

Magnetic Resonance Imaging of the Brain in Adults Presenting With New Onset Seizures

Pannag Desai K N¹, Ravi N²

¹(Department of Radiodiagnosis, BMC&RI, India)

²(Department of Radiodiagnosis, BMC&RI, India)

ABSTRACT:

Aim:

A seizure is a paroxysmal event due to abnormal excessive or synchronous neuronal activity in the brain. Although a variety of factors influence the incidence and prevalence of seizures, 5–10% of the population will have at least one seizure in their lifetime. The aim of this study is to study and classify brain magnetic resonance imaging findings in adults aged 18 to 80 years who presented with new onset seizures.

Materials and Methods:

Clinical records and imaging studies of patients between the ages of 18 to 80 years with first clinical presentation of seizures, who presented to the department of Radio-diagnosis, Victoria Hospital, BMCRI, for MRI examination of the brain between September 2013 and August 2014 were analyzed retrospectively.

Results:

Of the total 164 patients (male- 103, female-62) who presented to us, 73.7% (n=121) presented with generalized tonic clinic seizures, 10.9% (n=18) presented with focal seizures, 9.1% (n=15) presented with complex partial seizures and 6.0% (n=10) presented with other varieties. 45.7% (n=75) of brain MRI studies showed no abnormality, 15.2 % (n=25) showed infectious lesions, 20.1% (n=33) showed neuroparenchymal is chemical/bleed and their complications, 9.2% (n=15) showed intracranial tumours and 9.8% (n=16) showed other miscellaneous findings.

Conclusion:

54.3% of all adults with new onset seizures who underwent magnetic resonance imaging of the brain showed positive findings, suggesting that MRI can contribute significantly to the determination of causality of the seizure. This provides an explanation for the patient's seizures and points to the need for chronic anticonvulsant therapy or possible surgical resection.

Keywords – Adult seizures, epilepsy, magnetic resonance imaging, neuroimaging, new onset seizures.

1. Introduction

A seizure is a paroxysmal alteration in neurologic function resulting from abnormal excessive neuronal electrical activity. The pathophysiologic basis of seizures is loss of normal regulation of neuronal excitation and inhibition, resulting in a state of relative hyperexcitability. Epilepsy is a chronic condition characterized by recurrent seizures unprovoked by an acute systemic or neurologic insult (1).

The evaluation of seizures is a common indication for magnetic resonance (MR) imaging. MR imaging is clearly more sensitive imaging technique, particularly in the detection of early disease (2). It is important to obtain an accurate history, especially regarding the onset and nature of the seizures, from the referring clinician as the specific MR imaging technique used depends on the specific type of seizures the patient has. New-onset seizures in an adult require the acquisition of routine T1- and T2-weighted images, as well as gadolinium-enhanced images.

2. Materials and Methods

Clinical records and imaging studies of patients between the ages of 18 to 80 years with first clinical presentation of seizures, who presented to the department of Radio-diagnosis, Victoria Hospital, BMCRI, for MRI examination of the brain between September 2013 and August 2014 were analyzed retrospectively.

2.1 Protocol

A dedicated head coil is used with a field of view ~ 22 - 24cm. A slice thickness of 3mm is used with an interslice gap of 0.6mm. The matrix size used is 512 x 256. The following sequences are used:

- Axial and sagittal T1W for cortical thickness and the interface between grey and white matter.
- Axial and coronal T2W/ FLAIR for cortical and subcortical hyperintensities on the FLAIR, which can be very subtle.

- Axial DWI/ADC sequences to look for diffusion restriction in vascular compromise.
- Axial T2*/ SWI for haemoglobin breakdown products/ calcifications.
- Axial and coronal gradient echo sequences.
- Coronal T1W sequences angled perpendicular to temporal lobes in suspected temporal lobe pathologies.
- Axial T1 post contrast sequences.
- MR spectroscopy

2.2 Inclusion and Exclusion Criteria

We included patients between the age groups 18 -80 years and those who presented with a history of new onset seizures.

We did not include in our study those patients who had a previous clinical history of epilepsy syndromes or those who had history of neuro-developmental disorders.

3. Observations and Results

Our study was a hospital based retrospective study of 164 patients with clinical history of new onset seizures. Patients were of the age group between 18 – 80 years with a mean age of 49 years. Of the total 164 patients 103 were males (62.8%) and 61 were females (37.2%). 73.7% (n=121) presented with generalised tonic clonic seizures, 10.9% (n=18) presented with focal seizures, 9.1% (n=15) presented with complex partial seizures and 6.3% (n=10) presented with other varieties such as absence seizures (n=2), myoclonic jerks(n=3), post partum seizures (n=2) and status epilepticus (n=3) (Fig. 1).

A significant proportion of the patients had no detectable abnormality on magnetic resonance imaging of the brain. Post ischaemia/hemorrhagic changes were the most common (20%) pathological findings on MRI, followed by infection (15%) and neoplasm (9%). Mesial temporal sclerosis contributed to 3% of the pathological findings whereas vascular malformations formed 1% of the cases (Fig. 2).

Patients with focal seizures or complex partial seizures were more likely to have abnormal findings on a brain MRI (Fig 3).

Etiology of seizures in patients above the age of 65 years was more likely to be post ischaemic sequelae whereas infections and intracranial tumors predominated in patients aged less than 65 years (Fig. 4).

4. Discussion

MRI reveals potentially epileptogenic lesions in a majority of patients with a newly diagnosed seizure disorder. Lesions are most common in patients who have experienced focal seizures. A large proportion (45.7%) of the patients in our study showed no detectable pathological finding on MRI study of the brain.

4.1 Infections

Seizures are common with acute cerebral infections (viral encephalitis and bacterial and aseptic meningitis) as well as those with brain abscesses, parasitic infections, aspergillosis, and other fungal infections. Chronic epilepsy however may result from post-inflammatory glial scarring.

