

Imaging of Epilepsy in Children

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Epilepsy Definition

- At least 2 unprovoked seizures occurring more than more than 24 hours apart;
 - One unprovoked seizure and the probability of further seizures similar to the general recurrence risk of 60%
 - Diagnosis of an epilepsy syndrome
-
- International League Against Epilepsy

Introduction

- 50 million patients globally with epilepsy
- Paediatric population: **1%**; Adults: 0.4%
- Symptomatic cases with demonstrable brain pathology in:
 - Paediatric population 80%
 - Adult population 60%

Role of CT in Epilepsy

- Limited utility in neurodevelopmental disorders
- **Important screening exam**
- Infections: tuberculomas
- Tumours
- Infarcts
- Vascular malformations
- Calcified lesions
- Problem solving/complementary to MRI
- Post operative follow-up, including subdural collections

Role of MRI in Epilepsy

- MRI important for diagnosing neuronal migration disorders, surgical planning including defining the relation of a focal lesion to eloquent areas and as a base for functional studies including PET, SPECT, fMR
- Evaluate clinical history and EEG findings
- Need for sedation/General anesthesia

MRI Protocol Sequences Recommended in Children with Epilepsy in both 1.5T and 3T Scanners

Anatomic, thin-slice T1-weighted gradient-recalled-echo
sequence

Axial and coronal T2-weighted sequence through the whole
brain

Axial fluid-attenuated inversion recovery sequence (FLAIR)

High-resolution oblique coronal T2-weighted imaging of the
hippocampus (fast or turbo spin echo weighted sequence)

3T vs 1.5T MRI Imaging of the Brain

- Improvement in Quality of following areas
- 3D T2W images
- Gradient echo T2*
- 3D T1- pre and post Gadolinium
- T1 post Gad with fat saturation
- FLAIR- slight improvement in quality
- MRA

Optimizing Imaging on 1.5 T Scanner

- Coronal FLAIR sequence
- Thin section, no gap axial T2 (3-4 mm thick slices)
- Increasing the number of averages or number of excitations appropriately to help increase the signal-to-noise ratio
- MRI focused on area of concern based on the EEG findings
- Gradient echo sequence in areas with higher incidence of calcified lesions like tuberculomas and in patients with neuro cutaneous syndromes

Systematic Approach to MRI Scan Review for Epilepsy



- **Axial and Coronal T2-weighted images:**
- cerebral hemispheric asymmetry (both size and signal intensity)
- gyral folding pattern
- evidence of blurring of the gray and white matter junction
- symmetry of the white matter signal

Systematic Approach to MRI Scan Review for Epilepsy



- **T1-Weighted images:**
- midline structures including the hypothalamic region
- gyral folding pattern
- cortical thickness
- sulcal asymmetry
- uniformity of cortical signal
- subcortical and periventricular gray matter lesions
- **Hippocampi and temporal lobes are reviewed in detail**

Etiology of Seizures

- **V**ascular
- **I**schaemic/Iatrogenic
- **T**rauma
- **A**utoimmune
- **M**etabolic/Metastases
- **I**nfection
- **N**eoplasm
- **C**ongenital

Vascular

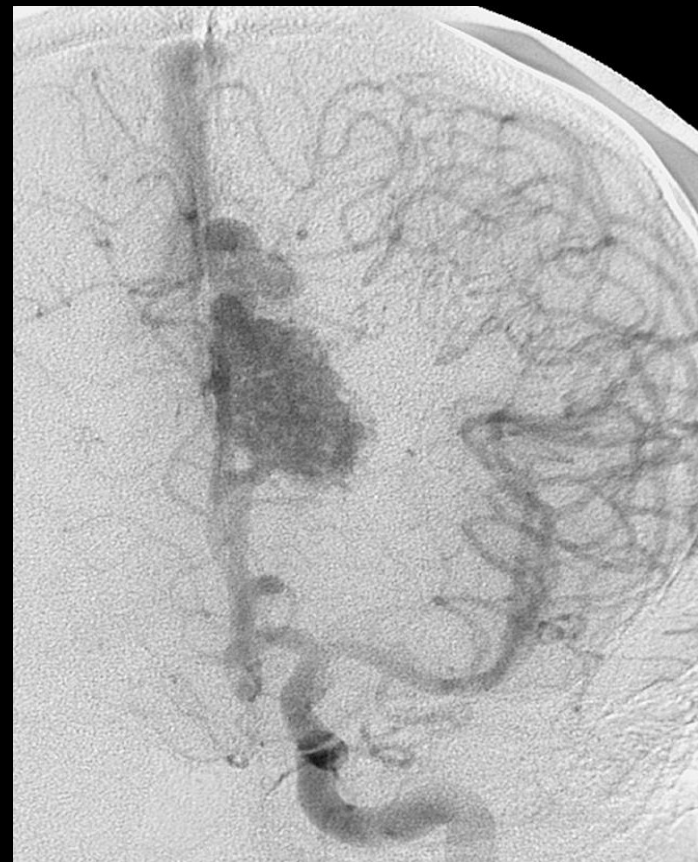


- A 15 year presenting with epilepsy



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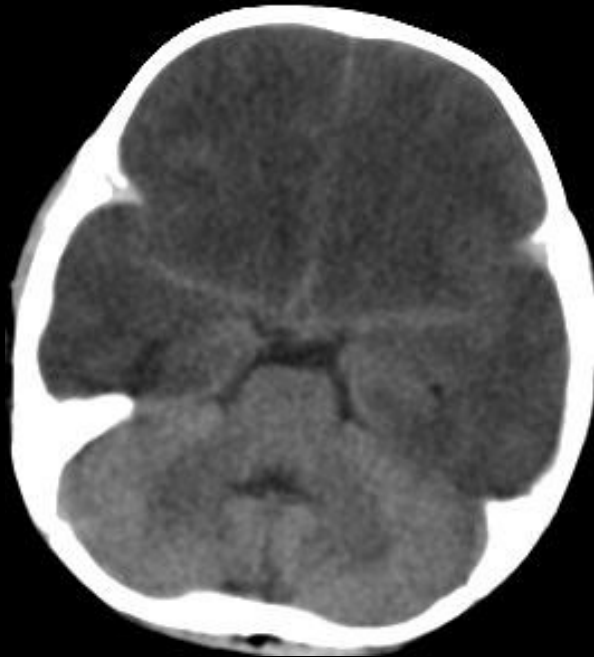
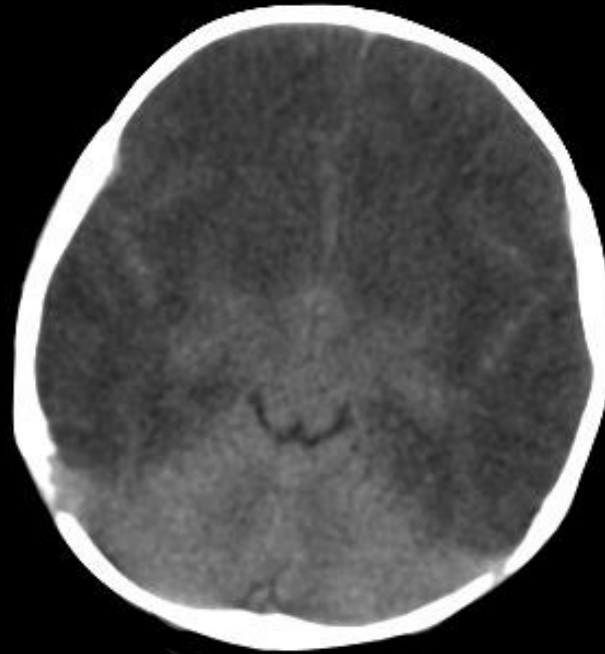
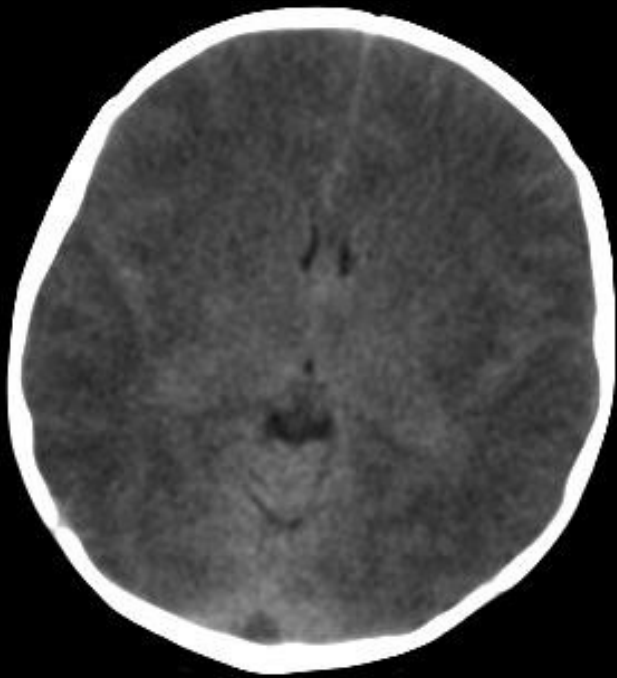


