MR Imaging in Epilepsy
From Anatomical to Functional Imaging

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*Role of MR Imaging

*Identify underlying structural abnormalities that require specific treatments.
*Preoperative evaluation in epilepsy surgery.
*Epileptogenic substrates*

- Hippocampal sclerosis
- Malformation of cortical development
- Neoplasm
- Vascular malformation
- Gliosis and miscellaneous abnormalities
Hippocampal Sclerosis
*Hippocampus*
Hippocampus
Hippocampus

The head is not covered by choroid plexus and has digitations.

- Collateral sulcus
- Parahippocampal gyrus
- Mammillary body
- Collateral white matter
- Amygdala
- Fornix
- Digitation

*Note: Diagram labels correspond to the text.*
*Hippocampus*

The body can be seen at the level of the anterior brain stem.
*Hippocampus*

The tail can be seen at the level of the cerebellum.
Hippocampal Sclerosis

*Hippocampal sclerosis refers to neuronal loss in CA1-4 and the dentate gyrus.

*Mesial temporal sclerosis implies more extended sclerosis of extrahippocampal tissue, such as the amygdala and parahippocampal gyrus.
Hippocampal Sclerosis: MRI findings

- Loss of internal architecture
- Loss of hippocampal head interdigitations
- Abnormal hypersignal T2 change of hippocampus
- Hippocampal atrophy
- Atrophy of the ipsilateral fornix
- Atrophy of the ipsilateral mammillary body
- Atrophy of the ipsilateral collateral white matter
- Dilatation of the ipsilateral temporal horn
Right Mesial Temporal Sclerosis
A 37 year-old female epilepsy since 2 years of age with visual aura.
*Mesial Hippocampal Sclerosis*
Mesial Hippocampal Sclerosis

Perfusion Study with 3D ASL
A 14 year-old male had seizure and abnormal EEG at the left temporal region.
A 14 year-old boy had abnormal EEG at the left temporal region.

**Perfusion Study with 3D ASL**

*Left Mesial Temporal Sclerosis*
A 14 year-old male had seizure and abnormal EEG at the left temporal region.
*Malformation of cortical development
*MCD is characterized by an abnormal structure of the cerebral cortex.

*Malformation Secondary to Abnormal Neuronal and Glial Proliferation or Apoptosis, Malformation Due to Abnormal Neuronal Migration, and Malformation Secondary to Abnormal Postmigration Development.

*MCD is an important cause of developmental delay and epilepsy.
*Focal Cortical Dysplasia (FCD): Imaging Findings*

* Cortical thickening
* Abnormal gyration
* Blurring of gray-white junction
* T2 prolongation in the cortex or subjacent white matter
* Decreased white matter volume
* Heterotopic gray matter
* CSF cleft
* Cortical dimple
<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristic features</th>
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| I    | a – focal cortical dysplasia with abnormal radial cortical lamination  
     | b – focal cortical dysplasia with abnormal tangential 6-layer cortical lamination  
     | c – focal cortical dysplasia with abnormal radial and tangential cortical lamination |
| II   | a – focal cortical dysplasia with dysmorphic neurons  
     | b – focal cortical dysplasia with dysmorphic neurons and balloon cells |
| III  | a – architectural distortion of cortical layer in temporal lobe with hippocampal atrophy  
     | b – architectural distortion of cortical layer adjacent to glial or glioneuronal tumor  
     | c – architectural distortion of cortical layer adjacent to vascular malformation  
     | d – architectural distortion of cortical layer adjacent to other lesions acquired in early childhood such as trauma, ischemic event, encephalitis |
FCD type I
A 13 year-old boy had seizure since 3 years of age.
EEG – Bisynchronous sharp-slow activity over bilateral frontal regions with right predominance.

* FCD type Ia
A 20 year-old female had seizure since 9 years of age. Seizure started from feeling of palpitation, followed by loss of awareness and whole body stiffening/jerking.
Microdysgenesis

Perfusion Study with 3D ASL
A 20 year-old female had seizure since 9 years of age. Seizure started from feeling of palpitation, followed by loss of awareness and whole body stiffening/jerking.
*FCD type Ila*

A 9 year-old boy, right handedness, had seizure since 2 ½ years of age and had intractable seizure.
FCD type IIa

A 9 year-old boy, right handedness, had seizure since 2 ½ years of age and had intractable seizure.

*Perfusion Study with 3D ASL*
A 7 year-old boy had seizure since 3 years of age. He had seizure starting from chewing and turning to the right side, followed by generalized seizure.
* Cortical/subcortical tubers
* Calcified subependymal nodule (hamartoma)
* Subependymal giant cell astrocytoma
* White matter lesions along lines of neuronal migration

* Diagnostic Imaging: Pediatric Neuroradiology by Barkovich
*Tuberous Sclerosis Complex*
Tuberous Sclerosis Complex

A 10 year-old girl had complex partial seizure.
*Tuberous Sclerosis*
*Tuberous Sclerosis*
Perfusion Study with 3D ASL
*Heterotopia represents collections of normal neurons situated in abnormal locations.