In our study, of the total 25 patients with infective etiology for the seizures, 16 patients had tuberculoma, 4 had neurocysticercosis, 2 had herpes encephalitis, 1 had progressive multifocal leucoencephalopathy and 2 others had cryptococcosis.

In the developing world, tuberculomas account for 15-50% of the intra-cranial tumours seen⁽³⁾. Symptoms are often limited to seizures and correlates of intra-cranial pressure. The MR features of the individual tuberculoma depend on whether the granuloma is non-caseating or caseating with a solid center, or caseating with a liquid center. The non-caseating granuloma is usually iso/hypointense on T1W and hyperintense on T2W images. These granulomas show homogeneous enhancement after injection of contrast agent. The caseating solid granulomas appear relatively isointense/hypointense on T1W images with isointense/hyperintense rim and isointense to hypointense on T2W images. These lesions show rim enhancement on post-contrast T1W imaging. The granulomas with central liquefaction of caseous material appear centrally hypointense on T1W and hyperintense on T2W images and show rim enhancement after contrast administration. MR Spectroscopy has been found to be specific for intracranial tuberculomas when combined with imaging. Intracranial tuberculomas are characterized by a spectral pattern that primarily involves long chain lipids, with a 0.9 to 1.6ppm peak range, associated with a virtual absence of all brain metabolites normally present⁽⁴⁾ (Fig. 5).

In India, neurocysticercosis has been reported to be the most common cause of new onset partial seizures. Inflammation surrounding the cysticercosis manifests as acute seizure disorder. In the inflammatory stage provoked by the dying parasite, the cerebral lesions

of cysticercus appear as small enhancing rings on CT and MR with variable degree of oedema in surrounding brain⁽⁵⁾ (Fig. 6).

Cryptococcosis is the third most common CNS infectious agent in HIV/AIDS patients, after HIV and *T. gondii*. Crypto usually occurs when CD4 counts drop below 50-100 cells/ μ L. Cryptococcal gelatinous pseudocysts are hypointense to brain on T1WI and very hyperintense on T2WI. The lesions generally follow CSF signal intensity and suppress on FLAIR. Perilesional edema is generally absent. Lack of enhancement on contrast enhanced T1 images is typical although mild pial enhancement is sometimes observed⁽⁶⁾ (Fig. 7).

Progressive multifocal leucoencephalopathy is generally multifocal, bilateral but asymmetric, with irregularly shaped hypointensities on T1WI. The lesions are heterogeneously hyperintense on T2WI and frequently extend into the subcortical U-fibers all the way to the undersurface of the cortex, which remains intact even in advanced disease. Smaller, almost microcyst-like, very hyperintense foci within and around the slightly less hyperintense confluent lesions represent the characteristic spongy lesions seen in more advanced PML⁽⁷⁾ (Fig. 8).

4.2 Vascular malformations

Some vascular malformations may present with epilepsy. The most noteworthy example is the cavernous malformation (CM) for which most common presentation is seizures. Arteriovenous malformations may occasionally cause seizures although more typically they will present with hemorrhage or other symptoms referable to mass effect. Although, in general, specialized MRI techniques are not needed to detect these lesions, MR does assist in lesions characterization and in many cases may be used to make a definitive diagnosis preoperatively⁽⁸⁾.

Key findings to detect in characterizing a CM on MRI include the presence of a complete hemosiderin ring, best seen with T2 sequence. Other characteristic findings include lack of adjacent edema (except in the setting of recent overt hemorrhage), reticulated internal architecture, and blooming of blood products on T2 GRE sequence⁽⁹⁾.

The T2 sequence may also be used to identify lesions too small to detect without the benefit of susceptibility effects. Also, with gadolinium, one may identify developmental venous malformations often associated with CMs, thereby aiding further in pre-operative planning^(10, 11) (Fig. 9, Fig. 10).

4.3 Trauma, parenchymal ischaemia and hemorrhage

Trauma and stroke are major causes of epilepsy in young to older adults. In general, such lesions do not represent a dilemma either in detection or in diagnosis. However, in select cases, the MRI may assist in lesion characterization and management⁽¹²⁾. The superior resolution provided by the MRI examination allows detailed morphologic evaluation including identification of gyri which are thinned.

4.4 Mesial temporal sclerosis

Mesial temporal or hippocampal sclerosis is characterized pathologically by pyramidal and granule cell neuronal loss in the cornu ammonis and gyrus dentatus often with hippocampal reorganization and evidence for changes in energy metabolism. It is the most common pathology associated with temporal lobe epilepsy, especially those refractory to medical therapy. The identification of MR abnormality in such patients, when correlated with EEG serves as useful prognosticator for successful surgical treatment⁽¹³⁾.

Primary findings seen on MRI in MTS are T2 high signal and atrophy of the hippocampus.³ Other findings have been described in MRI as well, notably diminished grey-white matter differentiation, often referred to as loss of internal architecture. Secondary findings include ipsilateral atrophy of the fornix and of the mamillary body. One may also note ipsilateral atrophy of the hippocampal collateral white matter as well as atrophy of the ipsilateral temporal lobe. These secondary findings are in general less helpful as they tend to be seen only in the more advanced MTS cases and may be misleading without the observation of the primary abnormality⁽¹⁴⁾ (Fig. 11).

Patients with MTS may have more than one lesion relevant to their epilepsy. The so-called dual pathology occurs in up to 15% of cases. Associated pathologies include cortical dysplasias, tumors, and vascular malformations. Further evaluation, management and potential surgical treatment will be directly altered by the presence of a second relevant lesion so the search for pathology does not end with the observation of MTS. In general, the finding of dual pathology decreases the likelihood of successful surgical treatment. In most cases, both lesions merit consideration of resection⁽¹⁵⁾.

