IMAGING IN EPILEPSY

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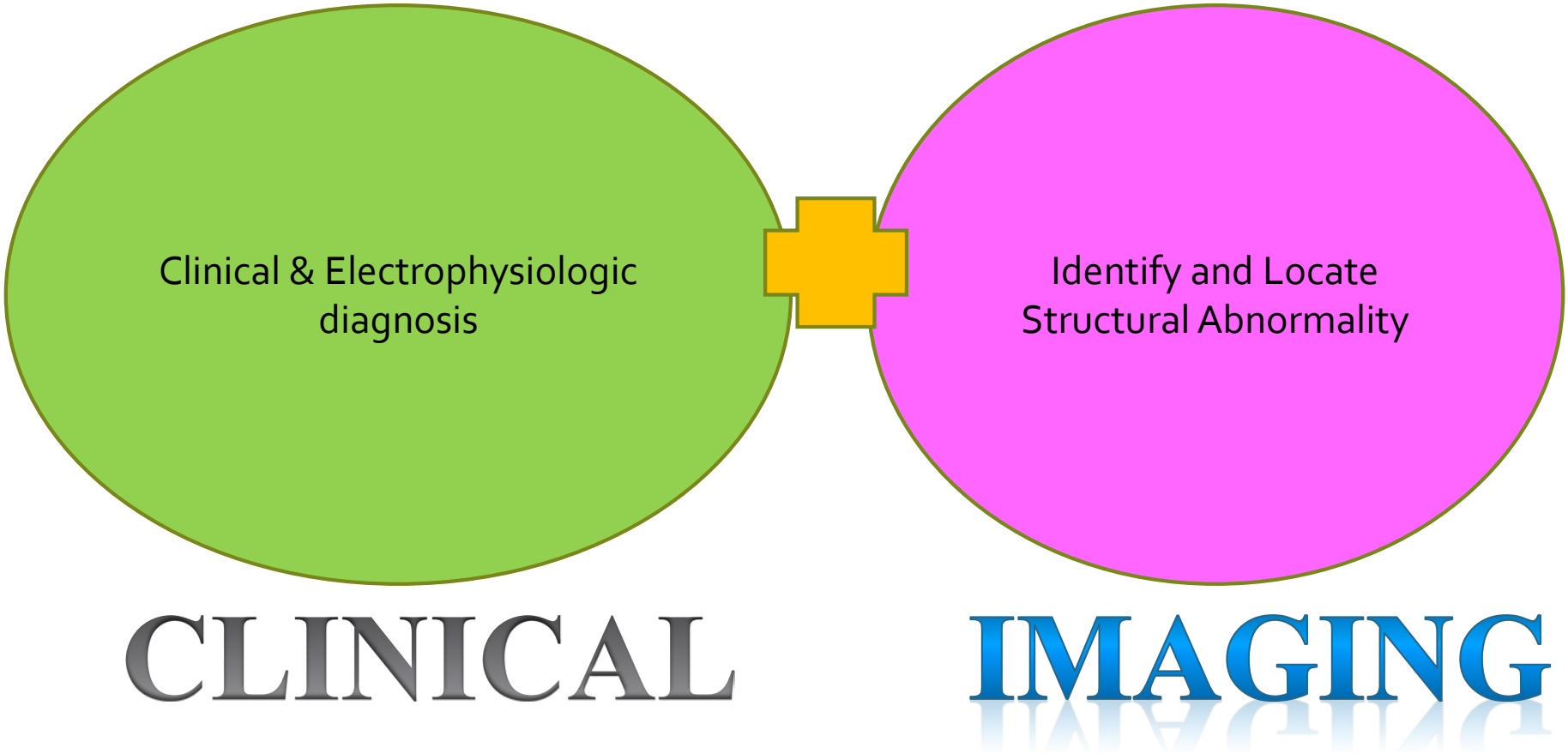
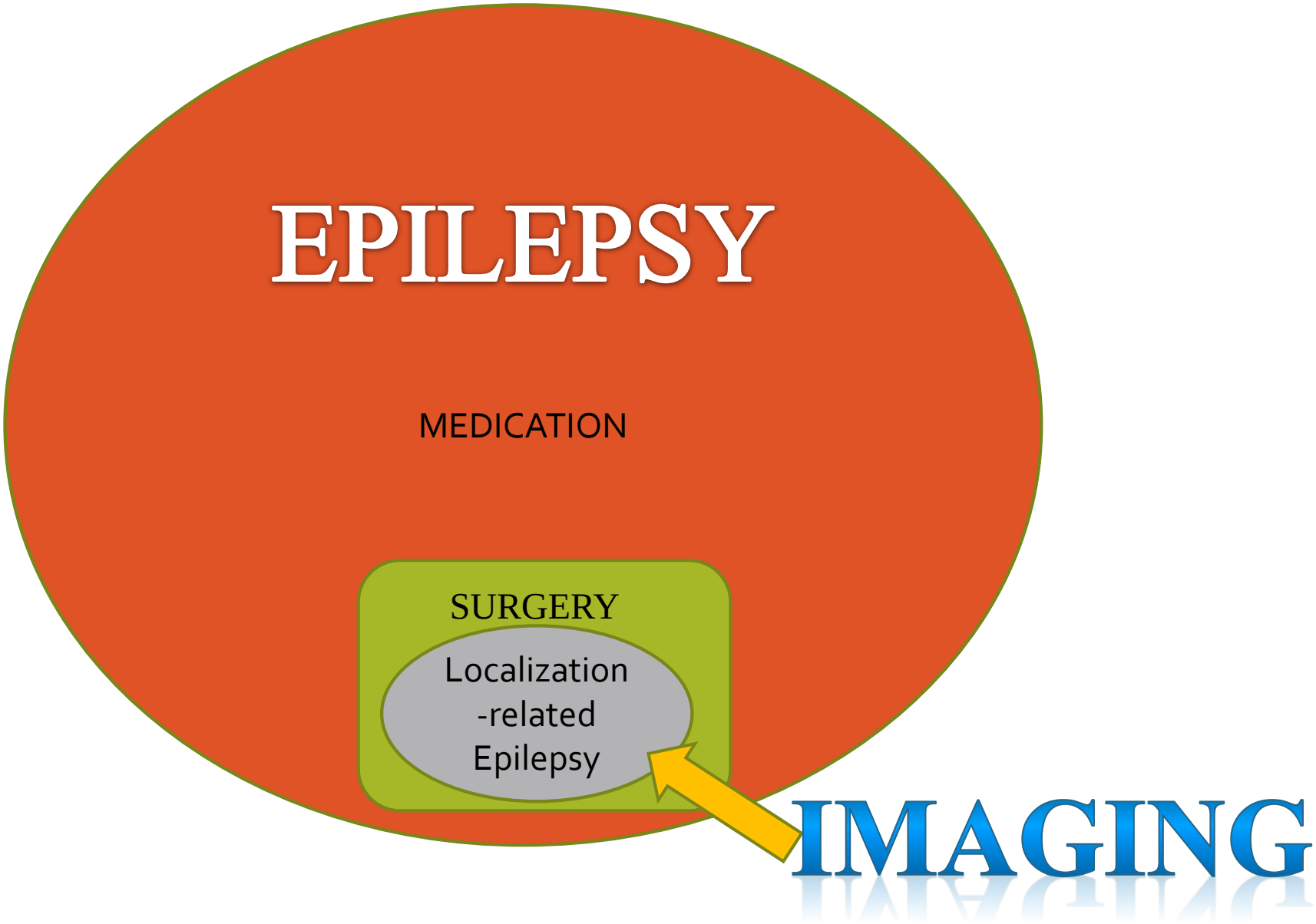
OUTLINE

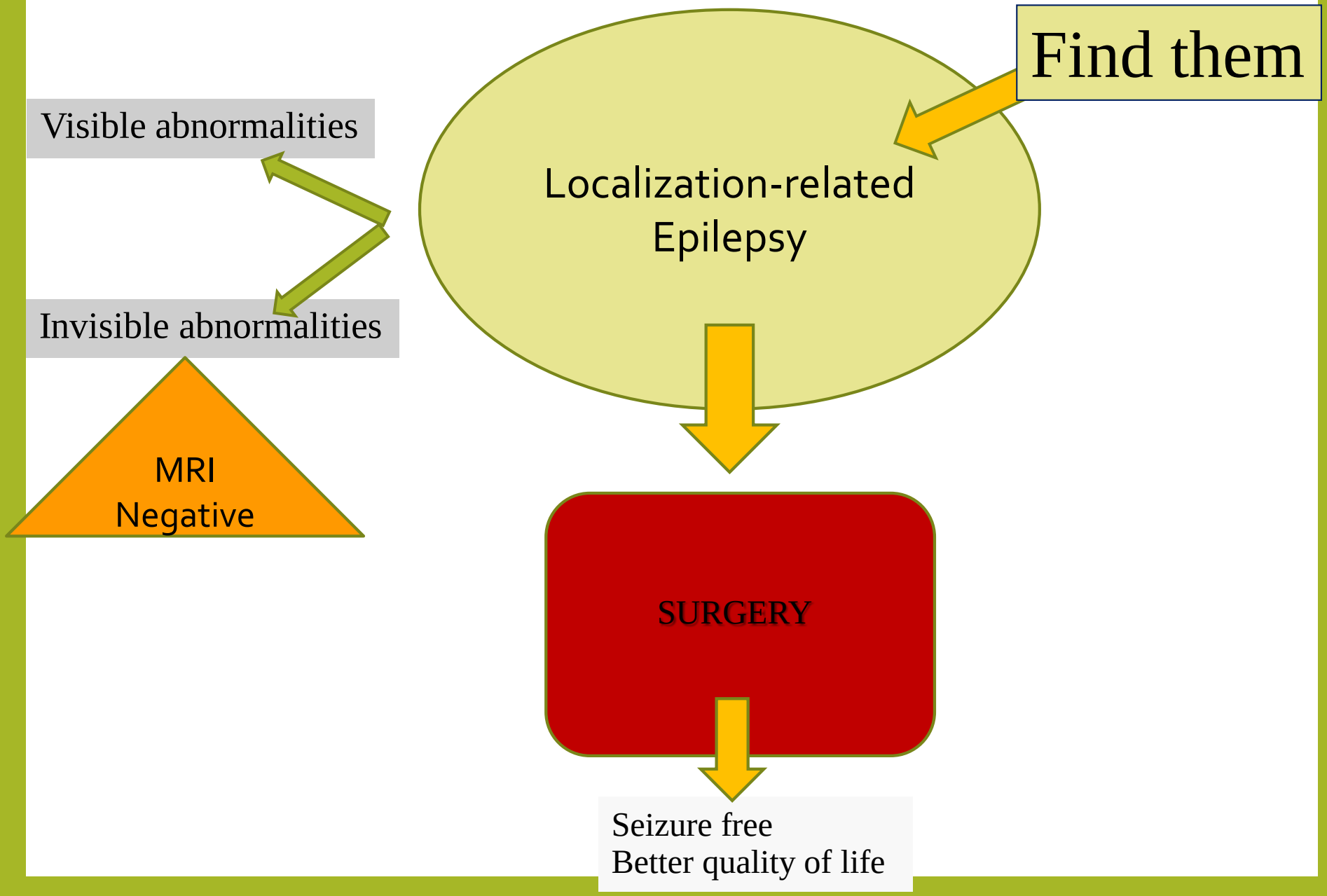
- Role of Imaging in Epilepsy
- Indication of Imaging
- Imaging Modalities and Updates
- Variety of epileptogenic substrates commonly identifiable with MRI


Clinical & Electrophysiologic diagnosis
Identify and Locate Structural Abnormality
CLINICAL
IMAGING

Role of Imaging

- Pre-surgery
  - Identify structural abnormality
  - Localize
- Plan for surgery
  - Help confirm epileptogenicity
  - Relationship with eloquent areas
  - Predict resectivity and Prognostication
- Post-surgery
  - Evaluate residual lesion
  - Surveillance


EPILEPSY
MEDICATION
SURGERY
Localization
-related
Epilepsy
IMAGING


Find them
Visible abnormalities
Invisible abnormalities
Localization-related
Epilepsy
MRI
Negative
SURGERY
Seizure free
Better quality of life

IMAGING IN EPILEPSY

- CT
- SPECT
- PET
- MRS

Anatomy/Structural vs Functional Imaging

Ideal Imaging

- Distinguish abnormal from normal -> **High resolution**
- Tell etiology/nature of abnormality -> **Good Characterization**
- Allow assessment of relationship with eloquent structures