Ischaemia

- There is a significant risk of developing epilepsy after perinatal stroke, hypoxic-ischemic injury, and intracerebral hemorrhage



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Trauma

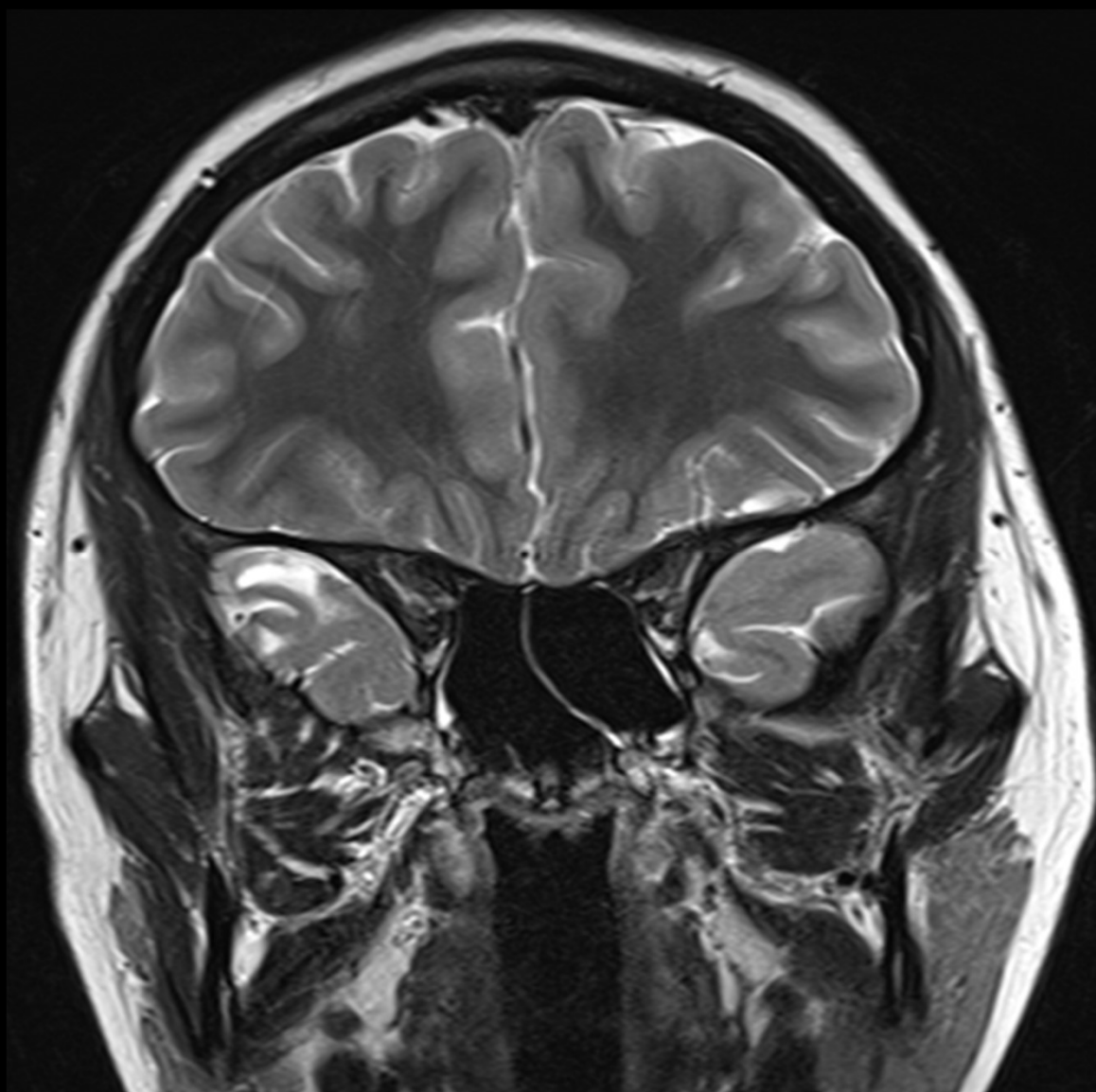
- Post traumatic seizures and epilepsy are relatively common in children
- Development of epilepsy post traumatic brain injury can occur up to 10 years after the injury
- Important review areas include the inferior frontal and temporal lobes, which are affected in patients due to contra coup mechanisms

Trauma

- Following brain trauma:
- Reactive gliosis
- Wallerian degeneration
- Microglial scar formation
- Cystic white matter lesions
- Case: 16-year-old female with history of traumatic head injury 5 years prior to this study presented with refractory temporal lobe epilepsy