4.5 Tumors

Although many neoplasms may cause seizures, a subset may present with chronic epilepsy. Highly epileptogenic tumors occur most often in the temporal lobe in or adjacent to cortex. The indolent tumors yielding chronic epilepsy include ganglioglioma, low-grade glioma and

dysembryoplastic neuroepithelial tumor (DNET) ⁽¹⁶⁾ (Fig. 12). These tumors tend to be small and well localized with little edema or mass effect. FLAIR and T2 imaging tends to be the most helpful, at first inspection, in detection of such lesions. The use of additional imaging planes and of gadolinium contrast is often helpful in further characterization.

DNET is a benign, usually cortically based lesion characterized by a multinodular architecture. Because DNET is often associated with cortical dysplasia, some neuropathologists believe it may be a congenital malformation rather than a true neoplastic lesion ⁽¹⁷⁾ (Fig. 13).

Brain metastases are not only a leading cause of cancer mortality but as a group have become the most common CNS neoplasm in adults. Most metastases are iso- to slightly hypointense on T1WI. Melanoma and hemorrhagic metastases can be heterogeneously hyperintense. On T2/FLAIR, the appearance varies

with tumor type, cellularity and presence of hemorrhage. Most commonly they are iso- to mildly hyperintense. On T2*, subacute blood and melanin show “blooming”. Almost all non hemorrhagic metastases enhance strongly on contrast administration. On DWI, the appearance is variable; most common being absence of restriction. However, highly cellular metastases may restrict. MRS generally shows a prominent lipid peak with elevated choline and depressed/absent creatine ^(18, 19).

4.6 Miscellaneous

Eclampsia is defined as the development of convulsions in pregnant women with hypertension and proteinuria. Studies of women with eclampsia disclose multiple foci of cortical and subcortical white matter edema, primarily in the occipital lobes ⁽²⁰⁾ (Fig. 14).

5. Figures

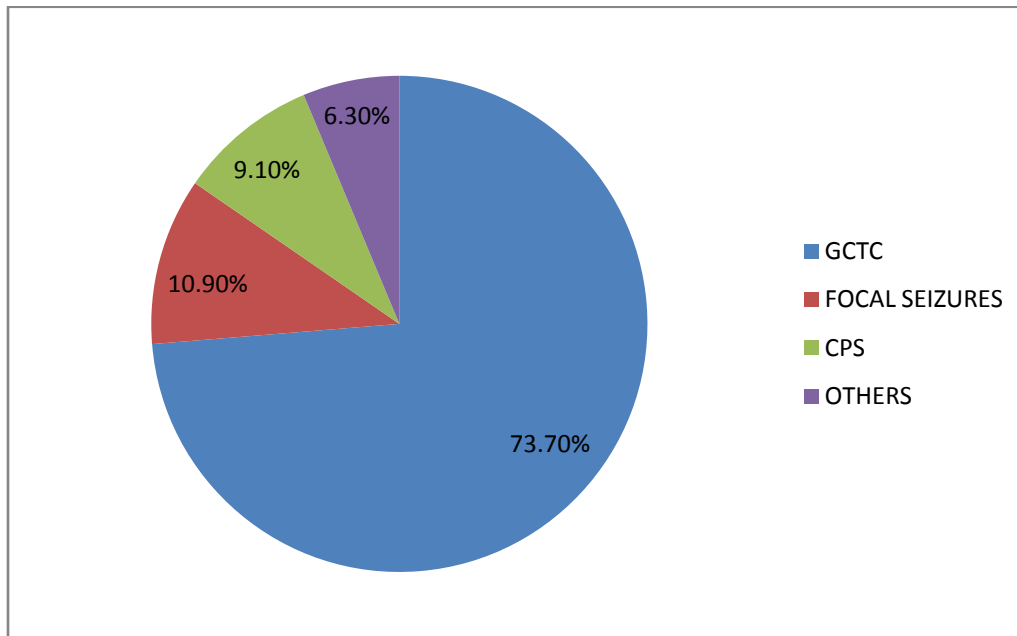


Fig. 1 Classification of patients based on seizure type.