*Heterotopia is isointensity to GM in all MRI sequences and reveals no contrast enhancement.
* Subependymal heterotopia
* Band (laminar) heterotopia
* Subcortical heterotopia
*Subependymal Heterotopia*
*Subependymal Heterotopia*

Perfusion Study with 3D ASL
A 34 year-old male had seizure starting from oral automatism, followed by bimanual automatism.
*Subcortical Heterotopia*

He had seizure 15-20 minutes before MRI.

Perfusion Study with 3D ASL
Malformation Secondary to Abnormal Postmigration Development

*Polymicrogyria (PMG)
*Schizencephaly
Polymicrogyria (PMG)

* Causes of PMG include prenatal infection, prenatal ischemia or exposure to toxins and chromosomal abnormalities.
* PMG is commonly located in perisylvian regions.
*Polymicrogyria (PMG)*

*Imaging findings*

* PMG may have a smooth surface, or multiple deep infoldings of the cortex with irregular G-W junction.
* Reduced WM volume is the affected region.
A 14 year-old boy, case of epilepsy, had epileptical discharge from bilateral centrotemporal regions and VF defect and decreased VA right eye.
Perfusion Study with 3D ASL
Perfusion Study with 3D ASL
*Schizencephaly is a cleft lined with GM and connecting subarachnoid space with the ventricular system.

*The wall of the cleft is lined by dysmorphic GM.

*Schizencephaly is divided into open-lip or closed-lip type.
A 22 year-old female seizure since childhood, slow speech and poor development.
Tumour
A 13 year-old boy had complex partial seizure during sleep.
A 13 year-old boy had complex partial seizure during sleep.
Pleomorphic xanthoastrocytoma

A 16 year-old male had first seizure attack 10 months ago.
A 26 year-old female had seizure for 9 months.
**Ganglioglioma**

- Benign mixed solid & cystic cortically based lesion, often calcification, variable enhancement, common location, temporal lobe.

A 8 year-old girl intractable seizure for 3 years.
*Pilocytic Astrocytoma*

- **Age of onset:** 8-13 years
- **The mesial temporal lobe is classical location.**
- **Imaging:** A cyst with an enhancing nodule. Variable enhancement of cyst wall.

A 17 year-old female complex partial seizure for 5 years.
A 40 year-old female focal seizure of left upper limb for ½ year.
A 40 year-old female focal seizure of left upper limb for ½ year.
A 13 year-old boy left-sided prior to generalized epilepsy.
Subcortical heterotopia at the right occipital lobe
* Subcortical heterotopia at the right occipital lobe

Optic Radiation
Subcortical heterotopia at the right occipital lobe

IFOF

ILF
M 22 years, left handedness, had right mesial temporal sclerosis
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A 28 year-old female, left handedness, had seizure with palpitation and chewing.
A 28 year-old female, left handedness, had seizure with palpitation and chewing.

Silent Word Generation Task.
A 28 year-old female, left handedness, had seizure with palpitation and chewing.

Silent Verb Generation Task
A 28 year-old female, left handedness, had seizure with palpitation and chewing.

Silent Picture Naming Task
A 28 year-old female, left handedness, had seizure with palpitation and chewing.
A 28 year-old female, left handedness, had seizure with palpitation and chewing.
A 28 year-old female, left handedness, had seizure with palpitation and chewing.
A 34 year-old male had seizure starting from oral automatism, followed by bimanual automatism.
He had seizure 15-20 minutes before MRI.
FMRI-Verb generation
MR Tractography
Optic Radiation
* MR Tractography
Arcuate Fasiculus
*Encephalomalacia
Left Cerebral Hemisphere
* Encephalomalacia
Left Cerebral Hemisphere
* Encephalomalacia Left Cerebral Hemisphere

Right Hand Fisting

Right Toes Movement
*Encephalomalacia
Left Cerebral Hemisphere*
Verb Generation

Listening to Short Story

* Encephalomalacia
Left Cerebral Hemisphere
A 43 year-old female had focal seizure starting from right arm to right leg for 3-4 months.
* A 43 year-old female had numbness and jerking right side for 1 week.
A 43 year-old female had numbness and jerking right side for 1 week.

Right Finger Tappings

Bilateral Finger Tappings
A 43 year-old female had numbness and jerking right side for 1 week.

Right toes Movement

Bilateral toes Movement
A 43 year-old female had numbness and jerking right side for 1 week.

Oligodendroglioma
*Thank You*