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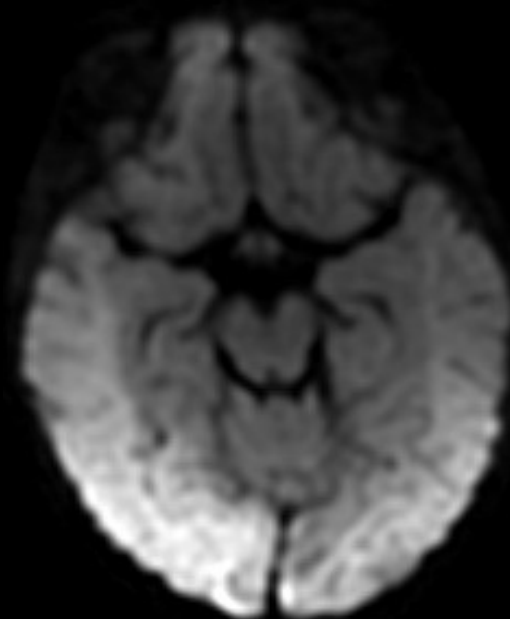
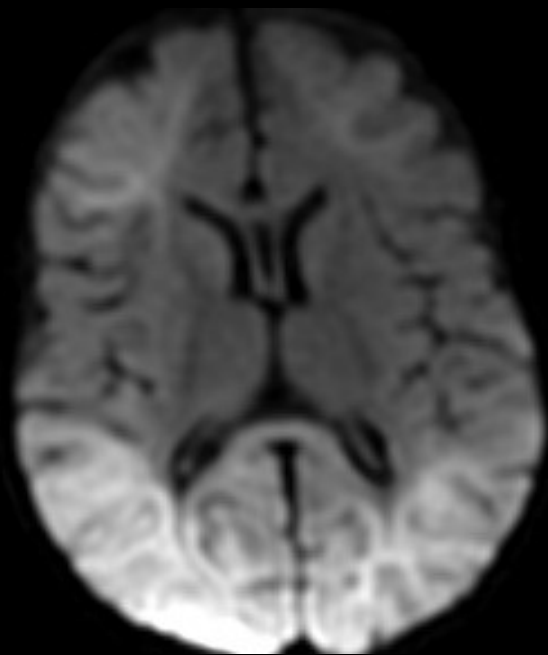
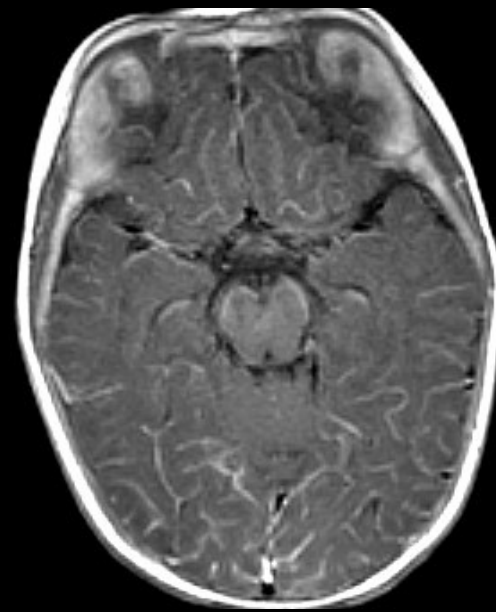
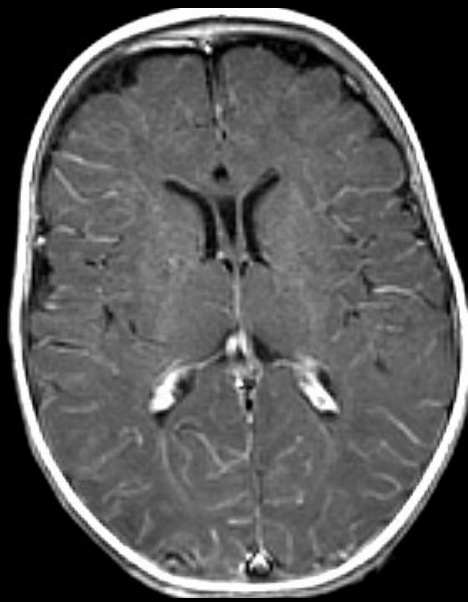


Infection

- Case: 6 year old with meningism and seizures

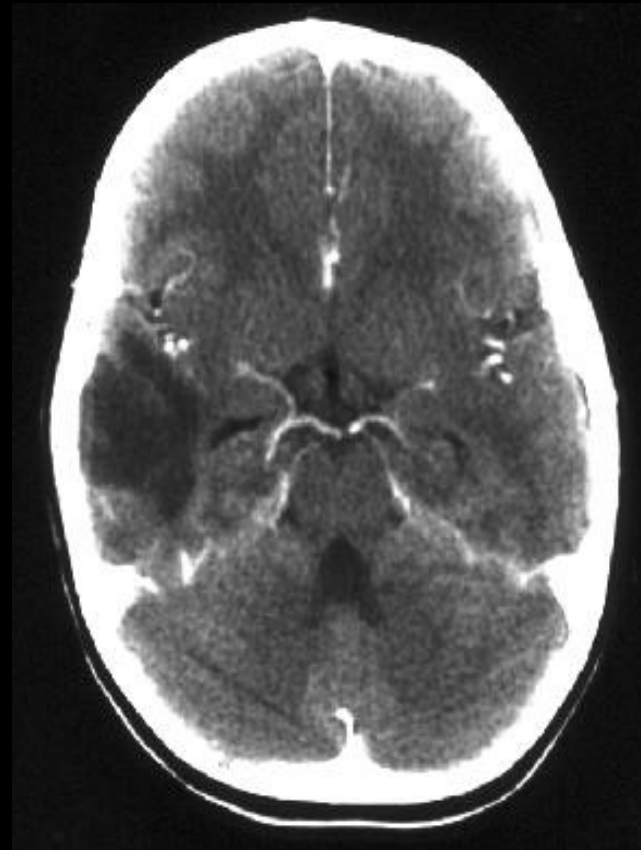
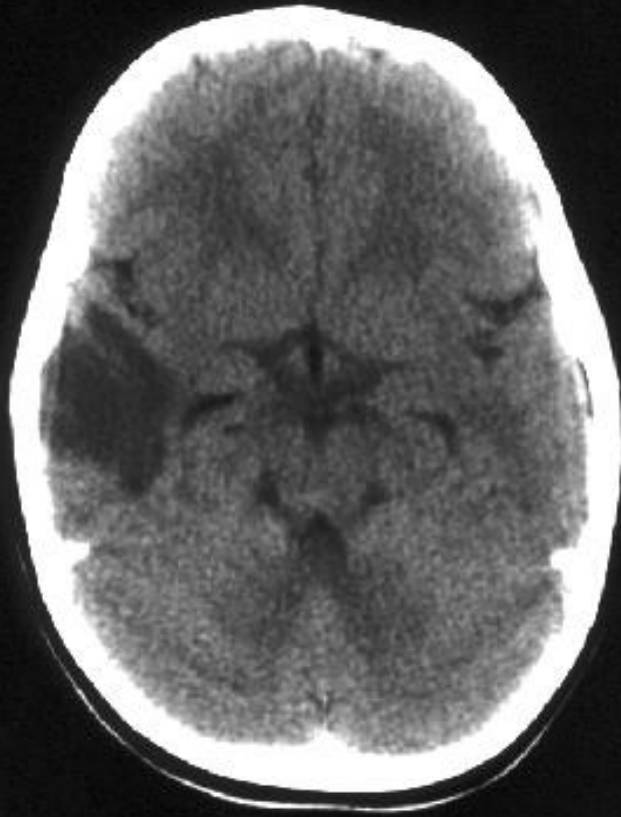


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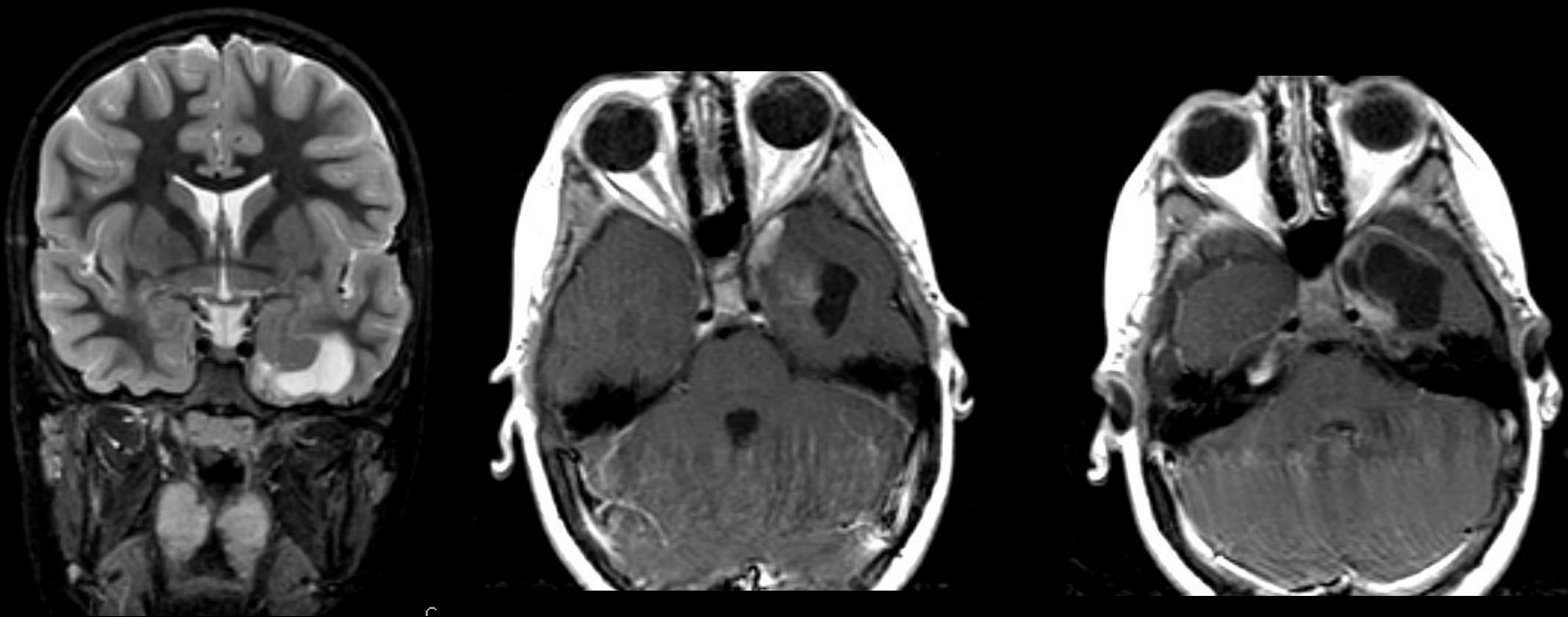