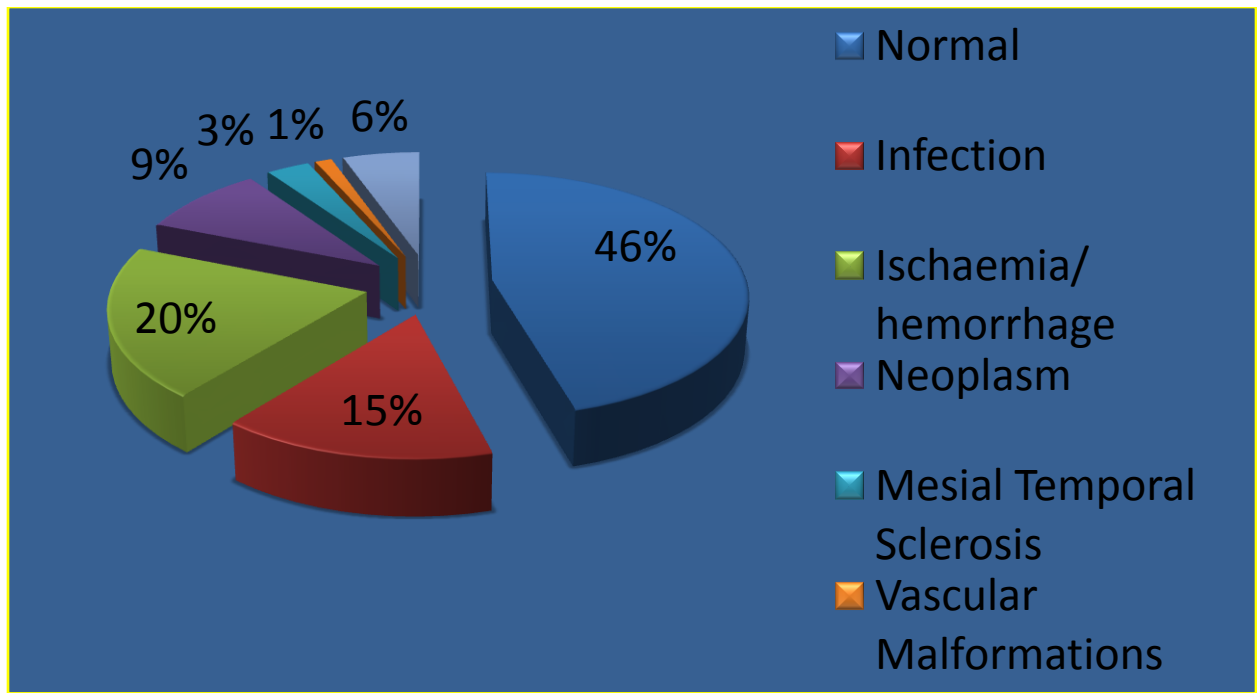


Fig 2. Classification of cases based on MRI findings.

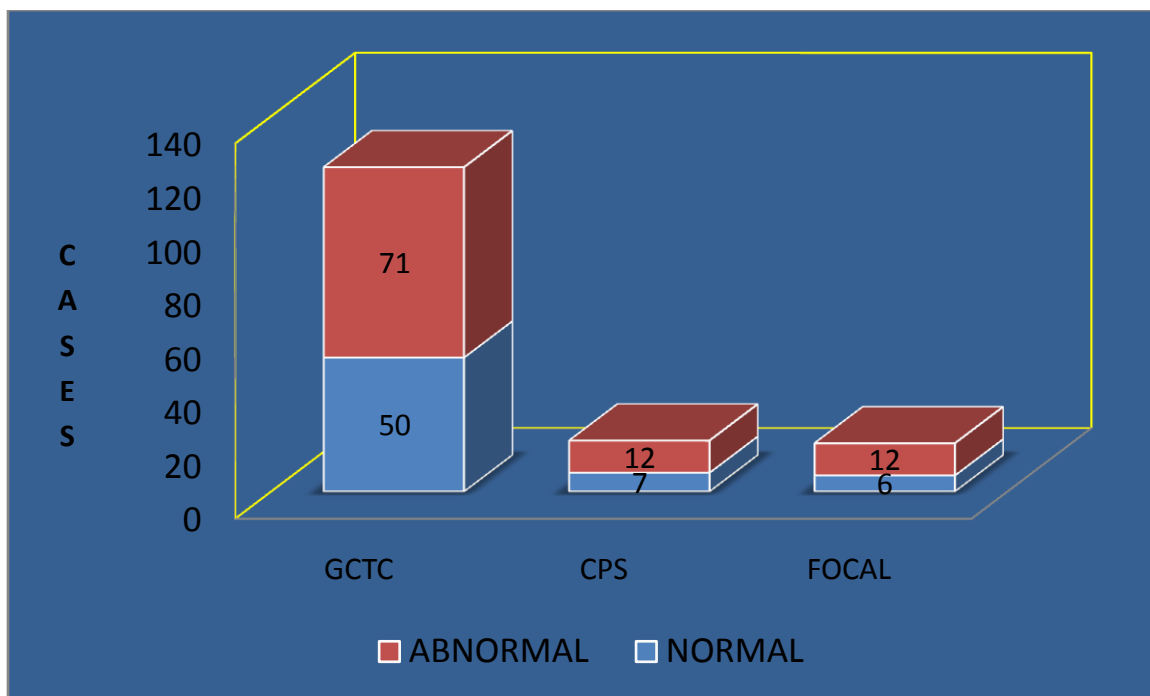


Fig. 3 Correlation of seizure type with MRI findings.