-> **Functional/Microstructural derangement**

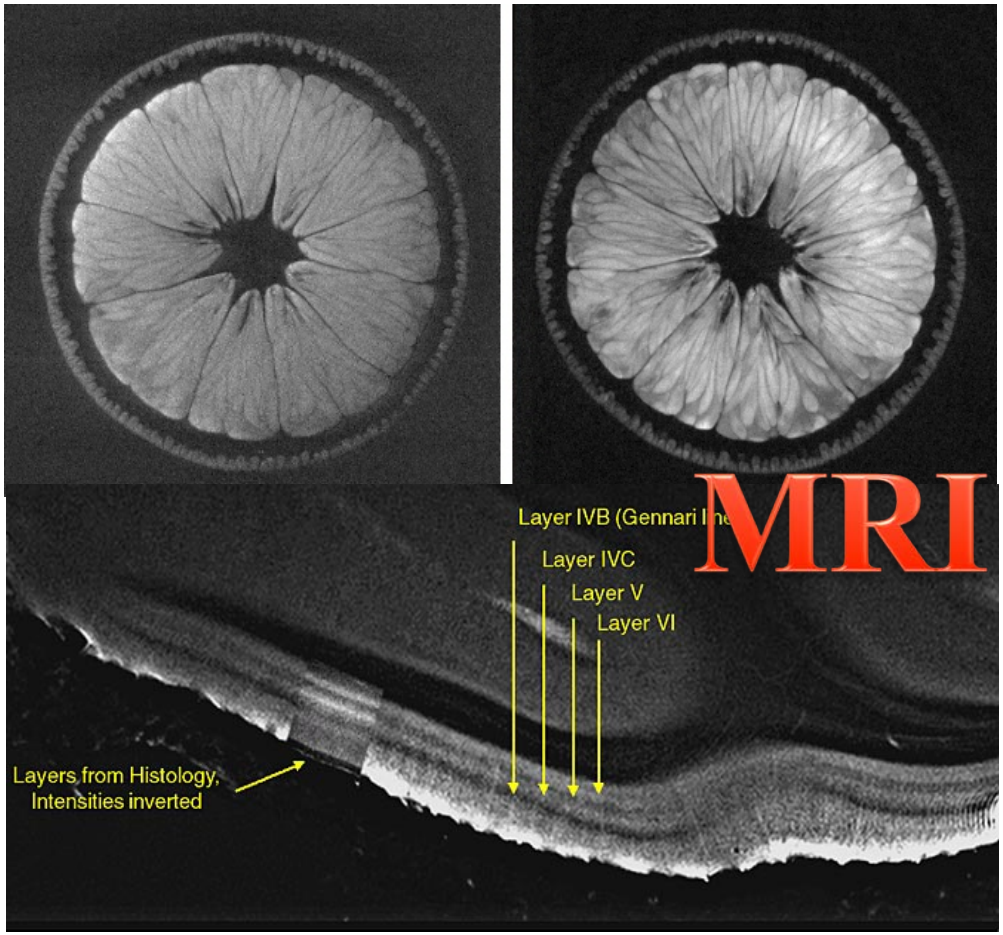
- Evaluate epileptogenicity ->**Physiologic data**

IMAGING CHOICES

Anatomy/Structural : CT, MRI

Physiology and Function: SPECT, PET, MEG, MRS, DTI, fMRI, Perfusion CT/MRI

Structural Imaging
MRI vs CT



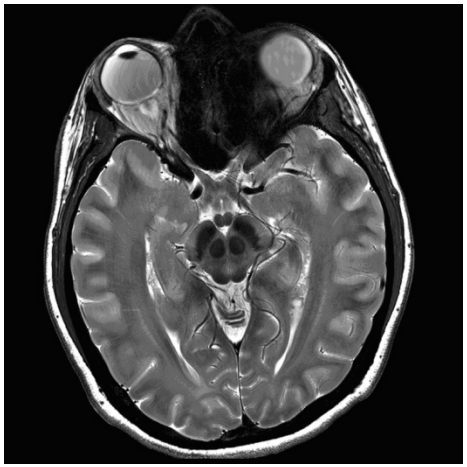


TABLE 9-3 **Sensitivity of CT, Standard MRI, and High-Resolution MRI (Number of Patients)**

Pathology	CT Only	Standard MRI	High-Resolution MRI
Hippocampal sclerosis	0	20	108
Vascular abnormalities	13	14	0
Tumor	4	19	2
Brain damage	18	6	0
Malformations of cortical development	0	13	0
Nonspecific white matter lesions	17	18	0

Reprinted with permission from Wieshmann UC. Clinical application of neuroimaging in epilepsy. J Neurol Neurosurg Psychiatry 2003;74(4):466–470.

IMAGING CHOICES

- Emergent -> CT results change management in patients with acute seizure.
- Non-emergent: MRI sensitivity 95% CT sensitivity 32%

CT: Indication

Emergency or First unprovoked seizure with neurologic abnormality

MRI

MRI **EPILEPSY** 15%

Localisation-related 85%

Conventional MRI: Pros

- Good spatial resolution
- Soft tissue contrast
- Multiplanar
- No ionizing radiation
- Continuous development of techniques and softwares

Conventional MRI: Cons

- Long Imaging time
- Contraindications:
  - Cardiac pacemaker, intracranial aneurysm clip, cochlear implant
  - Poor renal function……Gd
  - Attention deficit, mental disability
  - Claustrophobia
- Cannot assess epileptogenicity or functionality

PITFALLS OF MRI

- Widespread abnormality
- Multiple lesions
- Dual pathologies

MRI Negative

Too Subtle To Identify

- Microdysgenesis
- Molecular/chemical abnormalities

Combining physiologic data: EEG, SPECT, PET, Invasive methods

Solution for MRI Negative

Combine data from multiple sources

Multimodal imaging co-registration

Physiologic Imaging

- SPECT
  - Ictal SPECT
  - Post-ictal SPECT
  - Interictal SPECT
- PET
  - FDG PET

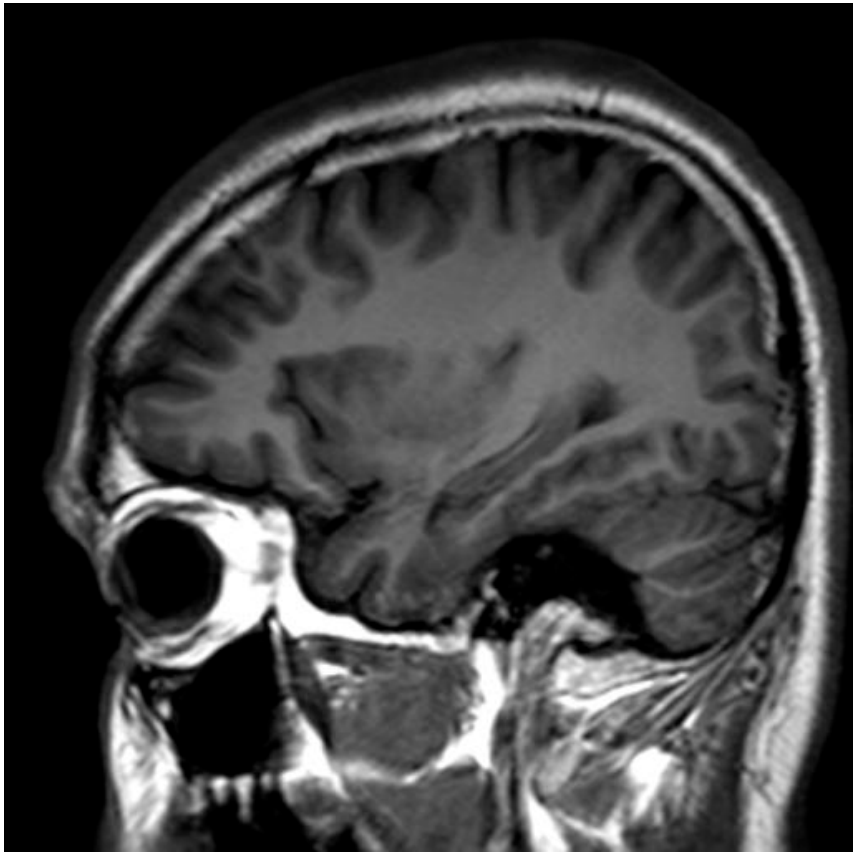
TO Maximize MRI sensitivity

- Appropriate MRI Protocol
- High performance MRI equipment
- Updated software
- Experienced (Neuro)radiologist

Clinical History, EEG finding

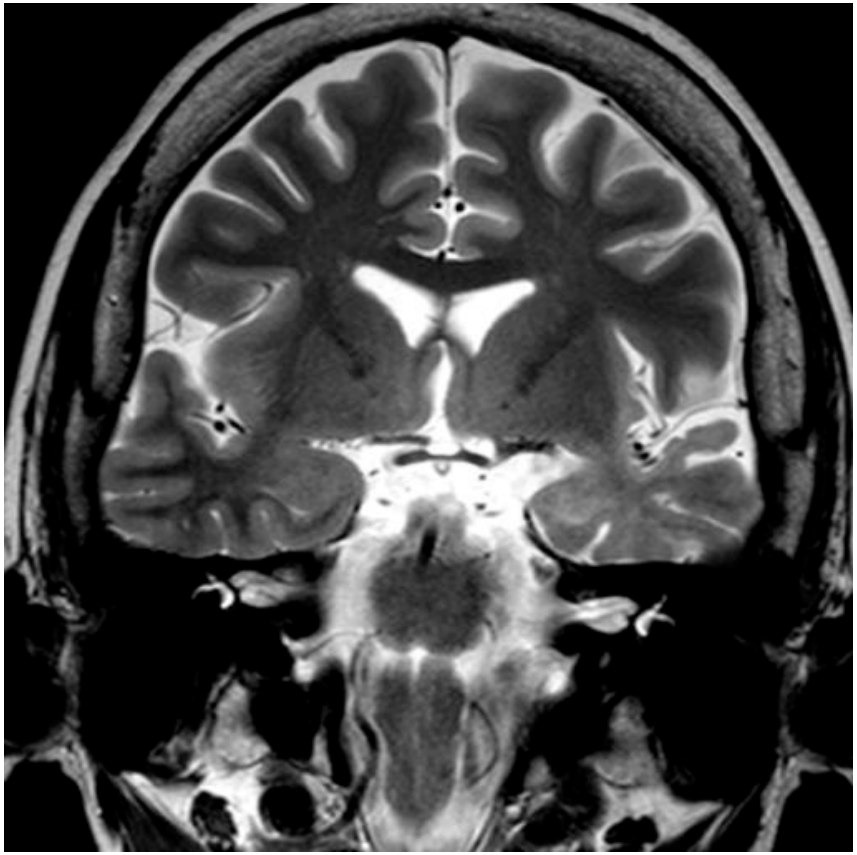
MRI PROTOCOLS

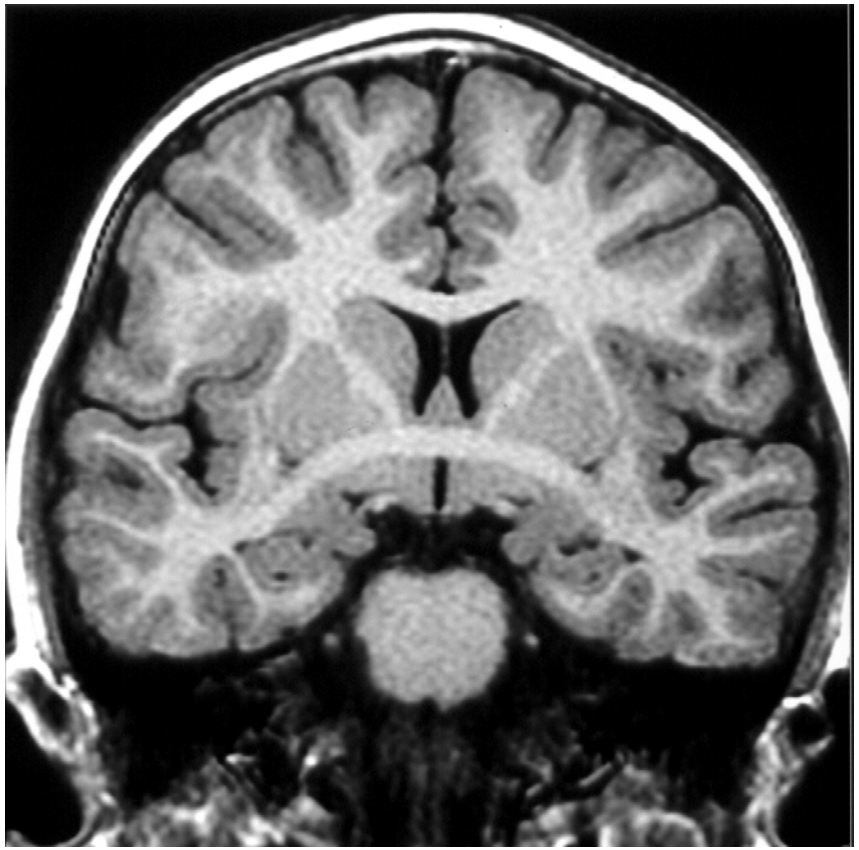
- Coronal oblique
- Volume (3D) SPGR T1W -> reformat & post-processing,IR T1W
- FLAIR, T2W
- Volume T2W
- Contrast not routinely used
- Phase-array coil-> high resolution
- Optional:volumetric analysis,T2 relaxometry, MRS