Neoplasm

- Dysembryoblastic Neuroepithelial Tumour
- Ganglioglioma
- Hypothalamic hamatoma



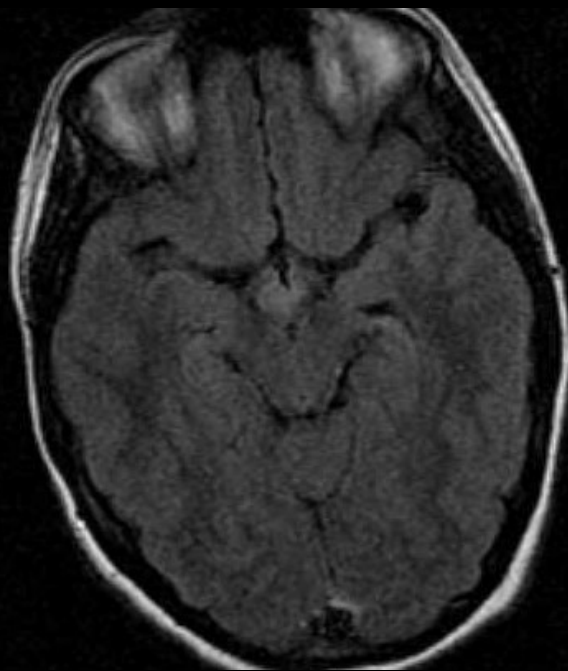
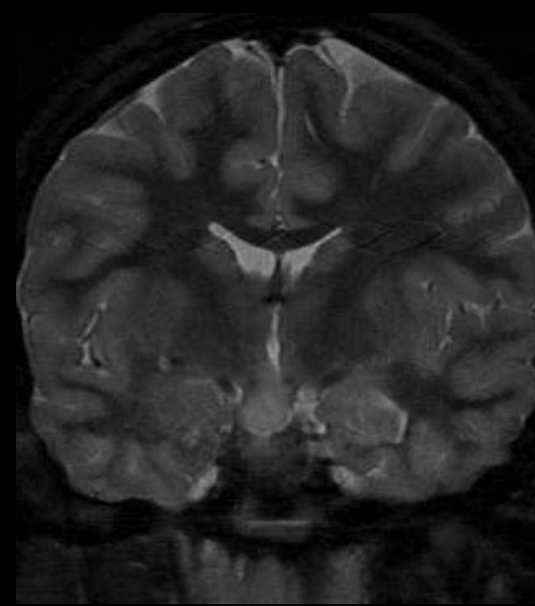
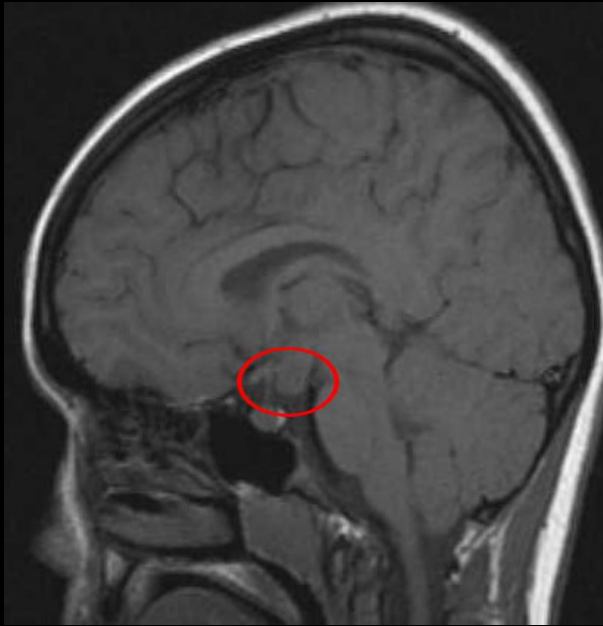
DNET- dysembryoblastic
neuroepithelial tumour



Ganglioglioma



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Congenital Conditions

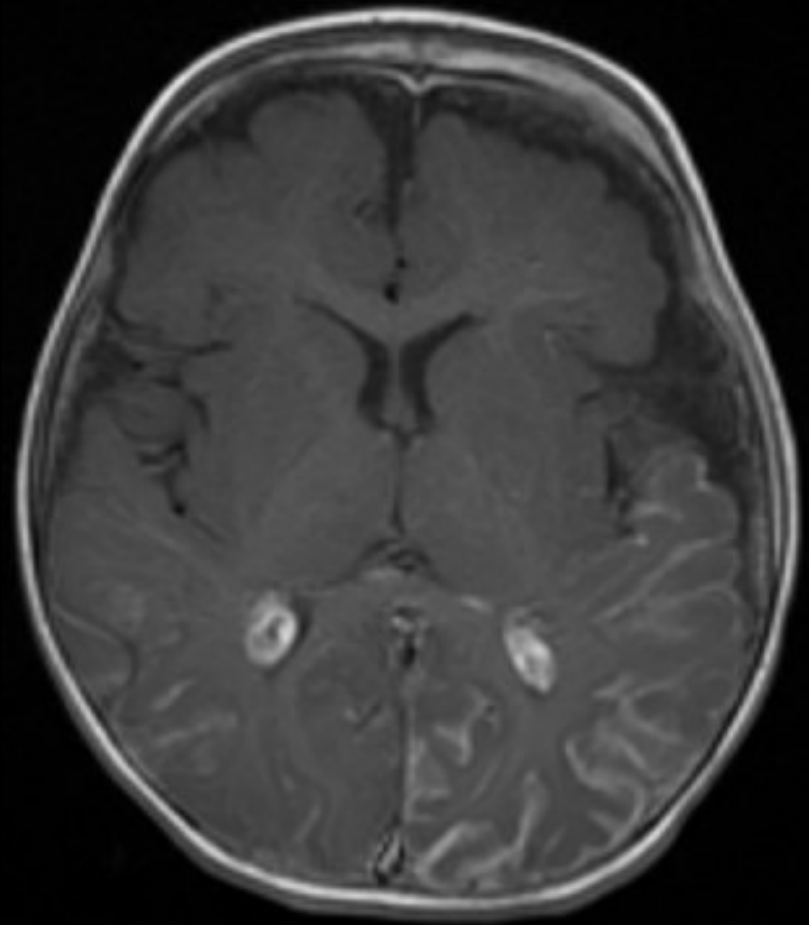
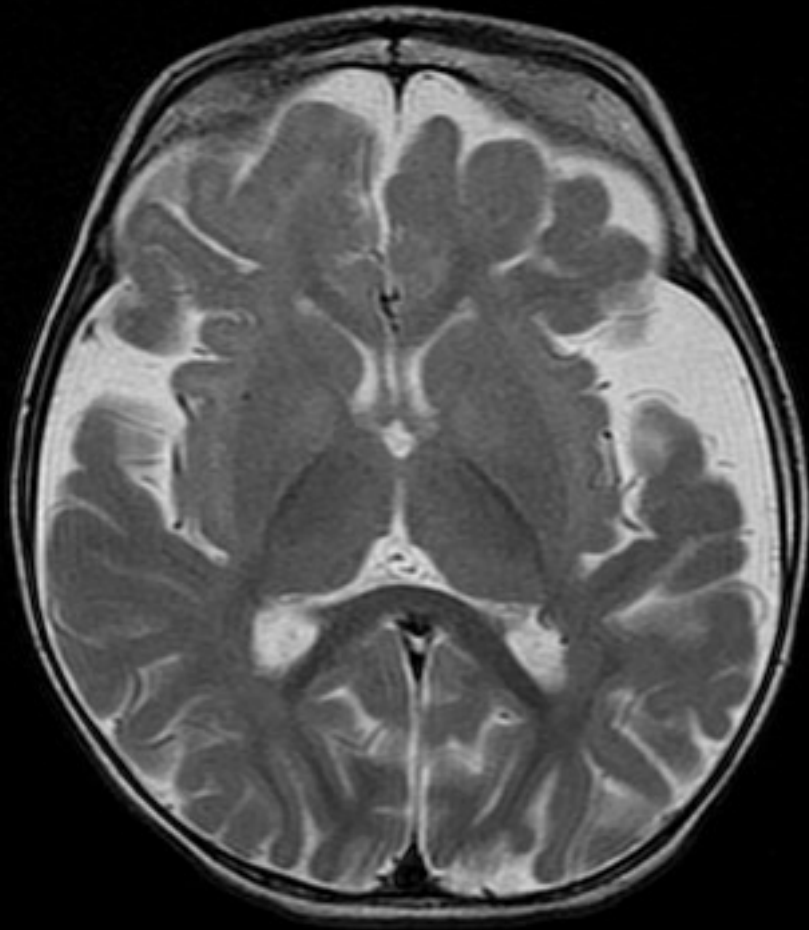
- Sturge Weber Syndrome
- Tuberous Sclerosis
- Mesial Temporal Sclerosis
- Malformations of Cortical Development
- Neuronal Migrational Disorders