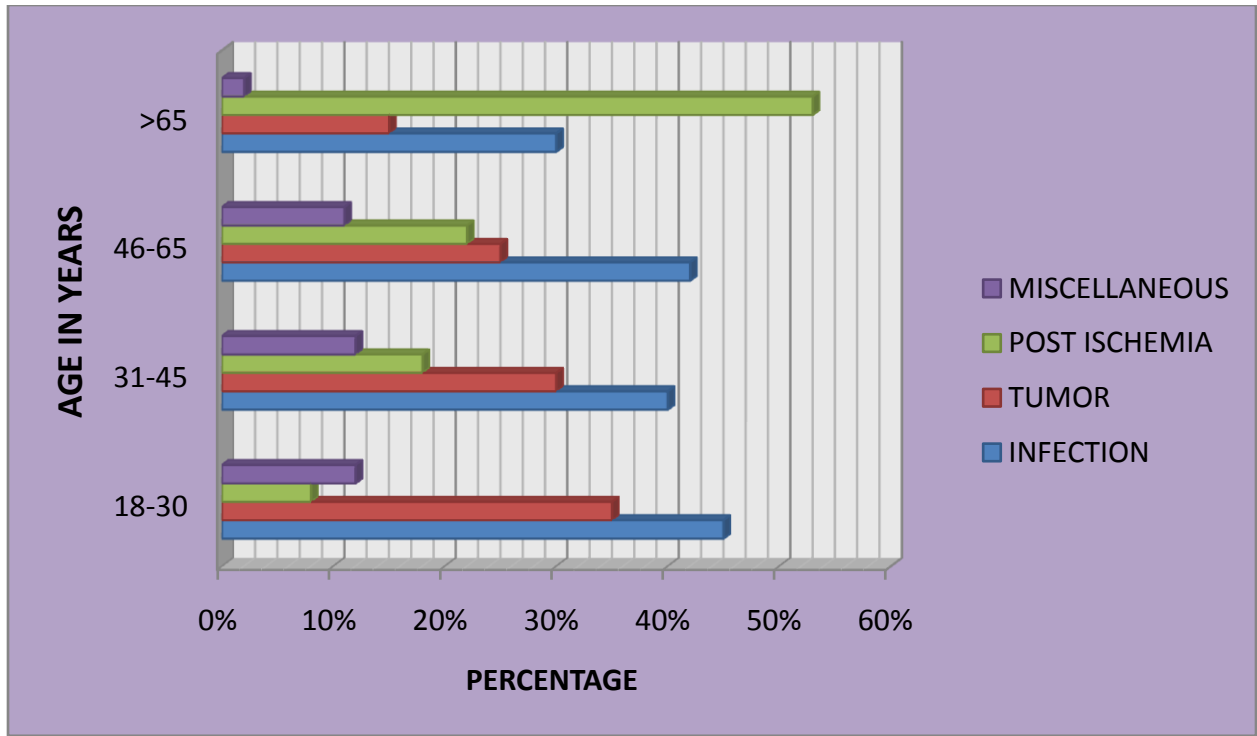
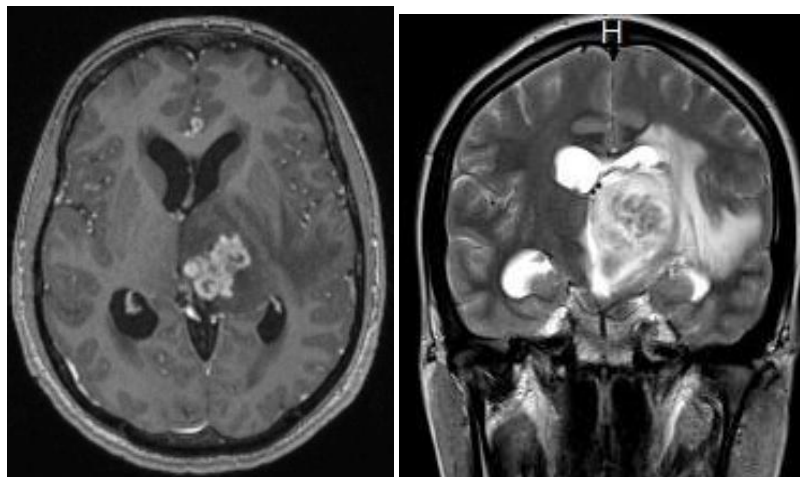


Fig. 4 Correlation of age of presentation with MRI findings.



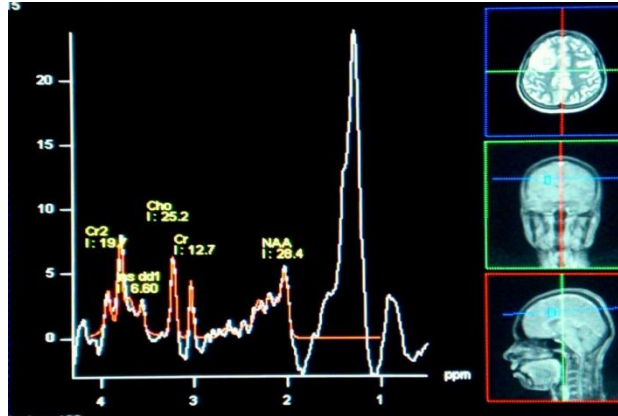


Fig. 5 Tuberculosis: The caseating solid granulomas appear relatively iso/hypointense on T1W images with iso/hyperintense rim and iso to hypointense on T2W images. The granulomas with central liquefaction of caseous material appear centrally hypointense on T1W and hyperintense on T2W

images and show rim enhancement after contrast administration. On MR spectroscopy, intracranial tuberculomas are characterized by a spectral pattern that primarily involves long chain lipids, with a 0.9 to 1.6ppm peak range, associated with a virtual absence of all brain metabolites normally present.

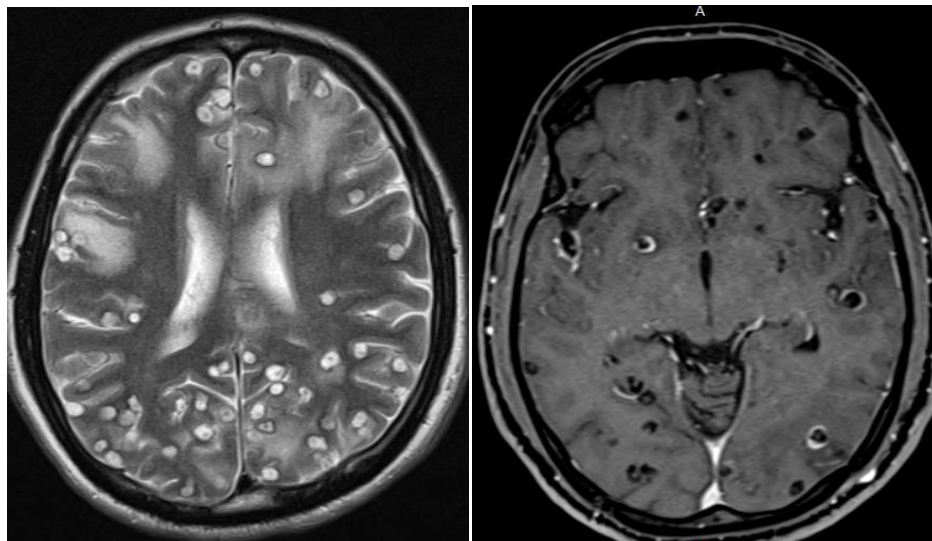


Fig. 6 Neurocysticercosis: Inflammation surrounding the cysticercosis manifests as acute seizure disorder. In the inflammatory stage provoked by the dying parasite, the cerebral lesions of cysticercus appear as small enhancing rings MR with variable degree of edema in surrounding brain.