30
25
20
15
10
5
2
Spacing : 3.0

T2W versus T1W





Etiologies/Epileptogenic Substrates Identifiable with MRI

PEDIATRIC	ADULT
Birth-related	Vascular (Stroke, AVM, cavernoma)
Congenital Malformation	Tumor (primary and mets)
Inborn-error of metabolism	MTS
Neoplasm	Prior brain injury
Infection	
Post trauma	
Vascular (malformation)	
MTS	

EPILEPSY MRI MNEMONIC

- **H** ippocampal size and signal
- **I** AC & atrium (check correct plane and positioning)
- **P** eriventricular heterotopia
- **P** eripheral
  - **S**ulcal morphology abnormality
  - **A**trophy
  - **G**ray matter thickening
  - **E**ncephalocele
- **O** bvious lesion

HIPPO SAGE

Common Epileptogenic Substrates

- MTS
- MCD
- Vascular Malformation
- Gliosis/scar
- Neurocutaneous syndrome
- Miscellaneous

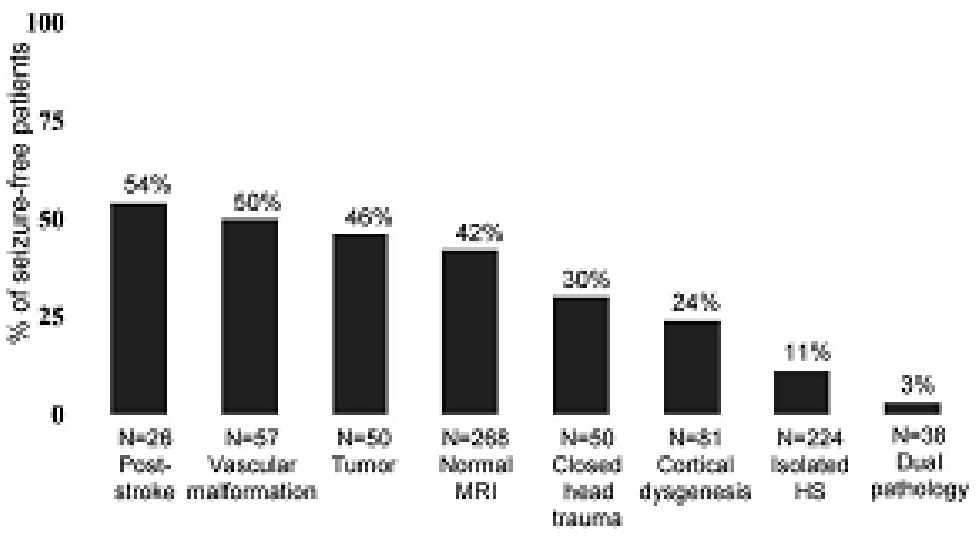
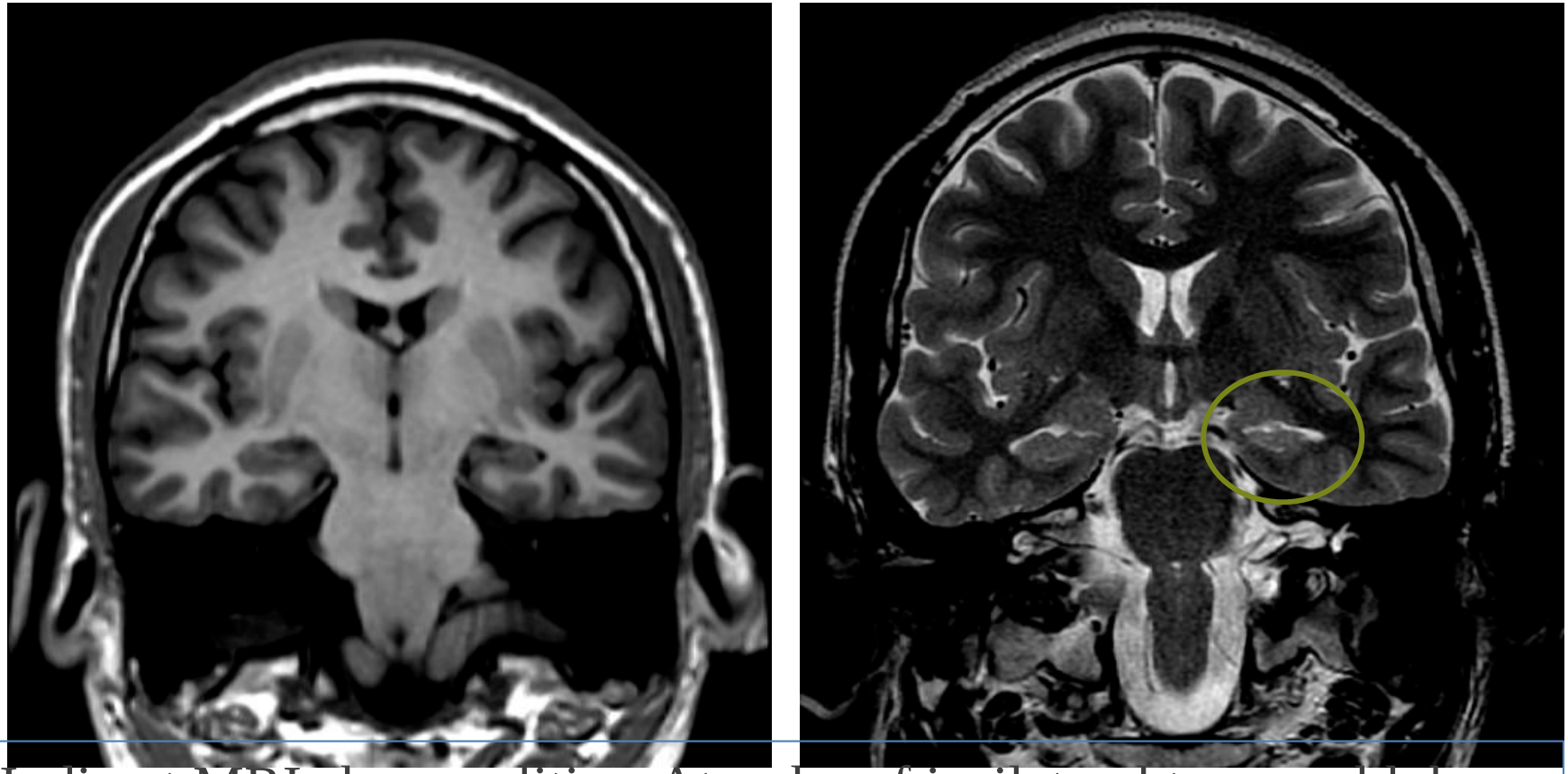


FIGURE 9-8 Seizure control in patients with partial epilepsy: the role of brain abnormalities detected by brain MRI.

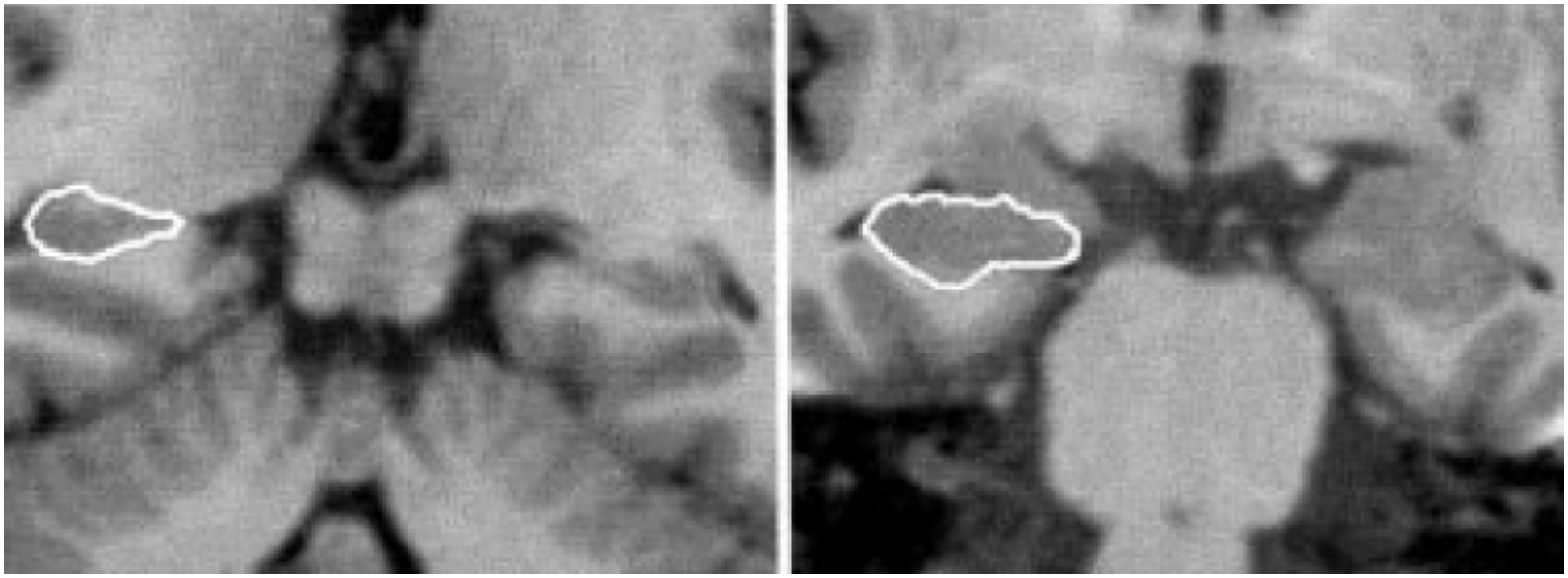
HS = hippocampal sclerosis.

Hippocampal Sclerosis

Atrophy & T2 hyperintensity



Indirect MRI abnormalities: Atrophy of ipsilateral temporal lobe, fornix, mamillary body, collateral WM



Hippocampal Volumetry

Neoplasm

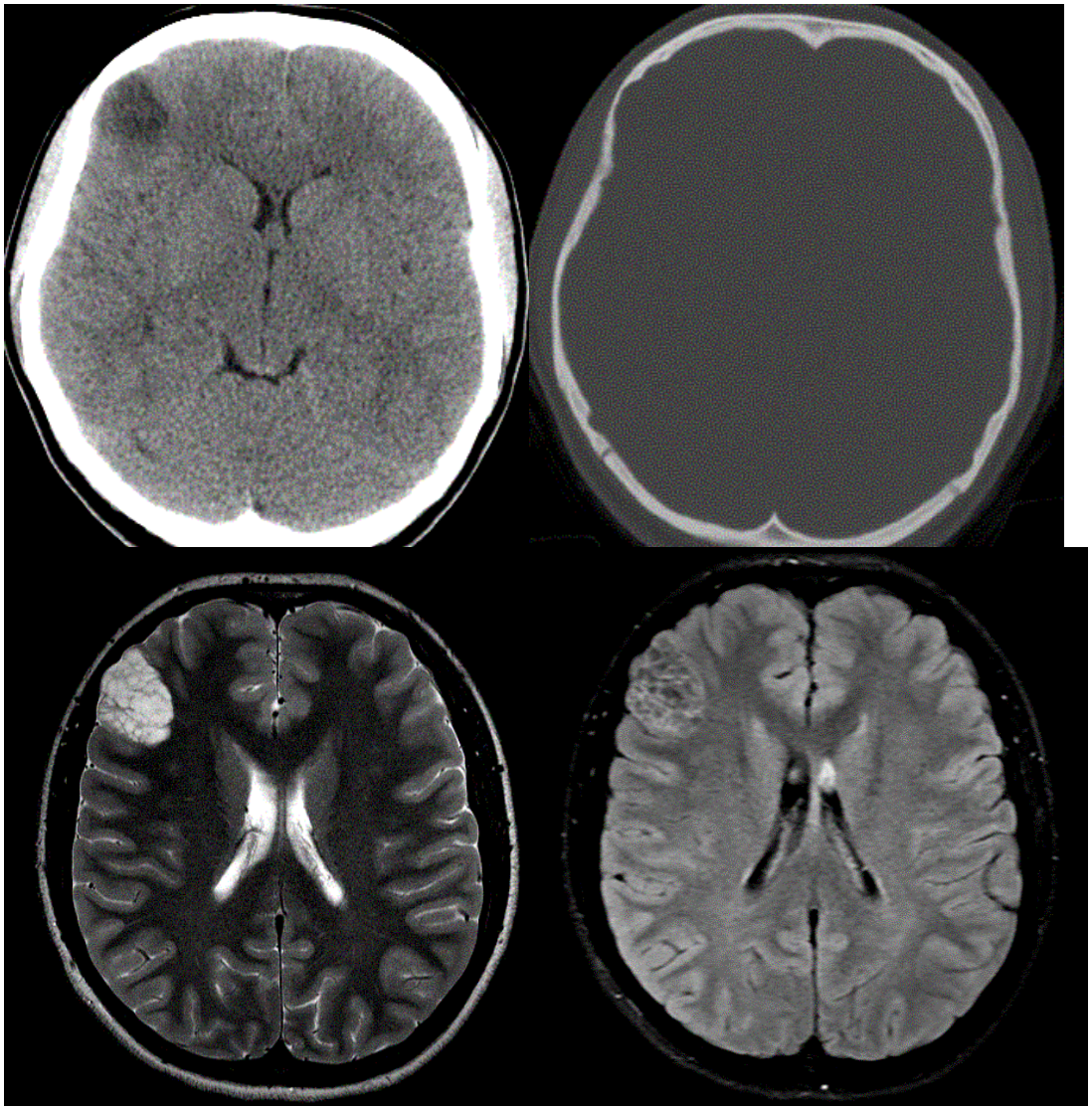
	Seizure frequency
Dysembryoblastic neuroepithelial tumour[5,11]	100%
Gangliogliomа[5,12]	80–90%
Low-grade astrocytoma[12,13]	75%
Meningioma[5,12]	29–60%
Glioblastoma multiforme[5,13]	29–49%
Metastasis[5,12]	20–35%
Leptomeningeal tumour[14,15]	10–15%
Primary CNS lymphoma[14]	10%