Sturge-Weber syndrome

- Neurocutaneous disorder clinically characterized
- Epilepsy
- Progressive mental retardation
- Facial telangiectatic nevi typically in the trigeminal nerve distribution
- Gadolinium-enhanced brain MRI is the most useful imaging study in the first year of life

Sturge Weber syndrome

- Case: 8 month-old female infant with bilateral facial port-wine stains, seizures and congenital glaucoma

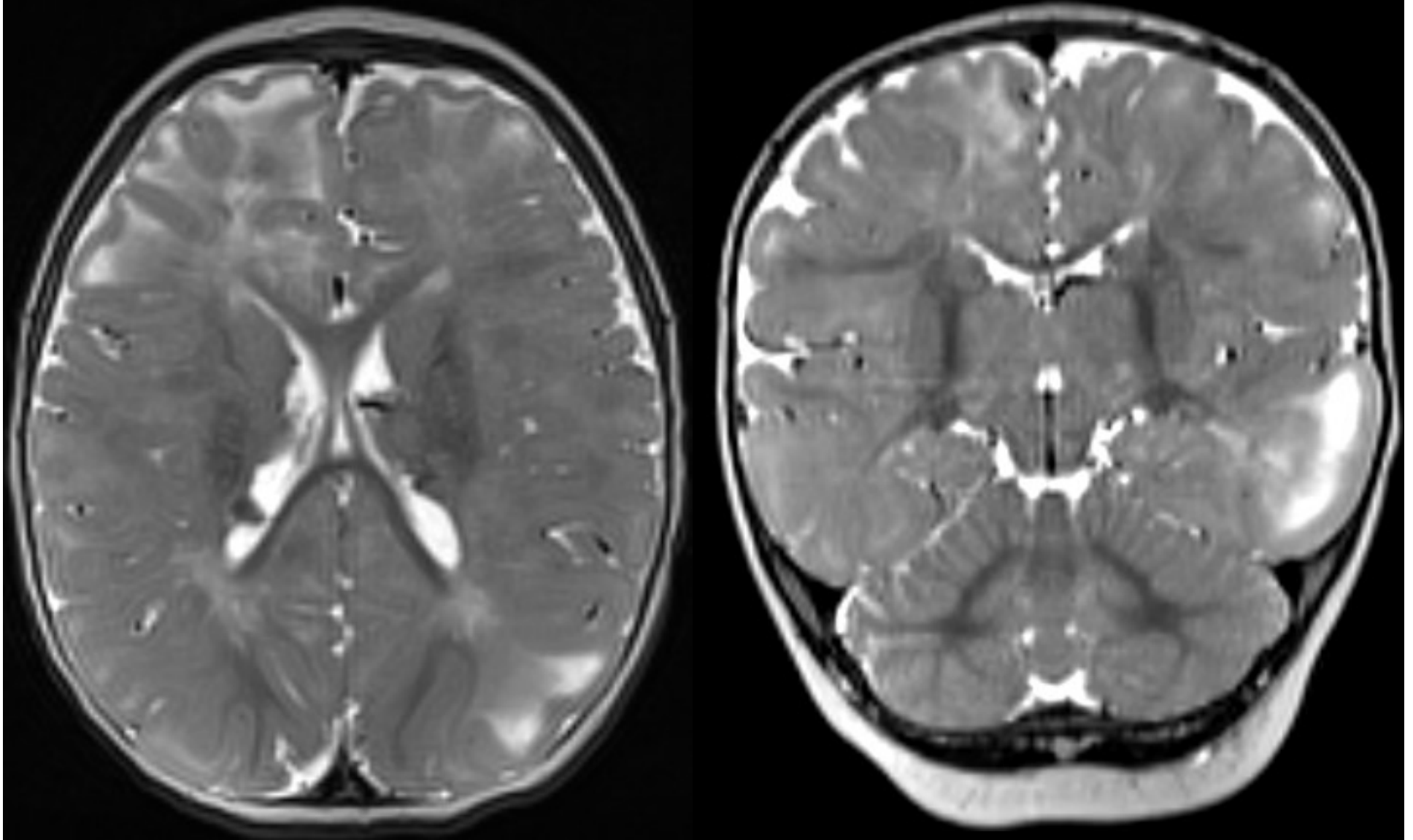


Tuberous sclerosis

- Tuberous sclerosis is a multisystem autosomal dominant genetic disorder
- Epilepsy is related to the neuropathological features of the disorder, including cortical tubers and other dysgenetic features

Tuberous sclerosis Brain

- Multimodality non-invasive tests including using a combination of MRI, PET ictal and SPECT
- MRI features
- Cortical and subcortical tubers
- Hyperintense on T2 wt
- Hypointense on T1 wt
- 10-15% enhance
- Subependymal nodules along lateral walls of ventricles
- 30-80% enhance, calcify over time