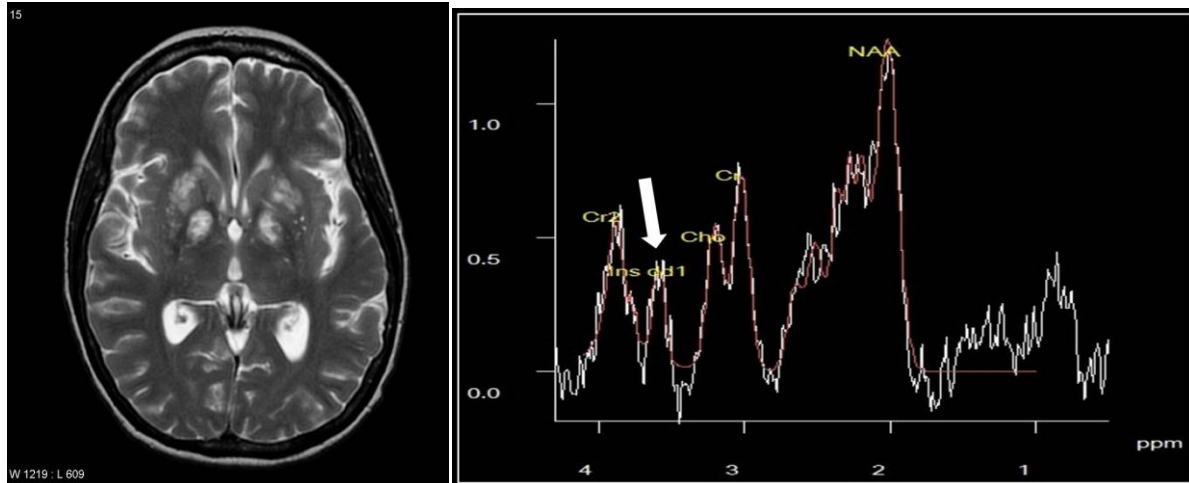


Fig. 7 Cryptococcosis: Cryptococcal gelatinous pseudocysts appear hypointense on T1W and very hyper intense on T2w images. Perilesional edema and contrast enhancement is absent. MRS shows mildly elevated Cho and decreased NAA. Multiple peaks resonating between 3.6 and 3.8 ppm are common and probably represent trehalose.

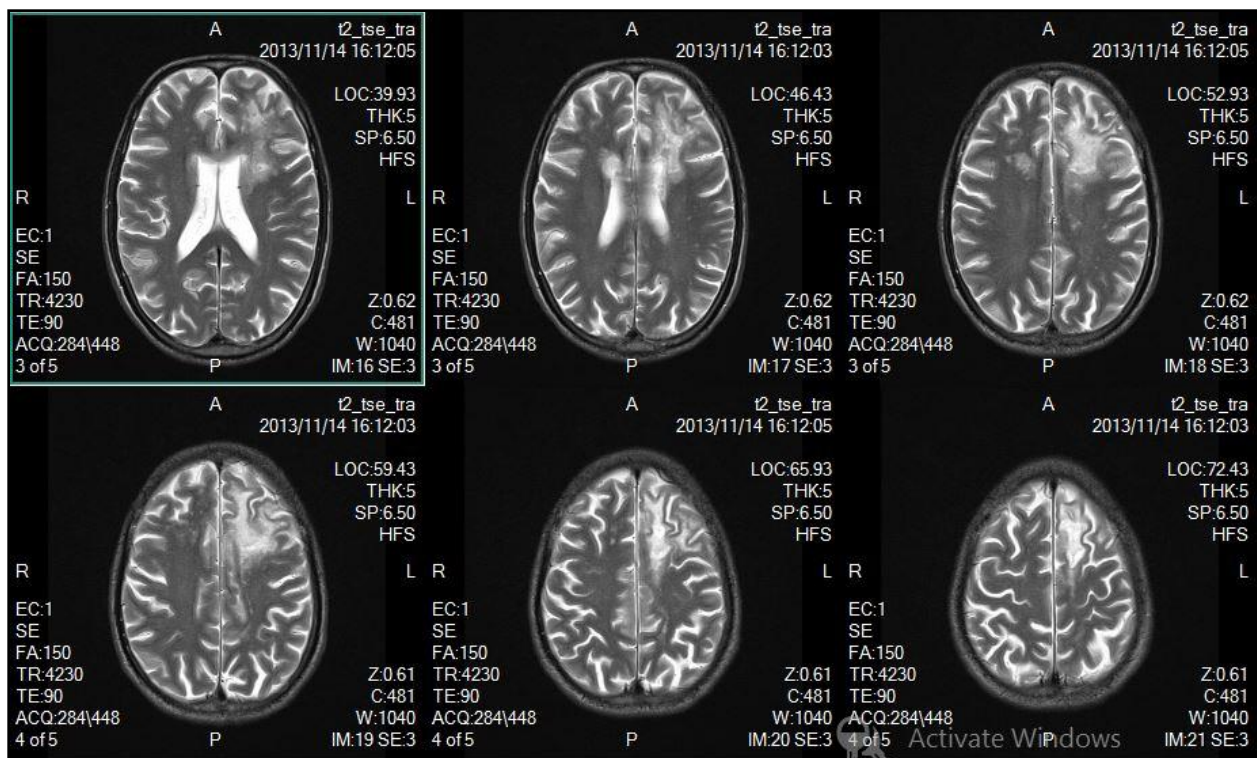


Fig. 8 Progressive Multifocal Leukoencephalopathy: Multifocal, bilateral but asymmetric, irregularly shaped T1w hypo and T2/FLAIR hyper intense lesions in supratentorial lobar white matter. The subcortical U fibers are affected while cortical ribbon is spared. Lesions generally do not enhance on T1 contrast.