Table 1: **Association between tumour type and seizure frequency**

Dysembryoplastic Neuroepithelial Tumor DNET

- Uncommon tumor with high epileptogenicity
- Most common and temporal lobe
- Associated with cortical dysplasia
- Imaging: Heterogeneous mass with no enhancement orcalcification, benign-appearing , characteristic bubbly appearance on FLAIR

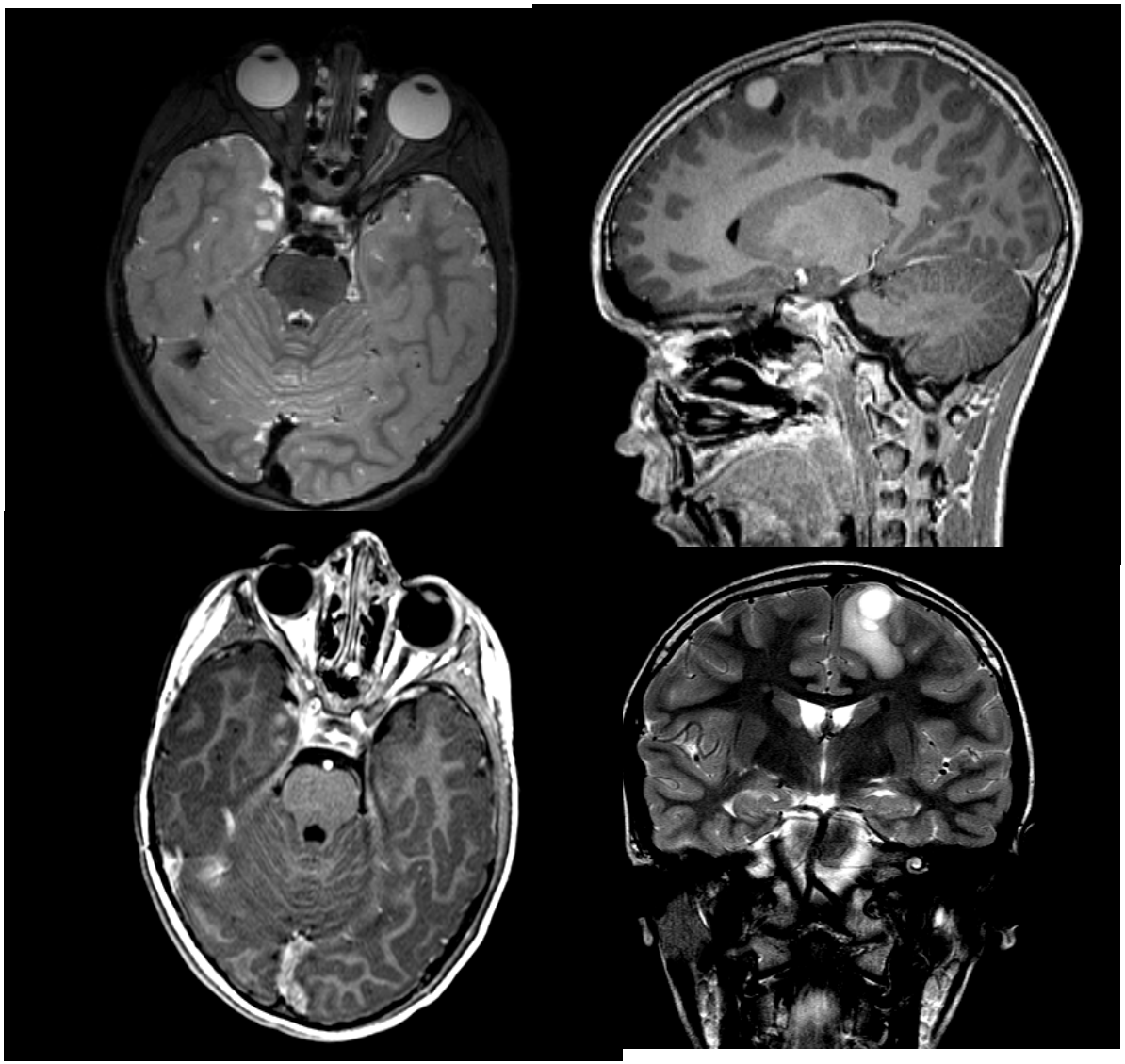
Dysembryoplastic Neuroepithelial Tumor DNET



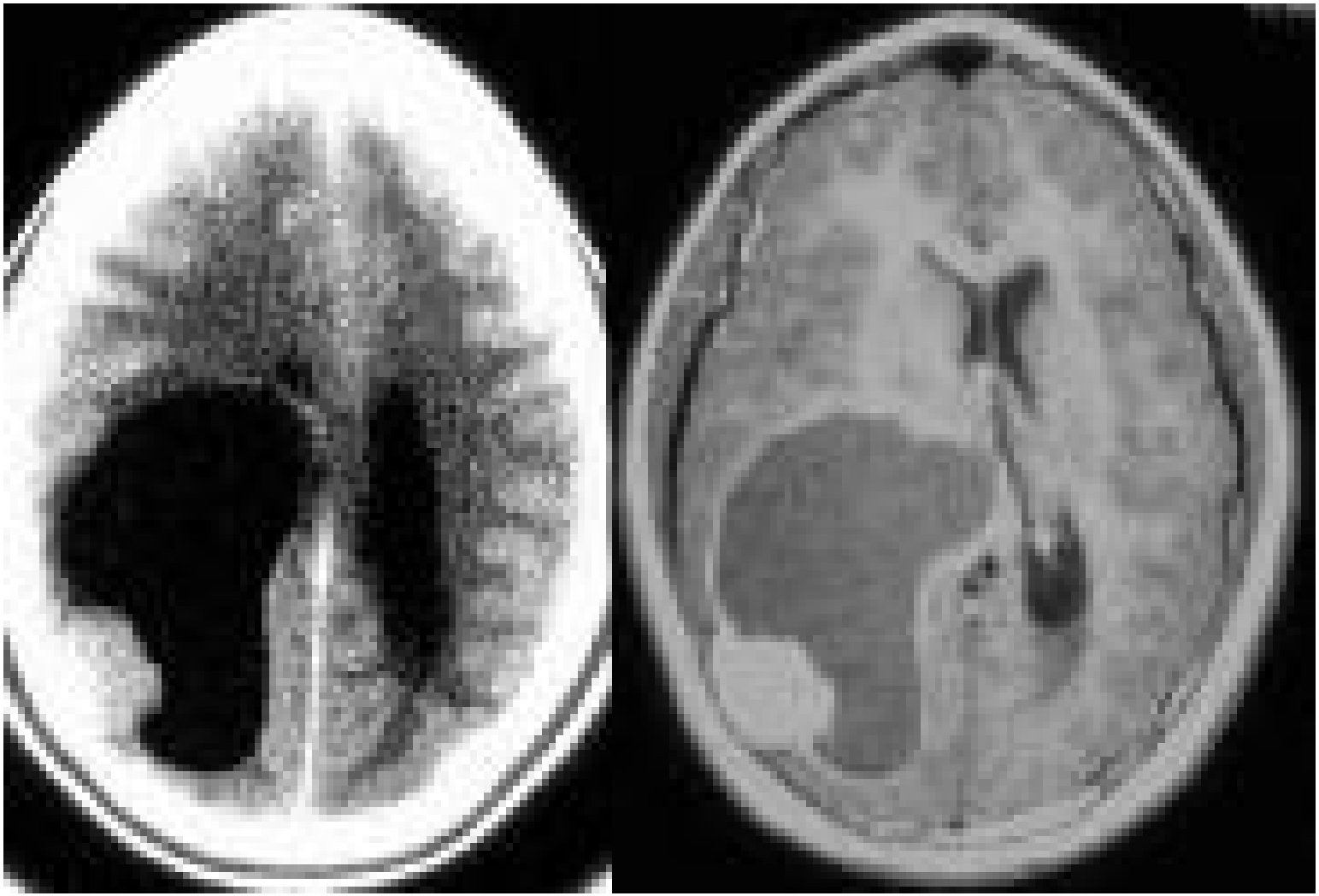
Ganglioglioma

- Rare tumor but highly epileptogenic
- Most common in frontal and temporal lobes
- Associated with cortical dysplasia
- Imaging: Solid or cystic mass with variable enhancement, approx.30% with calcification, benign-appearing