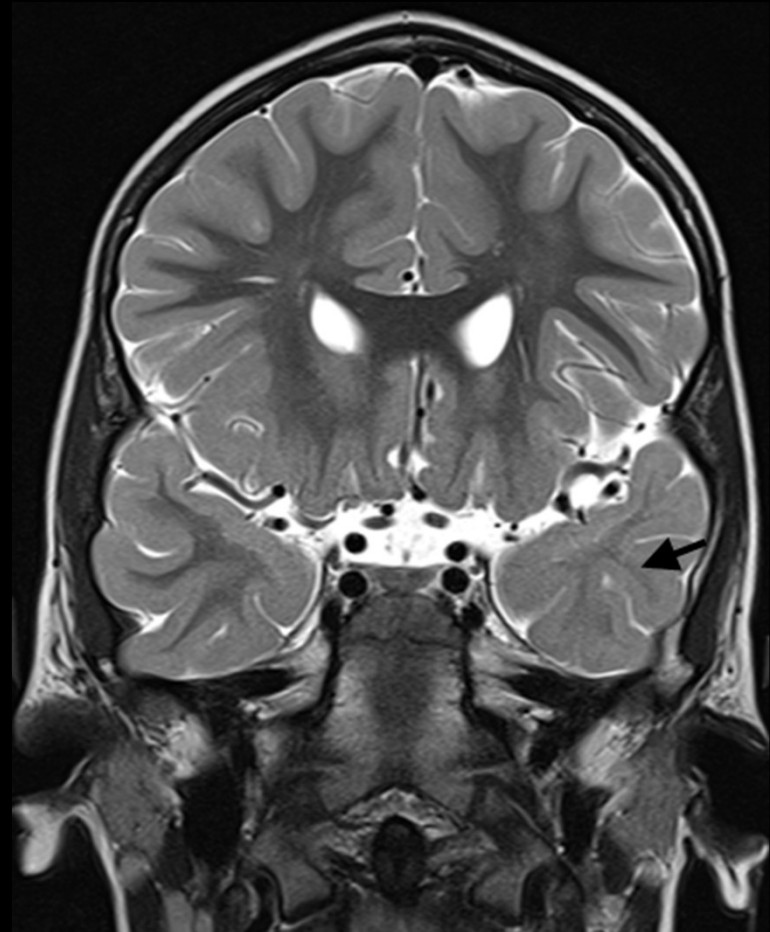
Mesial Temporal Sclerosis

- Uncommon finding in children
- Prolonged febrile seizures, prior infection and trauma are factors that increase vulnerability to neuronal injury like hippocampal dysgenesis
- Dedicated epilepsy protocols which include thin section coronal T2 and FLAIR perpendicular to the hippocampus

MRI Findings

Mesial Temporal Sclerosis

- hippocampal T2 hyperintensity
- reduced hippocampal size
- loss of hippocampal interdigitations
- atrophy of the collateral white matter
- reduced gray and white matter differentiation in the anterior temporal lobe
- decreased temporal lobe size and ipsilateral temporal horn enlargement



Malformations of Cortical Development

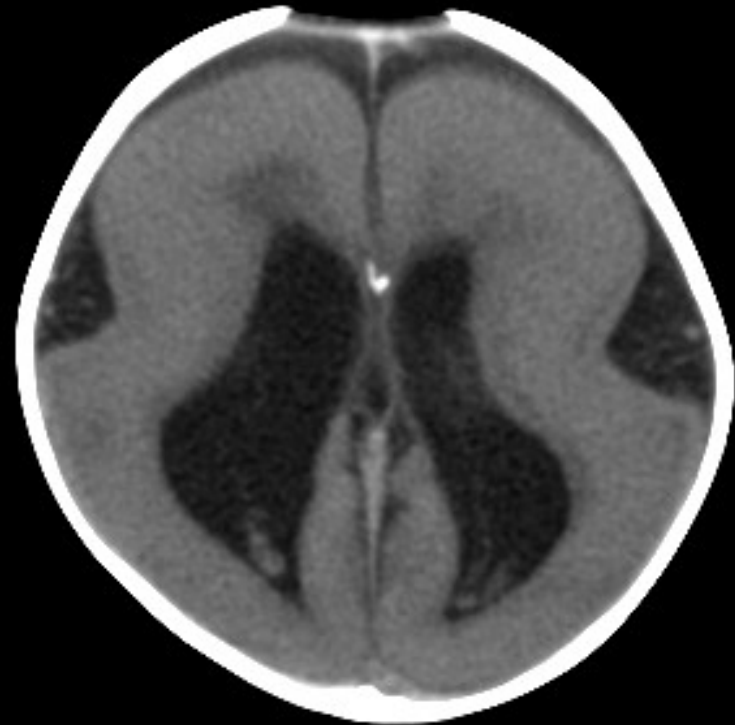
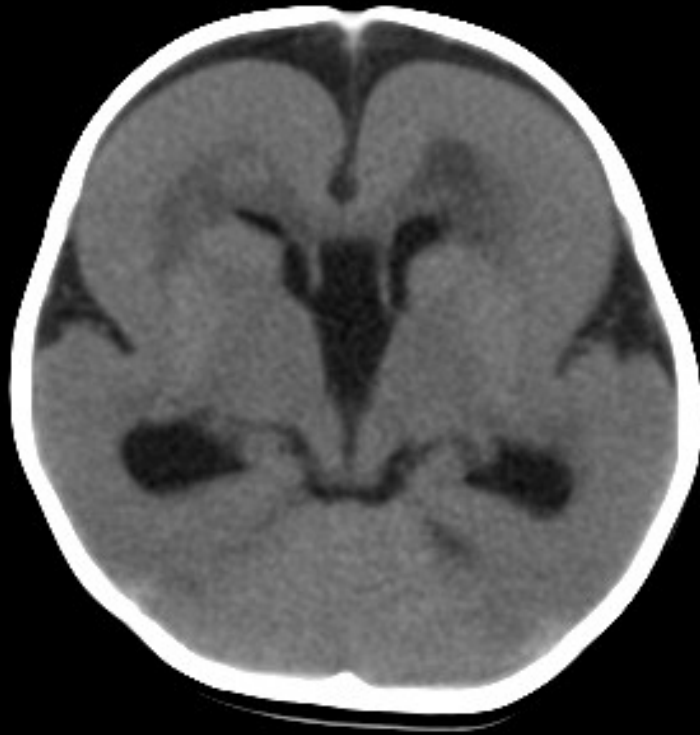
- Abnormal neuronal & glial proliferation
- Abnormal neuronal migration
- Abnormal cortical organization

Abnormal neuronal migration

- Lissencephaly
- Band heterotopia
- Multifocal Subependymal Nodular Heterotopia
- Peri sylvian Polymicrogyria
- Focal Cortical Dysplasia

Lissencephaly

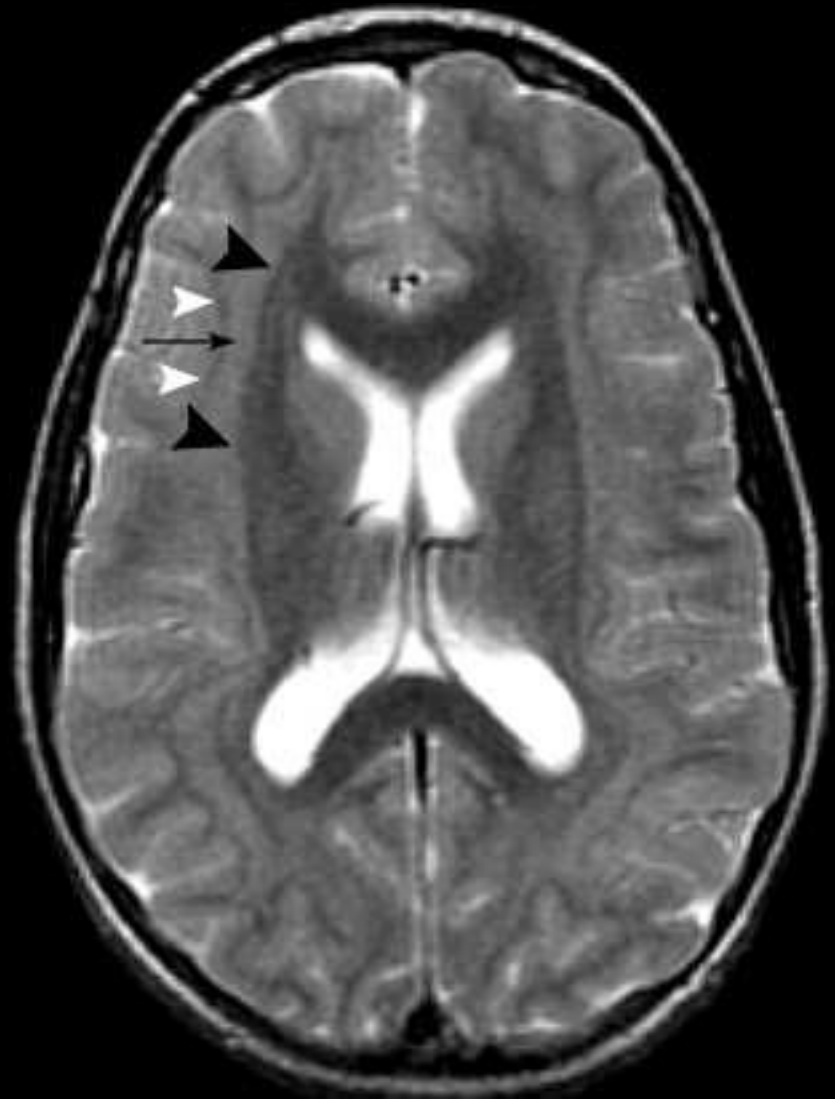
- Abnormal cortical malformation caused by arrested neuronal migration
- Resulting in a thick 4 layer cortex and smooth brain surface
- Figure of 8 shape of cerebral hemispheres
- Prominent vessels in shallow sylvian fissures
- Minimal sulci in cerebral hemispheres