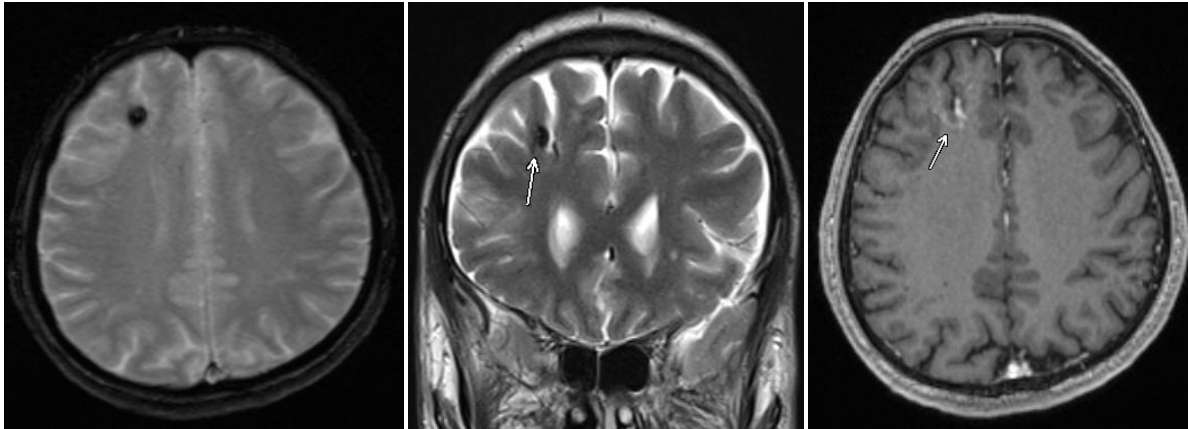


Fig. 9 Cerebral Venous Angioma: Characterized by the caput medusae sign of veins draining into a single larger collecting vein. SWI & T1+C are the most useful sequences in detection of these lesions.

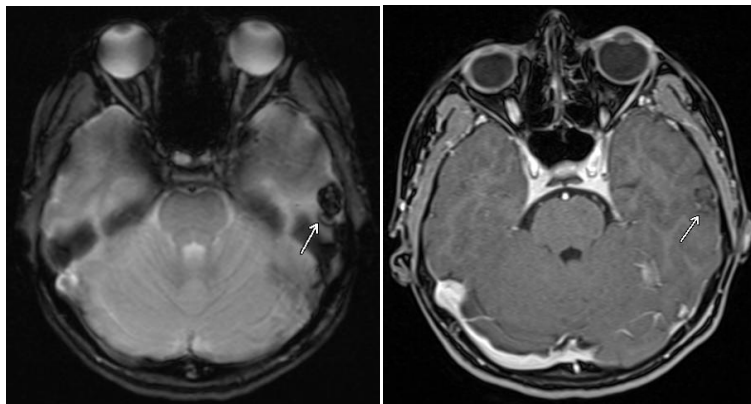


Fig. 10 Cerebral Cavernous Malformation: The classic CCM (Zabramski type 2) is a discrete reticulated or “popcorn ball” lesion caused by blood products contained within variably sized “caverns” or “locules.” The mixed signal core is surrounded by a complete hemosiderin rim on T2WI that “blooms” on T2* sequences.

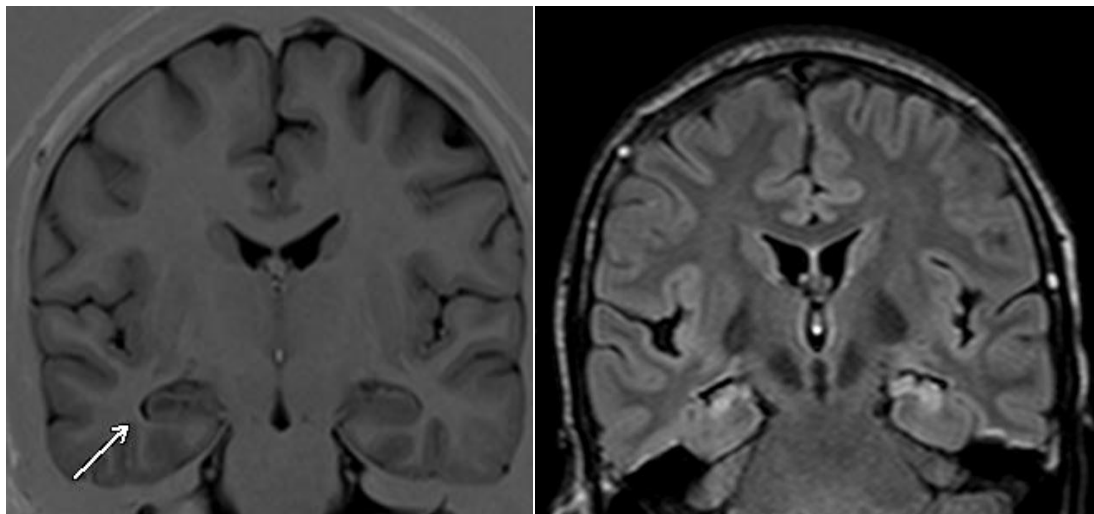


Fig. 11 Primary findings seen on MRI in MTS are T2 high signal with atrophy of the hippocampus and diminished grey-white matter differentiation.