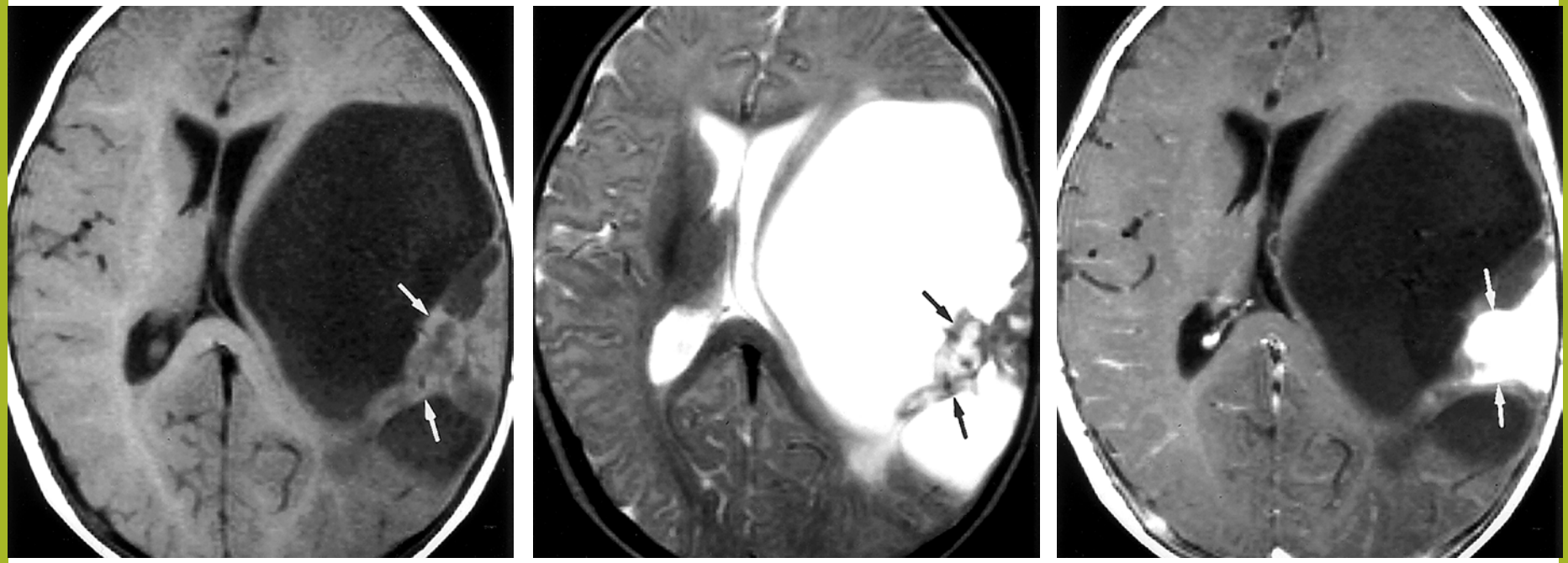
Ganglioglioma



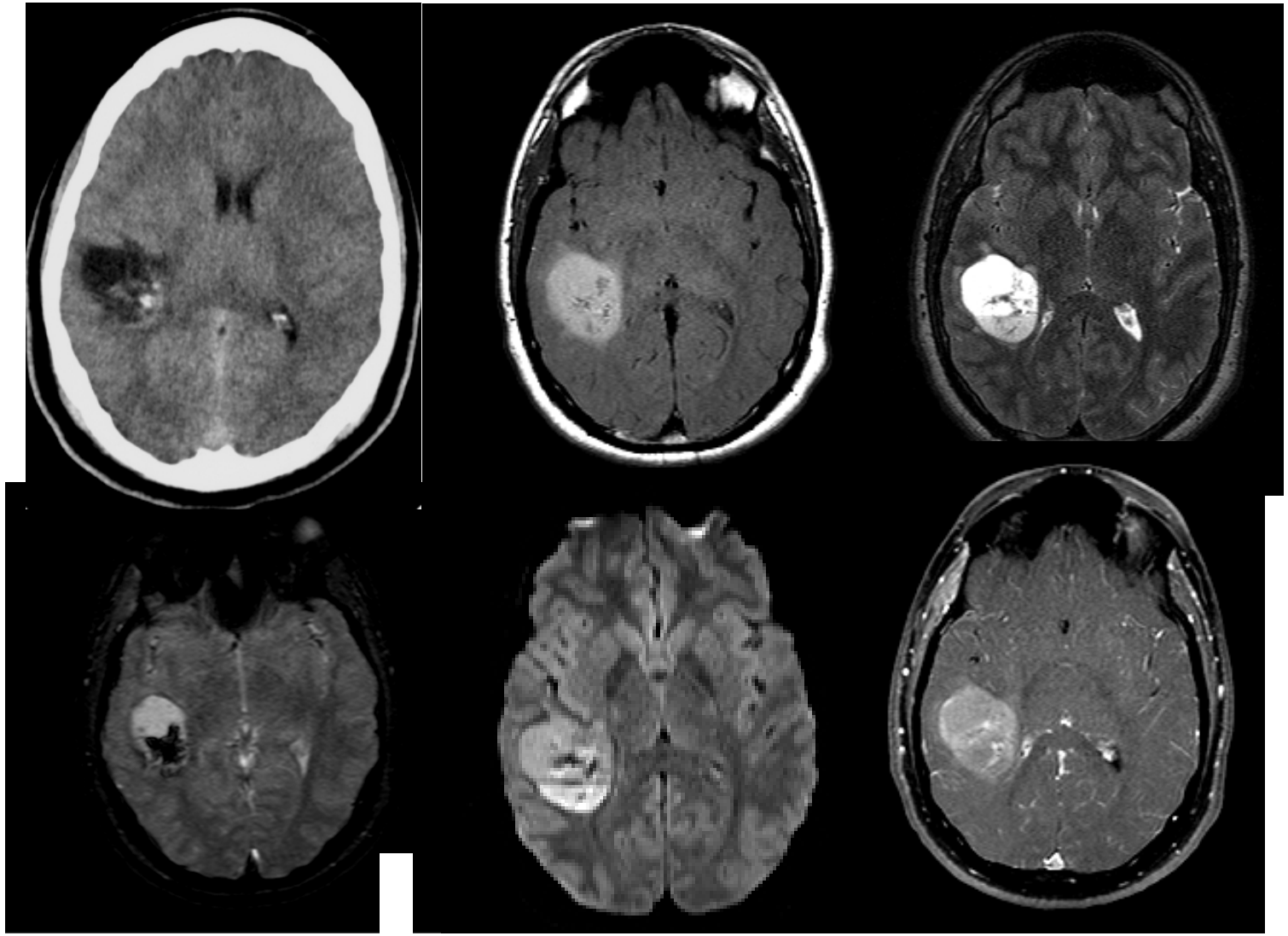
Pleomorphic xanthoastrocytoma



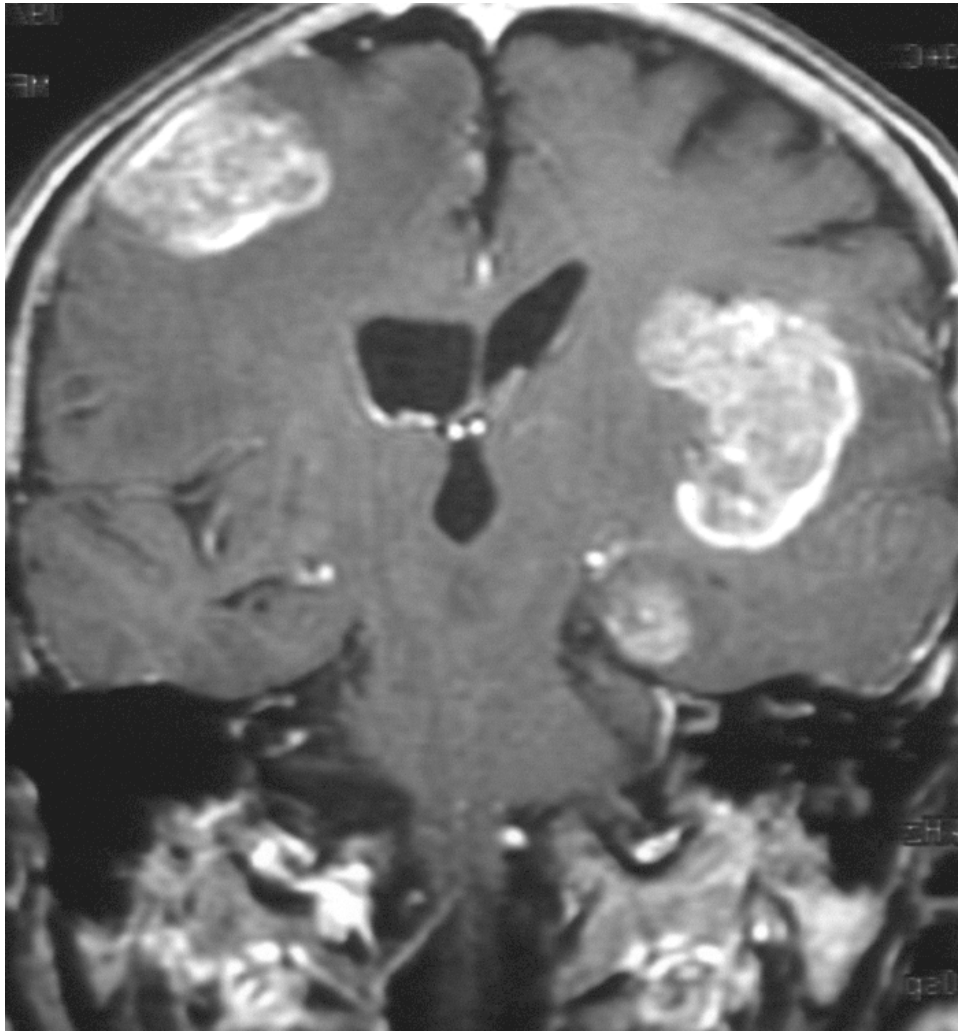
Desmoplastic infantile ganglioglioma



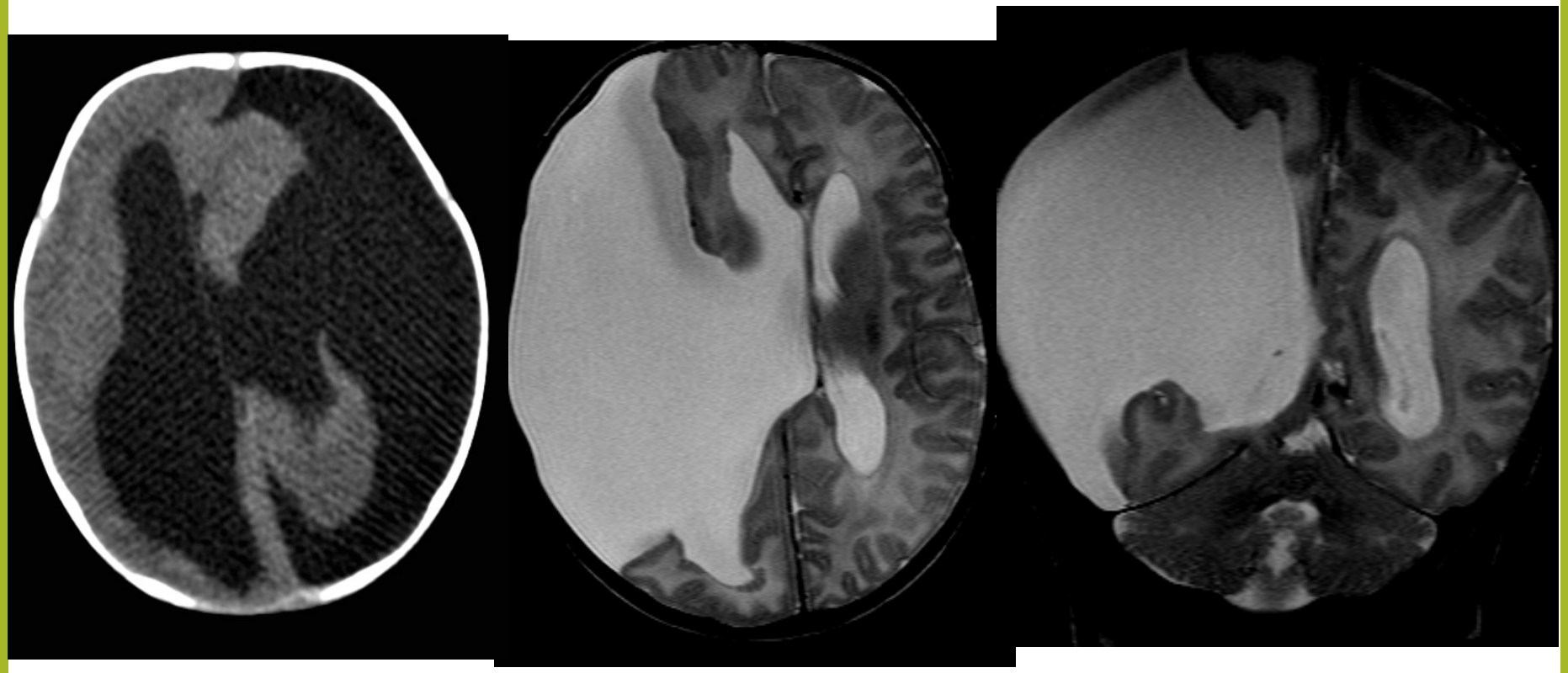
Oligodendroglioma



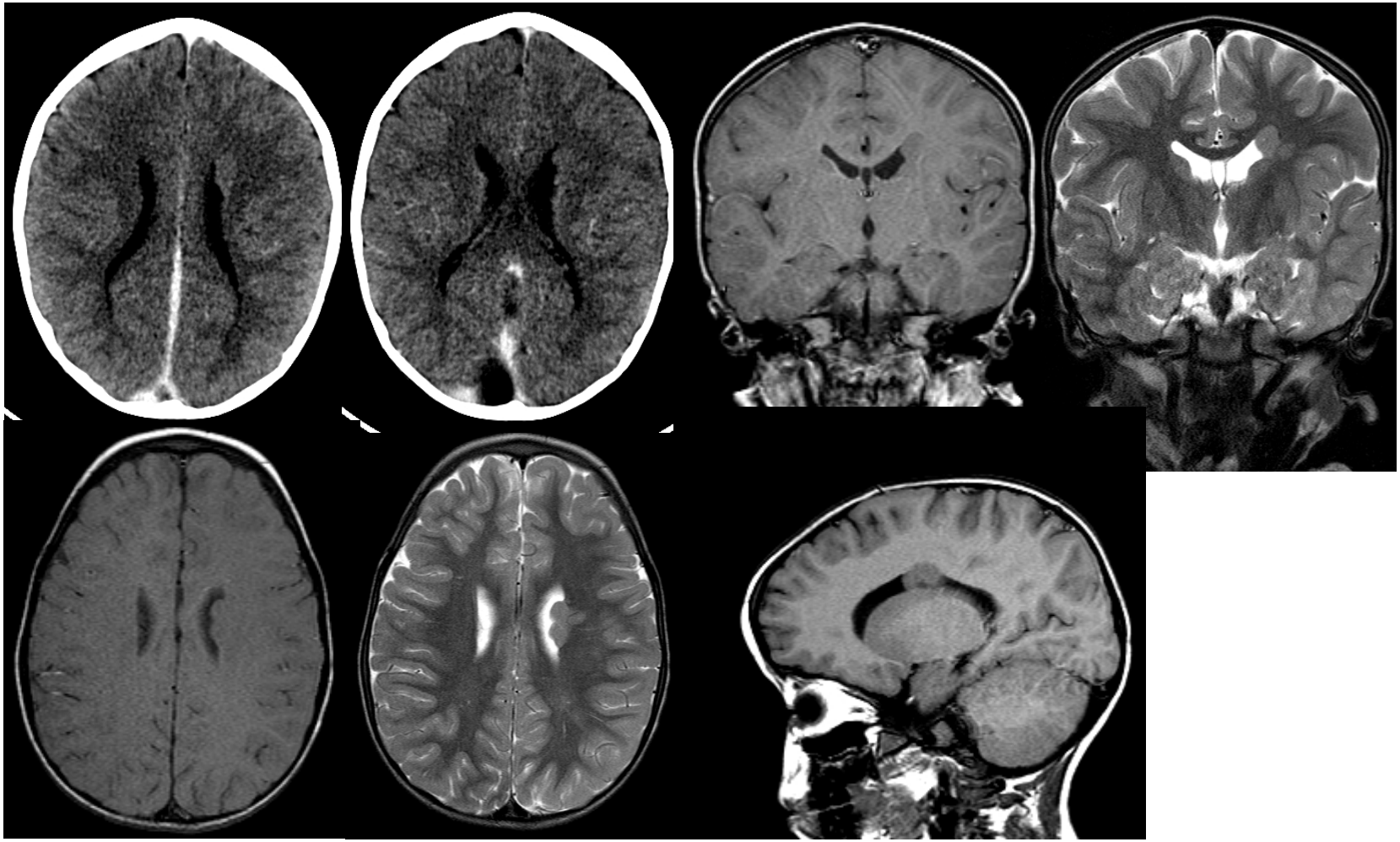
