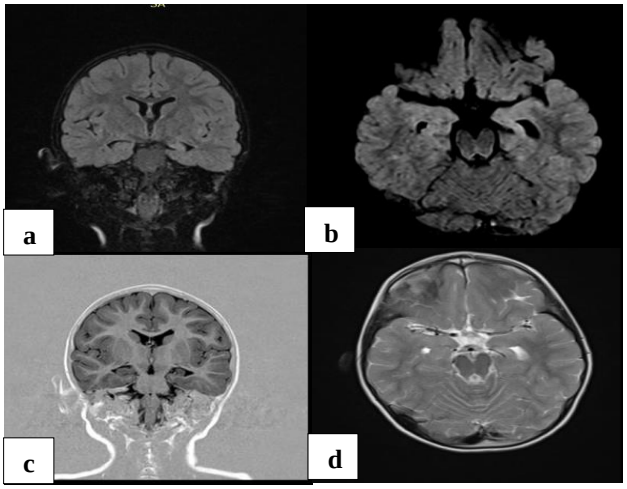

Figure 7: (a) IR coronal, (b) IR axial, (c) T1W IR coronal, and (d) T2W axial images show reduced left hippocampal volume and increased T2 signal, consistent with mesial temporal sclerosis.

Chronic cerebral infarcts with gliosis were observed in 3.2% cases. Most patients were older than 50 years of age. Chronic infarcts revealed T1W hypointense and T2W and FLAIR hyperintense signal, without any evidence of restriction on DWI and no post-contrast enhancement with dilatation of ipsilateral lateral ventricles, suggestive of atrophy and volume loss. Surrounding T2W and FLAIR hyperintense signal was noted suggesting gliosis. One patient (0.8%) showed features of acute infarct which revealed T1W hypointense and T2W and FLAIR hyperintense area in MCA territory with evidence of restriction on DWI. This is not comparable to the results of previous studies in which there was a higher incidence of stroke. Kaur et al reported stroke in 23% patients.[7] Similarly, Singh et al and Chabarwal et al both reported stroke in 20% patients with adult-onset seizures.[18,19]

In the current investigation, four patients (3.2%) had features of encephalitis whereas two patients showed features of cerebral abscess (1.6%). Encephalitis was characterized by the involvement of bilateral temporoparietooccipital regions revealing hyperintense signal on T2W and FLAIR sequences with gyral edema. Gyriform restriction was noted in these areas on diffusion images, along with gyriform enhancement on post-contrast images. Cerebral abscess was characterized by central necrotic contents showing a hypointense signal on T1W images and hyperintense signal on T2W and FLAIR images with a circumferential ring isointense to white matter on T1W and T2W images with post-contrast enhancement. Vasogenic edema which is hypointense on T1W and hyperintense on T2W sequences was also seen around the cerebral abscesses.

Two patients (1.6%) revealed cavernomas in this study. Well-defined focal non-enhancing lesions were seen in the subcortical white matter of the left parieto temporal lobe as well as the cerebellum in one patient, and in right

temporo occipital lobe in another patient. The lesions showed a classic 'pop-corn' appearance characterized by mixed signal intensity on T1W and T2W images with T2W hypointense hemosiderin rim and blooming on SWI sequences suggesting hemorrhage. Kayali et al studied 37 patients with cavernoma on MRI and concluded that 57% of the patients showed supratentorial location of the lesions.[22] Rigamonti et al studied 9 patients of proven cavernoma using both CT and MRI and concluded that cavernomas are common in the fourth and fifth decades of life and frequently located in the white matter of the supratentorial compartment.[23] Multiple sclerosis was seen in only one patient (0.8%) presenting with seizures. T2W and FLAIR sequences demonstrated hyperintense periventricular, juxtacortical, and infratentorial demyelinating plaques mainly on the callososeptal interface with few of the lesions showing a post-contrast open ring pattern of enhancement. 0.8% patients had cerebral venous thrombosis (CVT), showing absence of signal void in the right transverse and sigmoid sinus, with a hyperintense signal on T1W and FLAIR images suggestive of a subacute clot. TOF MRV demonstrated the thrombus in these sinuses. An intraaxial cortical-subcortical area of T1W and T2W hyperintense signal with blooming artifact on SWI and surrounding vasogenic edema was noted in adjoining right occipitotemporal region suggesting hemorrhagic venous infarct. 2.4% had seizures due to traumatic brain injury. One patient had a sulcal subarachnoid hemorrhage in the high frontal lobe with blooming on SWI sequences. One patient had focal hemorrhagic contusions in bilateral frontal lobes and one patient had subacute subdural hemorrhage characterized by a hyperintense signal on T1W, T2W and FLAIR sequences with blooming on SWI. Frey concluded that in 2–17% of all patients with head injuries seizures are early-onset, and are more common in children than adults, and correlated with the severity and distribution of head-injury.[24]

Limitations

Advanced neuroimaging techniques like functional MRI (fMRI), diffusion kurtosis imaging (DKI), quantitative hippocampal volumetry, ^{18}F-FDG PET, and SPECT will detect conventionally invisible epileptogenic lesions in patients with normal MRI findings. Use of 3 Tesla MRI will further improve detectability as compared to 1.5 Tesla used in the present study.

CONCLUSION

From our study, it could be concluded that MRI has an outstanding place in the evaluation of patients presenting with seizures. Suitable imaging protocols and methodical reviewing of the images helps in the identification of the underlying cause of seizures and localization of epileptogenic focus which is crucial for finding an effective treatment. The findings of the present study will be valuable in epilepsy management in developing country like ours and MRI will emerge as a beam of light amidst the shadowiness of myths for patients with seizures.

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