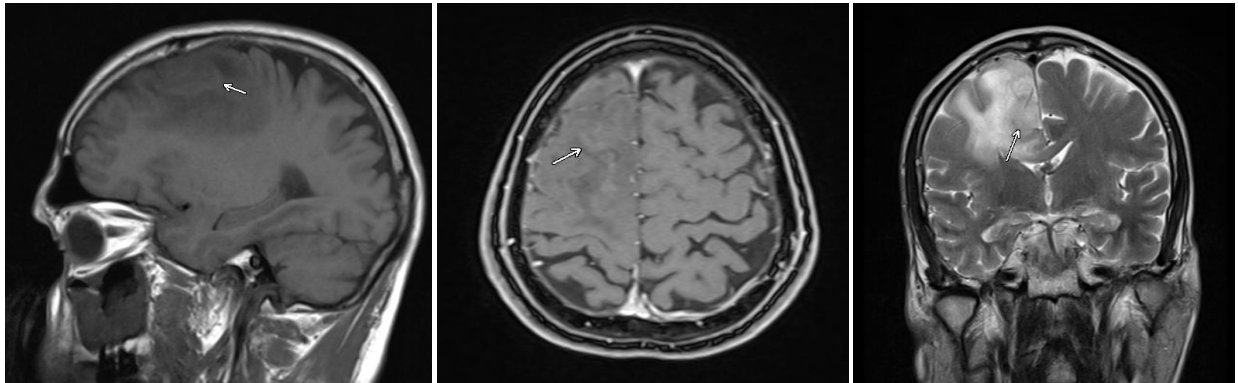


Fig. 12 Low grade astrocytoma are hypointense on T1WI and hyperintense on T2/FLAIR and do not enhance following contrast administration.

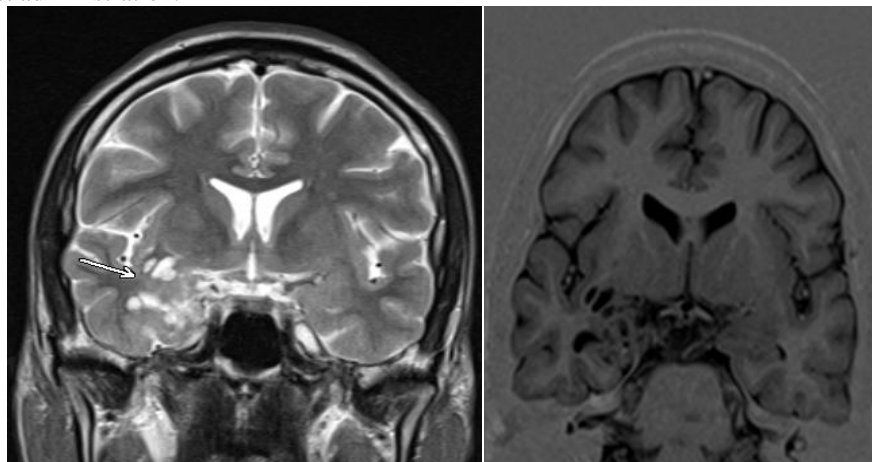


Fig. 13 DNET are benign, usually cortically based lesion characterized by a multinodular architecture, described as "bubbly appearance". FLAIR and T2 imaging tends to be the most helpful in detection of such lesions.

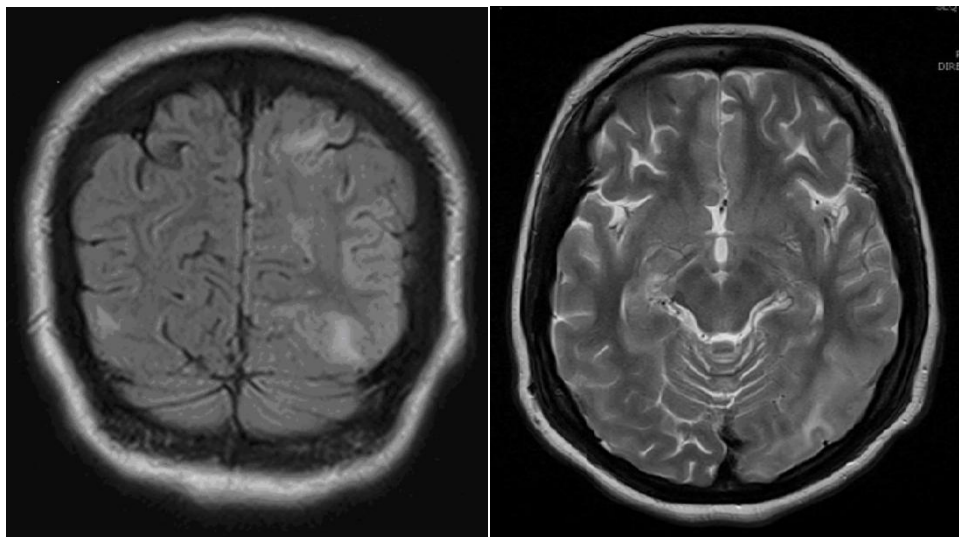


Fig. 14 Post partum seizures: Bilateral hyperintense lesions on T2-weighted images and hypointense lesions on T1-weighted images without diffusion restriction, mostly involving the occipital and parietal lobes.

6. Conclusions

MRI reveals potentially epileptogenic lesions in a

majority of patients with a newly diagnosed seizure disorder. Lesions are most common in patients who have experienced focal seizures and complex partial

seizures. FLAIR and T2 inversion recovery sequences are the most important sequences in evaluation of patients with seizures. First fit protocols should certainly have all three orientations included as well as temporal orientated coronal FLAIR and T2 weighted sequences. MRI provides an explanation for the patient's seizures and points to the need for chronic anticonvulsant therapy or possible surgical resection. In patients who had a normal MRI study of the brain, further evaluation with electroencephalogram correlation might be helpful in detecting the epileptic focus.

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