BRAIN METASTASIS



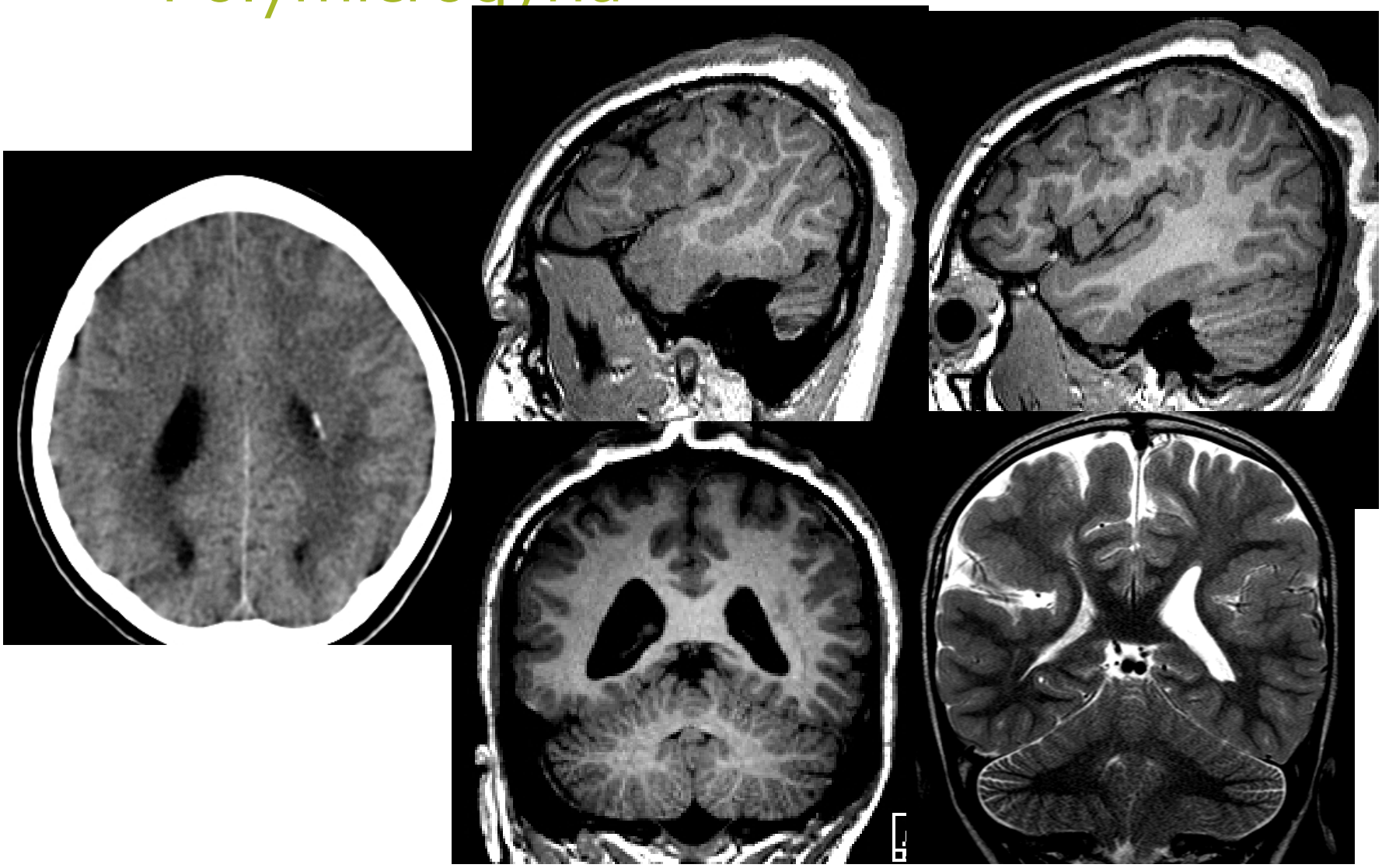
Schizencephaly



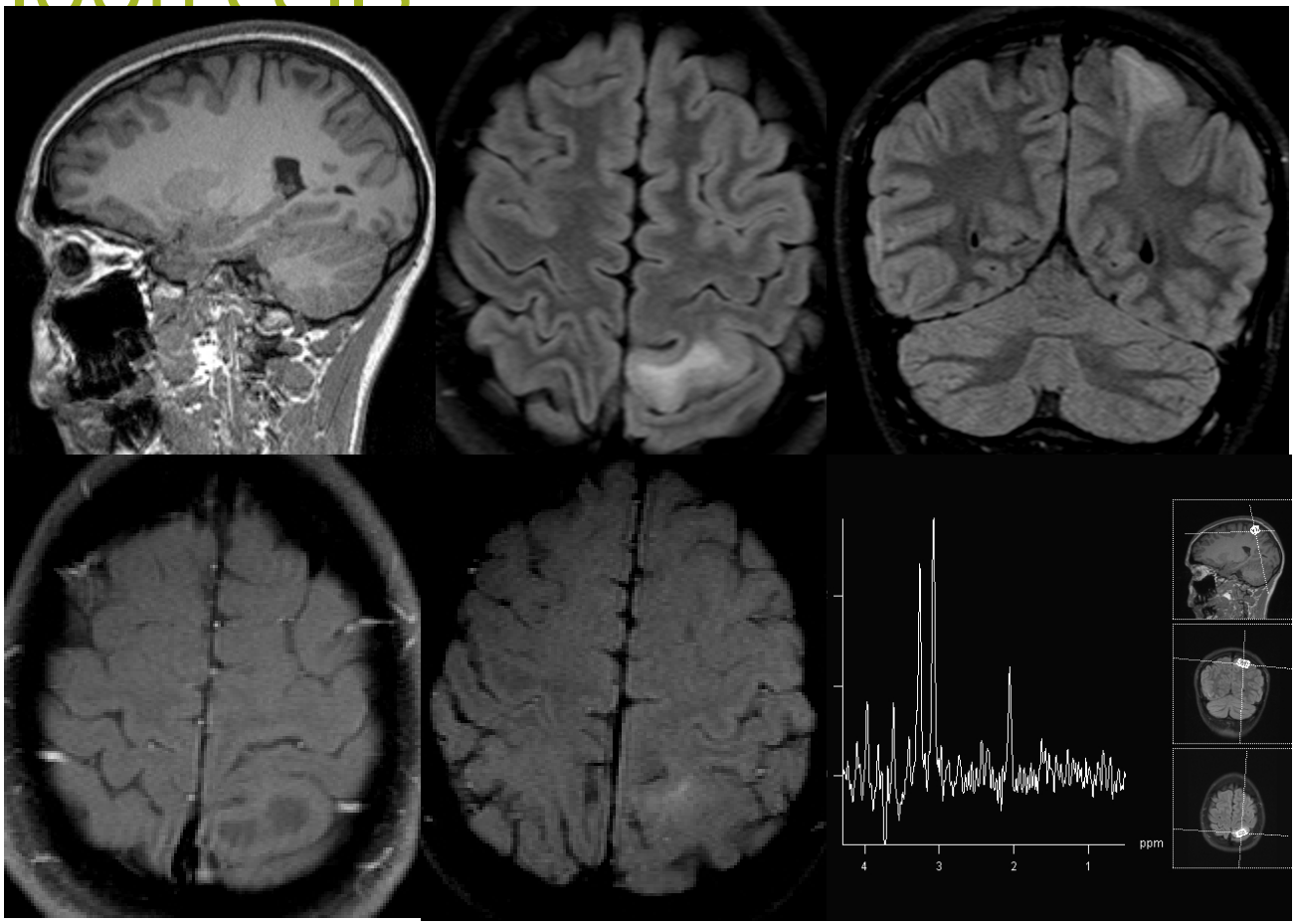
Subependymal/ Periventricular heterotopia



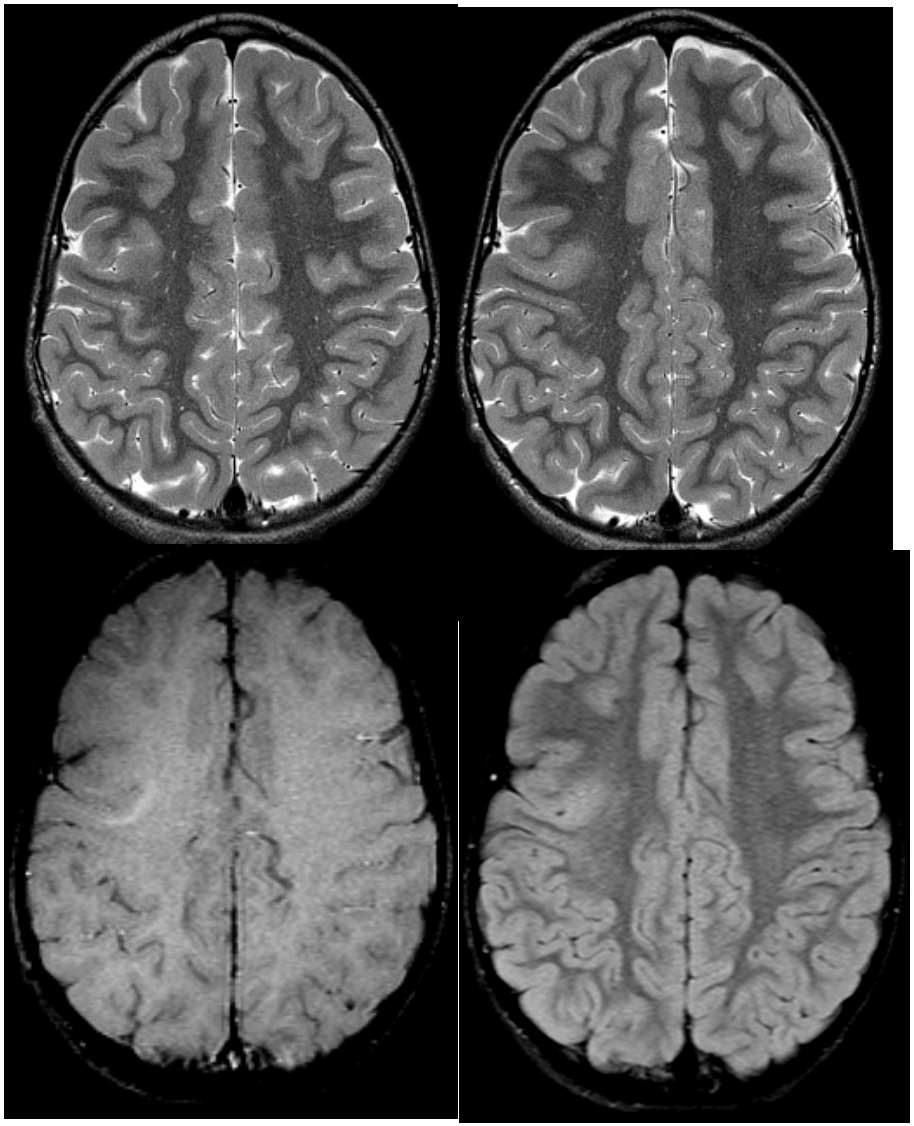
Polymicrogyria



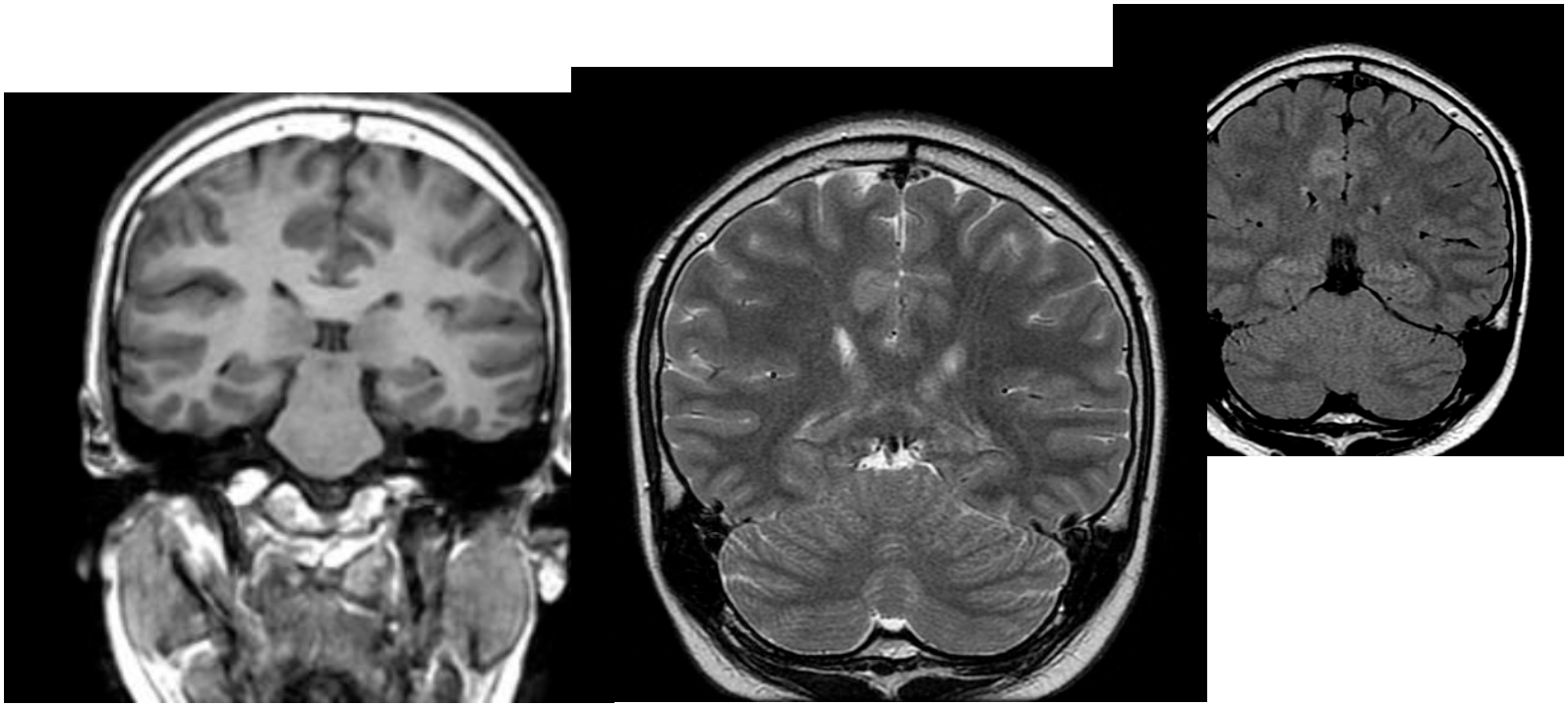
Focal cortical dysplasia with balloon cells