Abnormal neuronal migration

Band heterotopia

- More common in females
- Double cortex
- Band of smooth grey matter separated from cortex by layer of normal appearing white matter
- Overlying cortex has shallow sulci

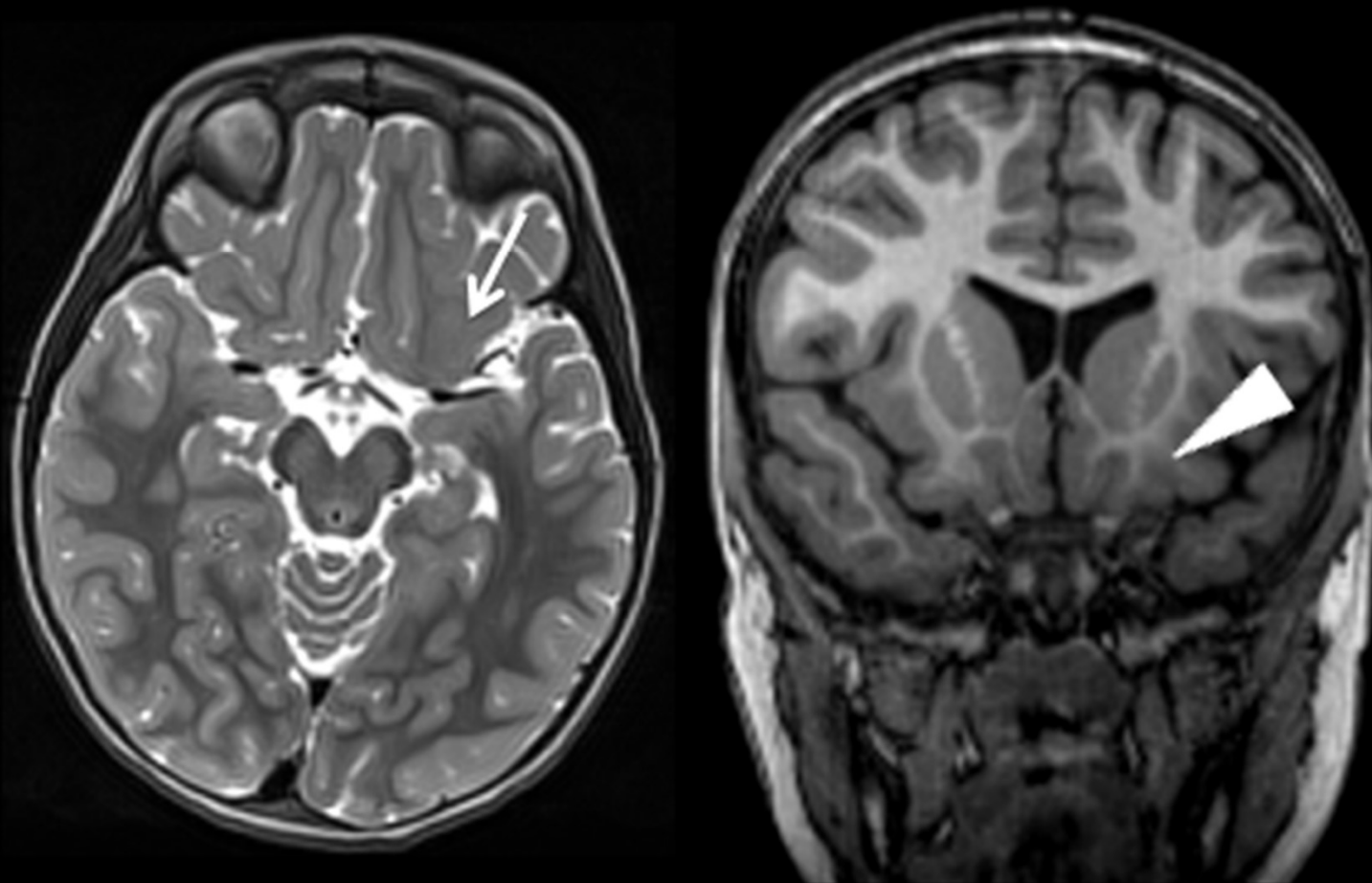


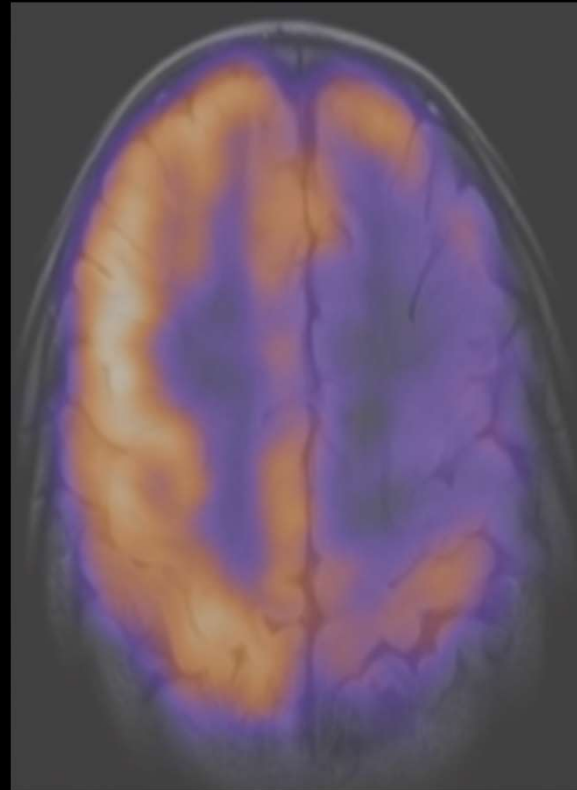
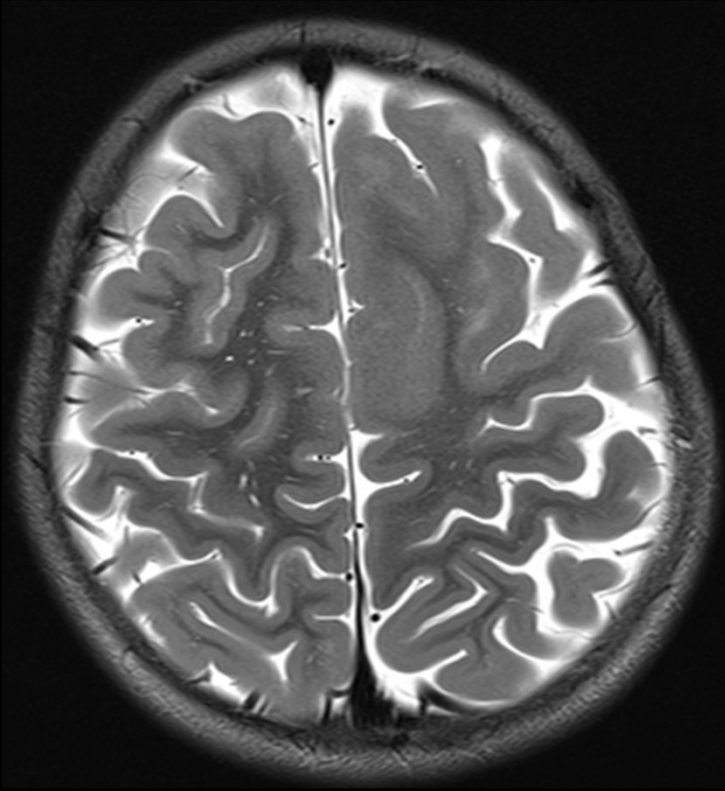
Focal cortical dysplasia