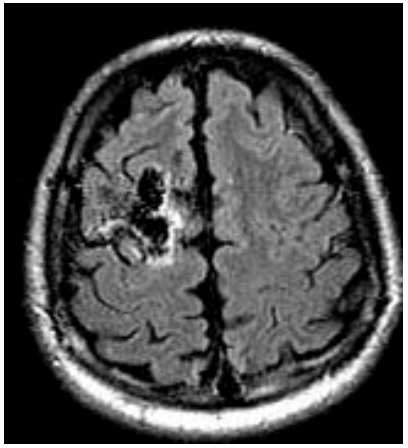
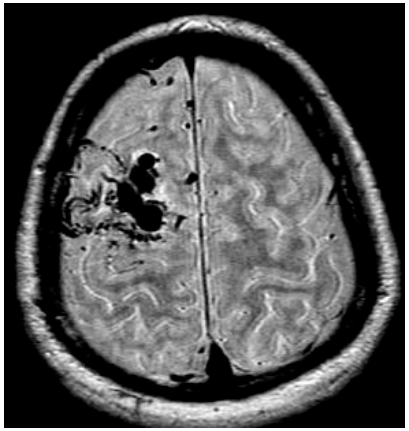
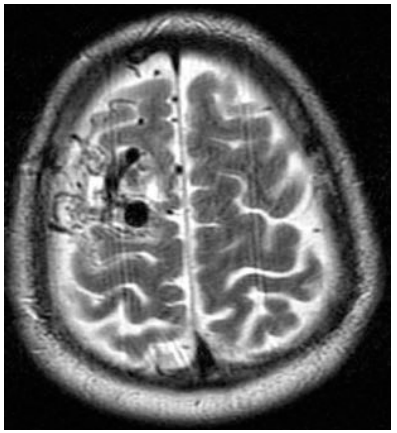
Cortical Dysplasia without Balloon cells