- MRI include
- cortical thickening (confirmed in at least two planes and two different imaging sequences)
- blurring of the gray and white matter junction
- T2 and FLAIR hyperintensity in the cortex and adjacent subcortical white matter
- abnormal sulcal / gyral pattern
- In practice, it may be possible to distinguish between Type I and Type II dysplasia

FCD Type 1A

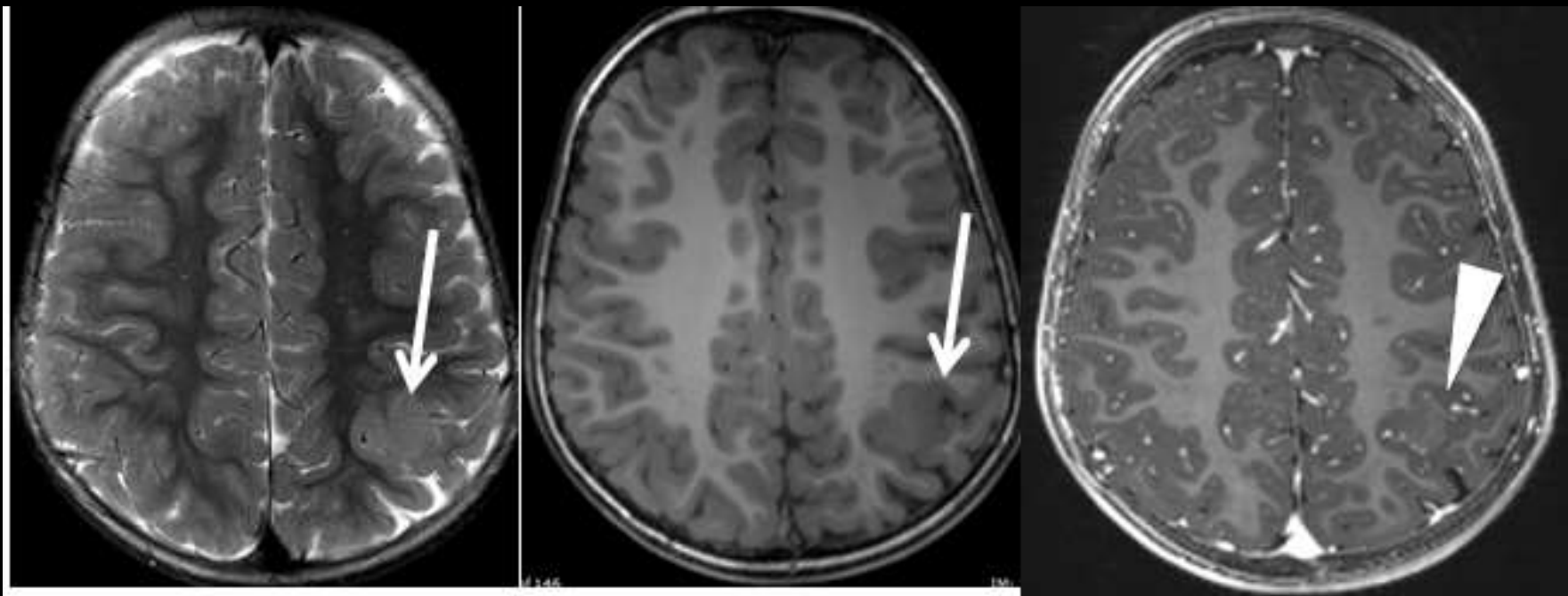
- Case: 3 year-old female with pharmacoresistant left frontal lobe epilepsy





Neoplasm masquerading as FCD

- 3 year-old male presenting with new onset seizures



Angiocentric glioma

Conclusion

- Advances in neuro-imaging continues to improve the rates of detection of lesional substrates in pediatric patients with epilepsy
- It is important to utilize tailored MRI protocols

Imaging of intractable paediatric epilepsy

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Approximately 20% of paediatric patients with epilepsy are refractory to medical therapies. In this subgroup of patients, neuroimaging plays an important role in identifying an epileptogenic focus. Successful identification of a structural lesion results in a better outcome following epilepsy surgery. Advances in imaging technologies, methods of epileptogenic region localisation and refinement of clinical evaluation of this group of patients in epilepsy centres have helped to widen the spectrum of children who could potentially benefit from surgical treatment. In this review, we discuss ways to optimise imaging techniques, list typical imaging features of common pathologies that can cause epilepsy, and potential pitfalls to be aware of whilst reviewing imaging studies in this challenging group of patients. The importance of multidisciplinary meetings to analyse and synthesise all the non-invasive data is emphasised. Our objectives are: to describe the four phases of evaluation of children with drug-resistant localisation-related epilepsy; to describe optimal imaging techniques that can help maximise detection of epileptogenic foci; to describe a systematic approach to reviewing magnetic resonance imaging of children with intractable epilepsy; to describe the features of common epileptogenic substrates; to list potential pitfalls whilst reviewing imaging studies in these patients; and to highlight the value of multimodality and interdisciplinary approaches to the management of this group of children.

Introduction

Approximately 20% of children with epilepsy are refractory to medical therapy, which has a significant adverse effect on patients and their families.¹ The term 'drug-resistant epilepsy' has been proposed by the International League against Epilepsy (ILAE) to replace terms such as refractory and intractable epilepsy. Neuroimaging plays an important role in identifying epileptogenic foci that can be surgically resected. Advances in neuroimaging, including advances in scanner hardware and software, have allowed improved signal-to-noise ratio and achieve faster scan times and fewer motion artifacts. In addition, use of advanced imaging techniques, including multimodality fusion, has enabled improved lesion detection and localisation. It is important to choose tests based on their potential to further define the epileptogenic region, acknowledge their known strengths and limitations, and weigh the expected clinical benefit and incremental cost-effectiveness. Any additional test should be chosen on the basis of the likelihood that it can change the resection plan or surgical method. It should be pointed out that a review in 2011 by an ILAE panel found no studies that qualified as class 1 evidence, and little class 2 evidence on the utility of diagnostic tests in pre-surgical evaluation of patients with paediatric epilepsy.² Recommendations provided in the present review are based on the first author's personal experience of working in paediatric epilepsy groups over the last decade and is similar to consensus recommendations from various ILAE panels.³

Phases in the evaluation of children with epilepsy

Phase 1

One must first define the seizure syndrome and ensure that medical therapy is optimised; this includes a detailed history, including pre- and postnatal events, seizure history including the semiology (type of seizure), characteristics of onset and manifestations of the seizures, a full neurological examination, detailed electrophysiology via several electroencephalography (EEG) exams that record interictal and ictal events, and neuroimaging.

Functional imaging with single-photon emission computed tomography (SPECT) and/or positron emission tomography (PET), functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG) are also used in some cases. Results are discussed at multidisciplinary team meetings involving specialists in neurology, neurosurgery, neurophysiology, neuroradiology and neuropsychology. If the anatomical and functional images are concordant with the

Acknowledgement



- Prof S Prabhu Boston Children's hospital, Harvard

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8 November 2019

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Accommodation reservations:
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