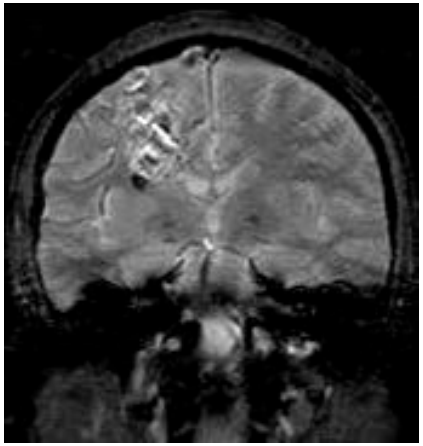


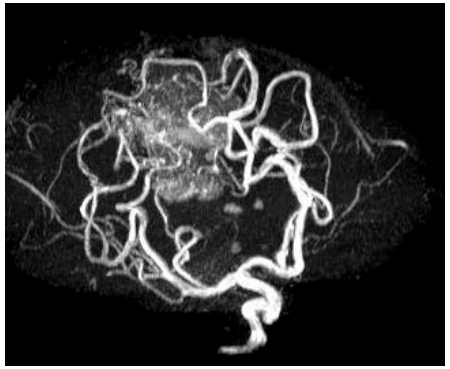
MCD: cortical dysplasia



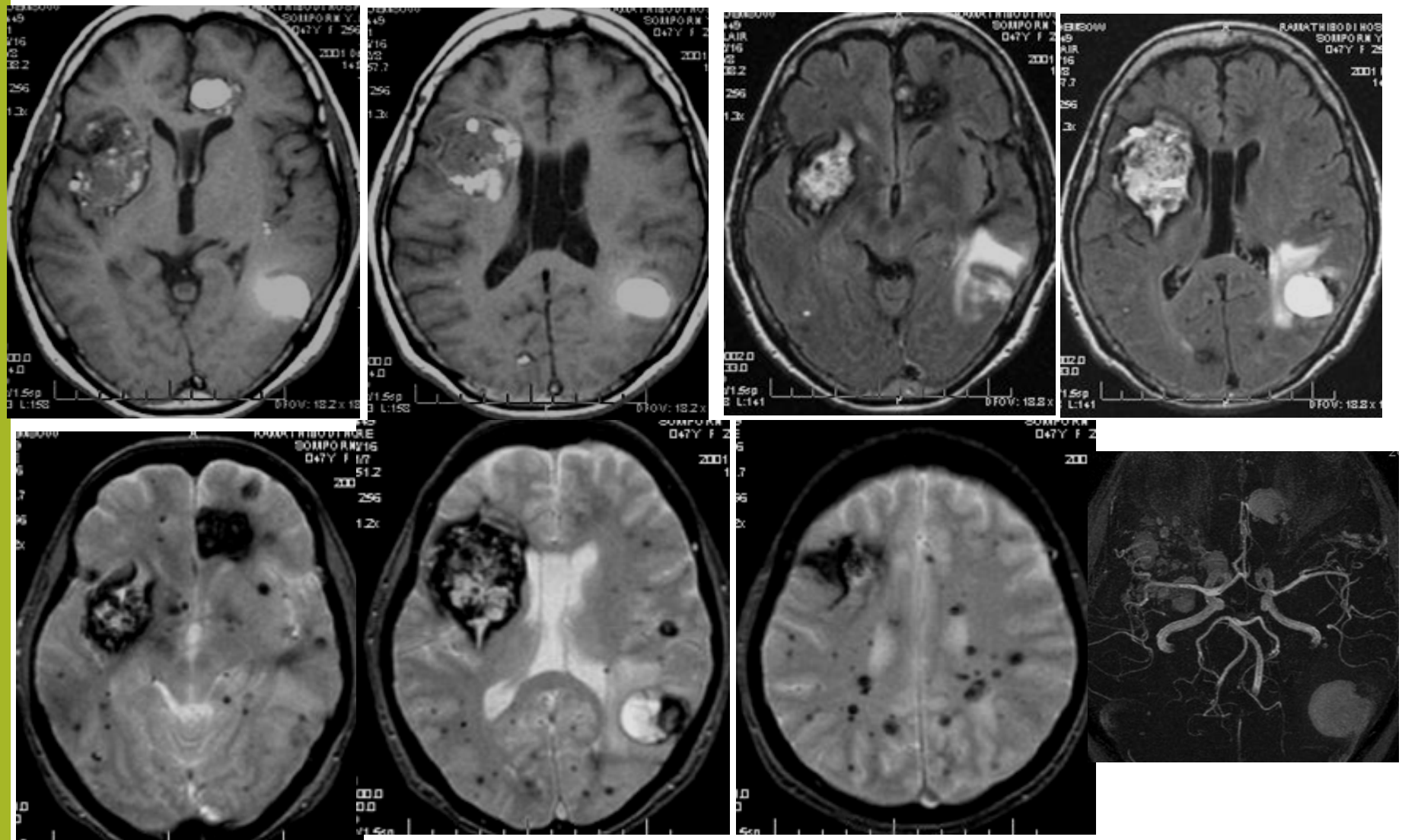
AVM

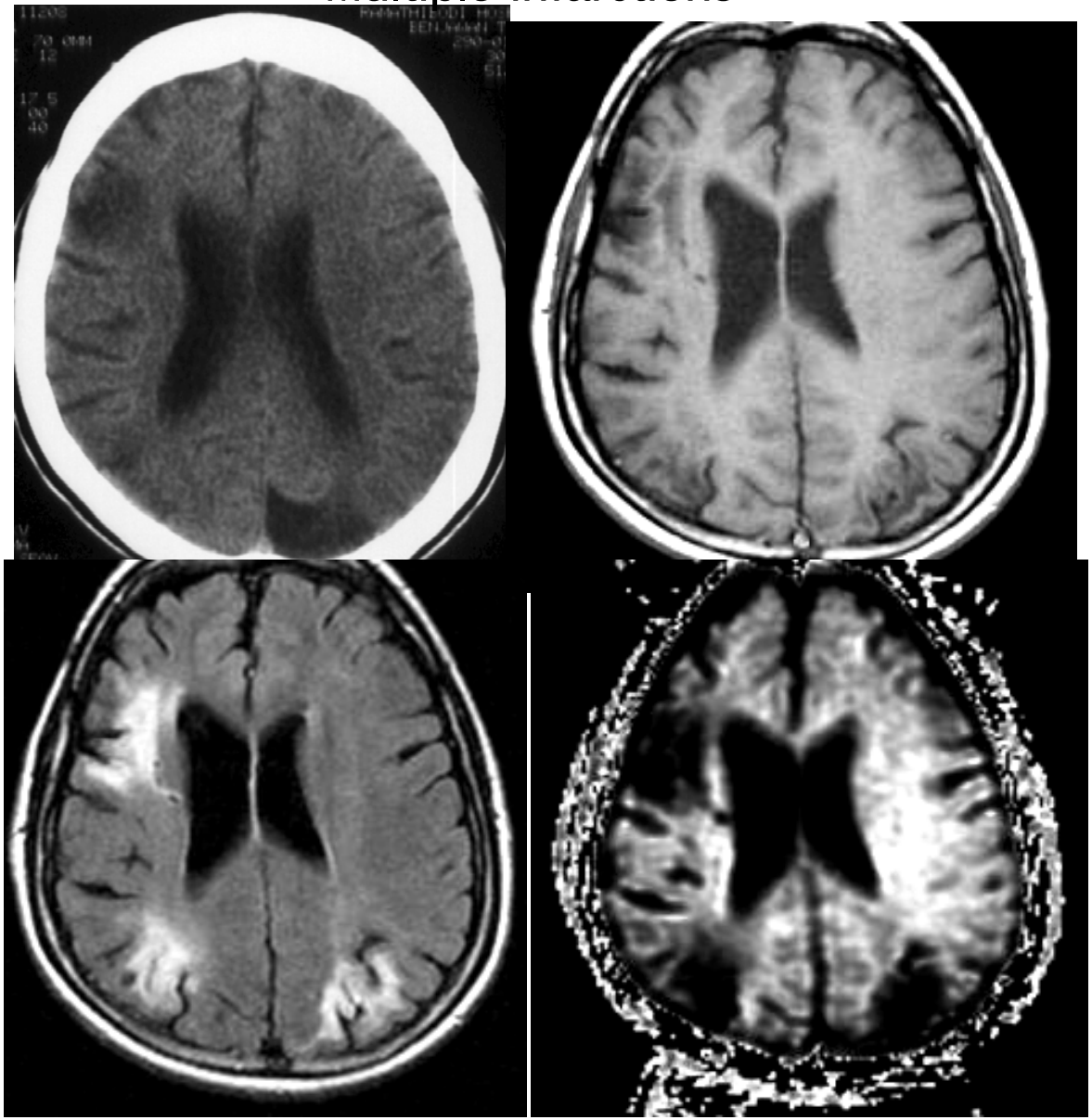




Cavernomas

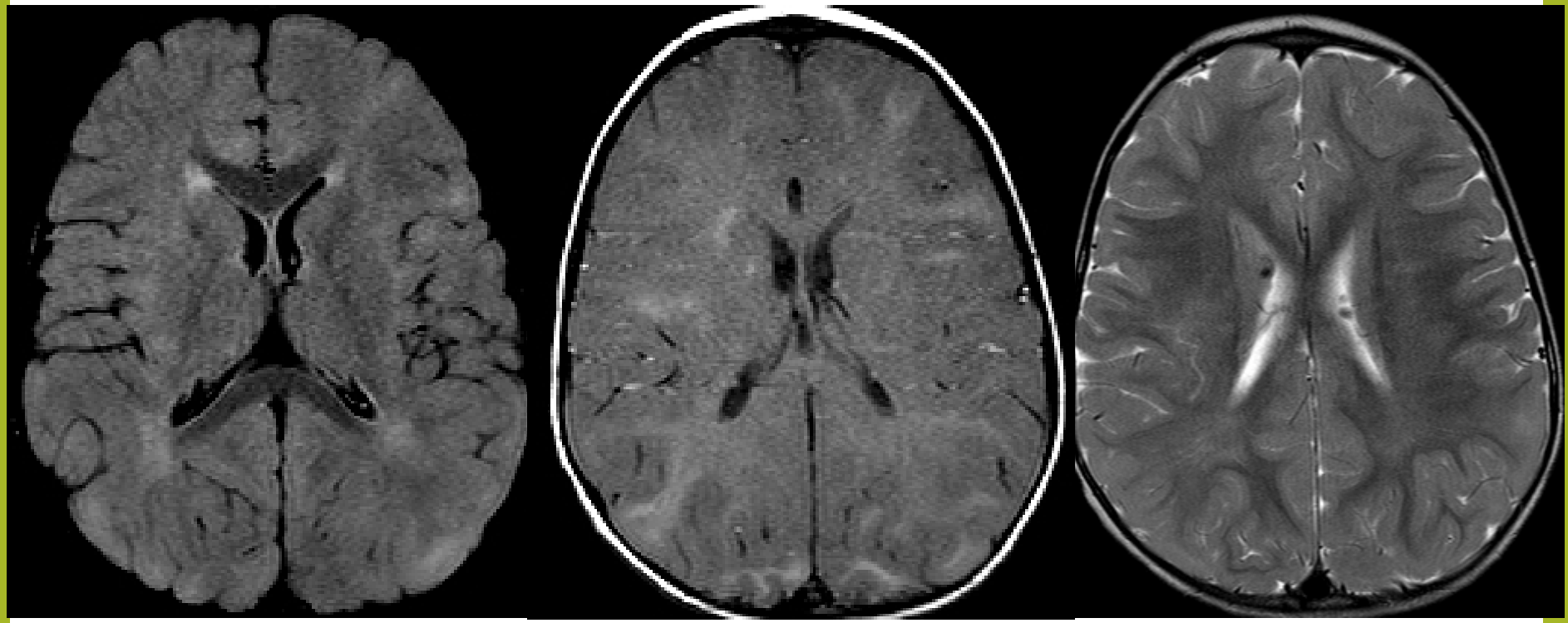


Multiple infarctions

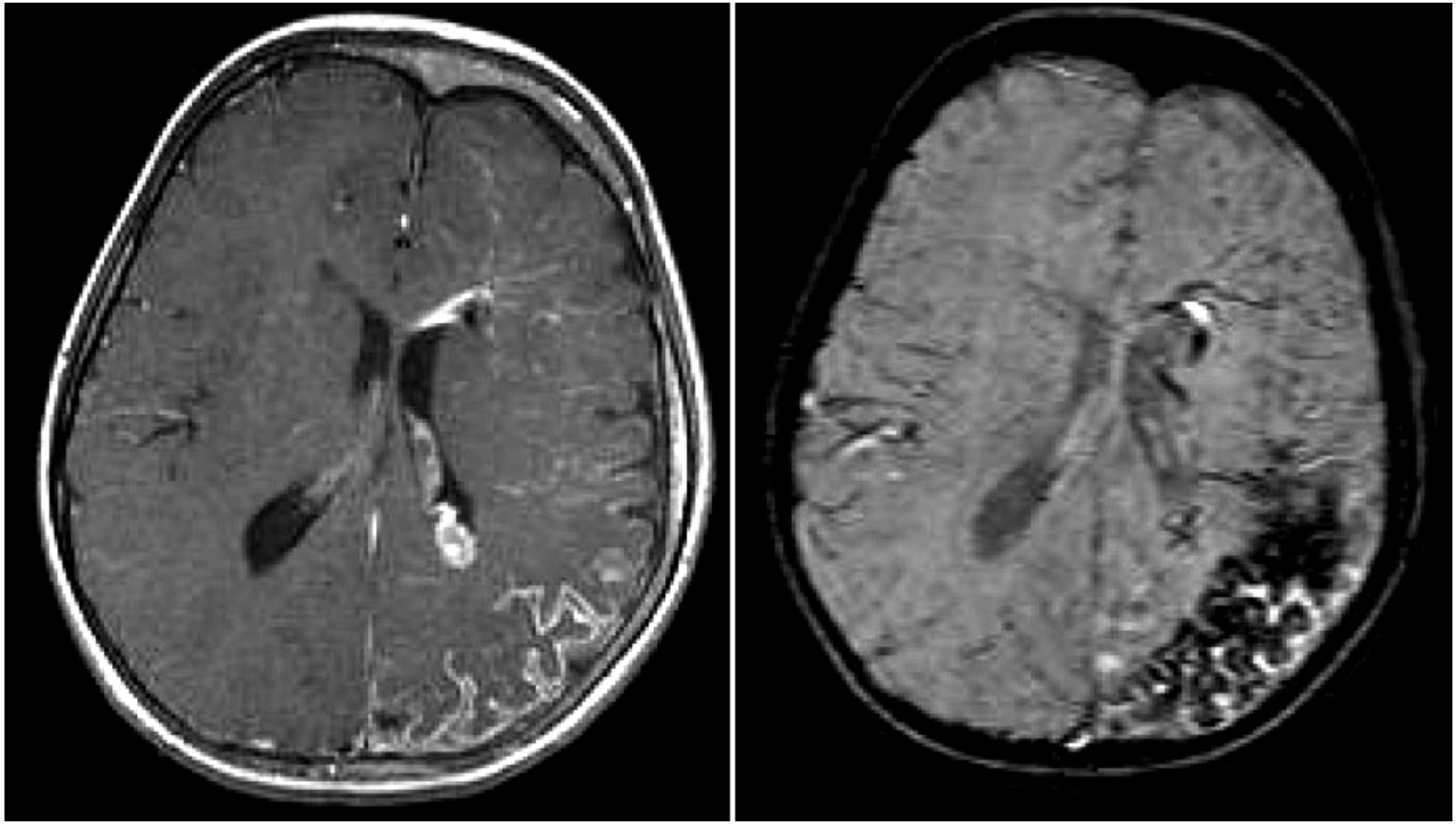


Encephalomalacia/scar

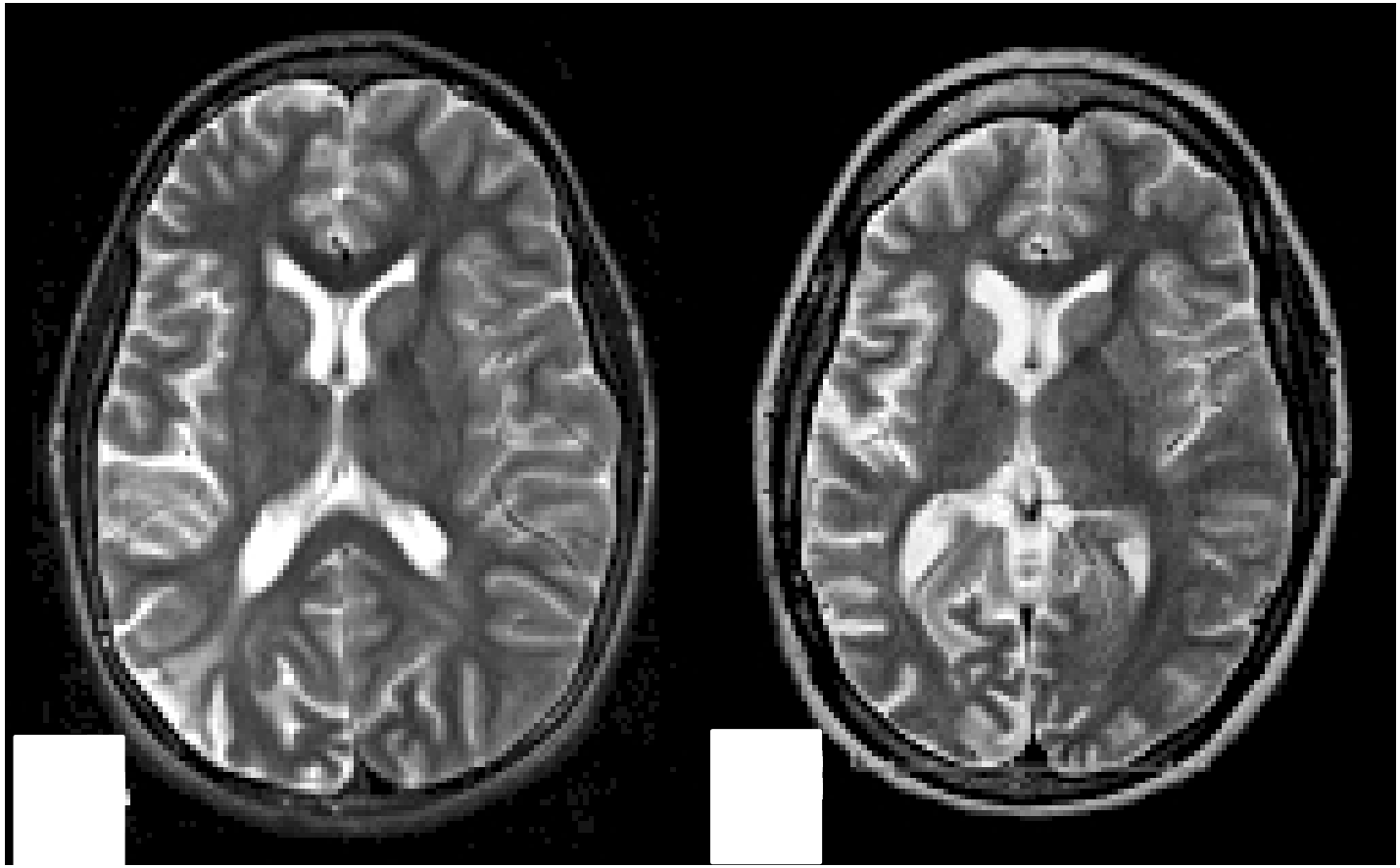
Tuberous sclerosis



Sturge Weber syndrome

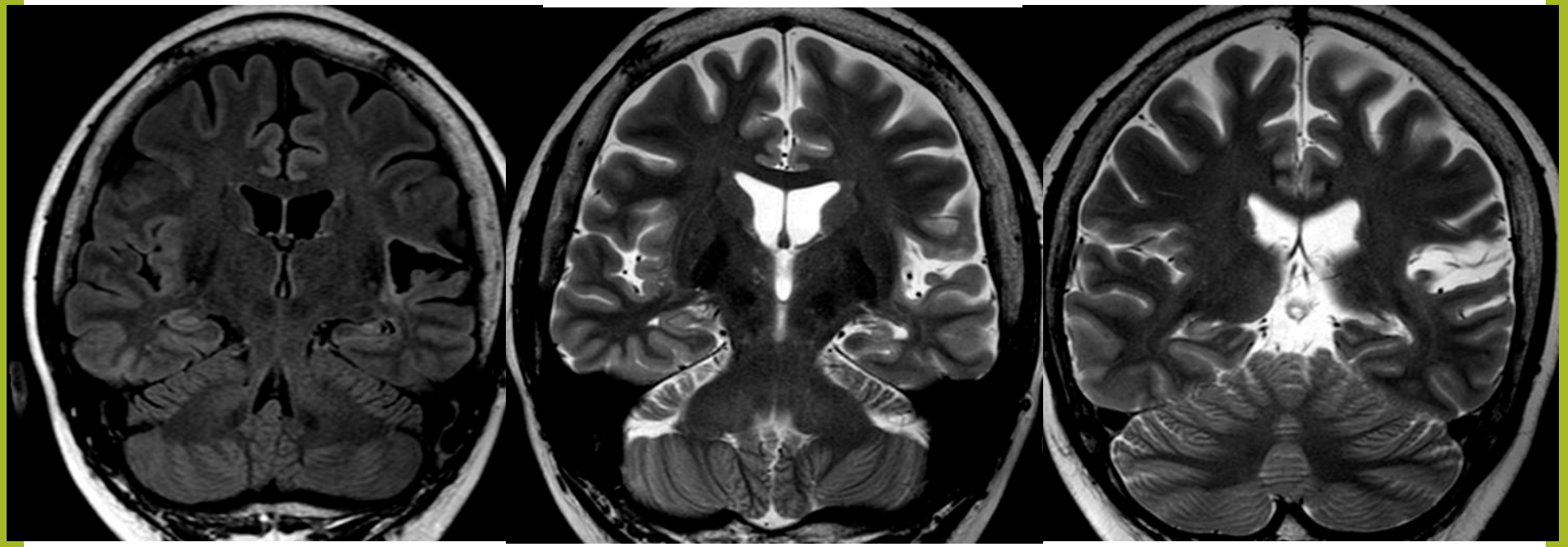


Rasmussen encephalitis

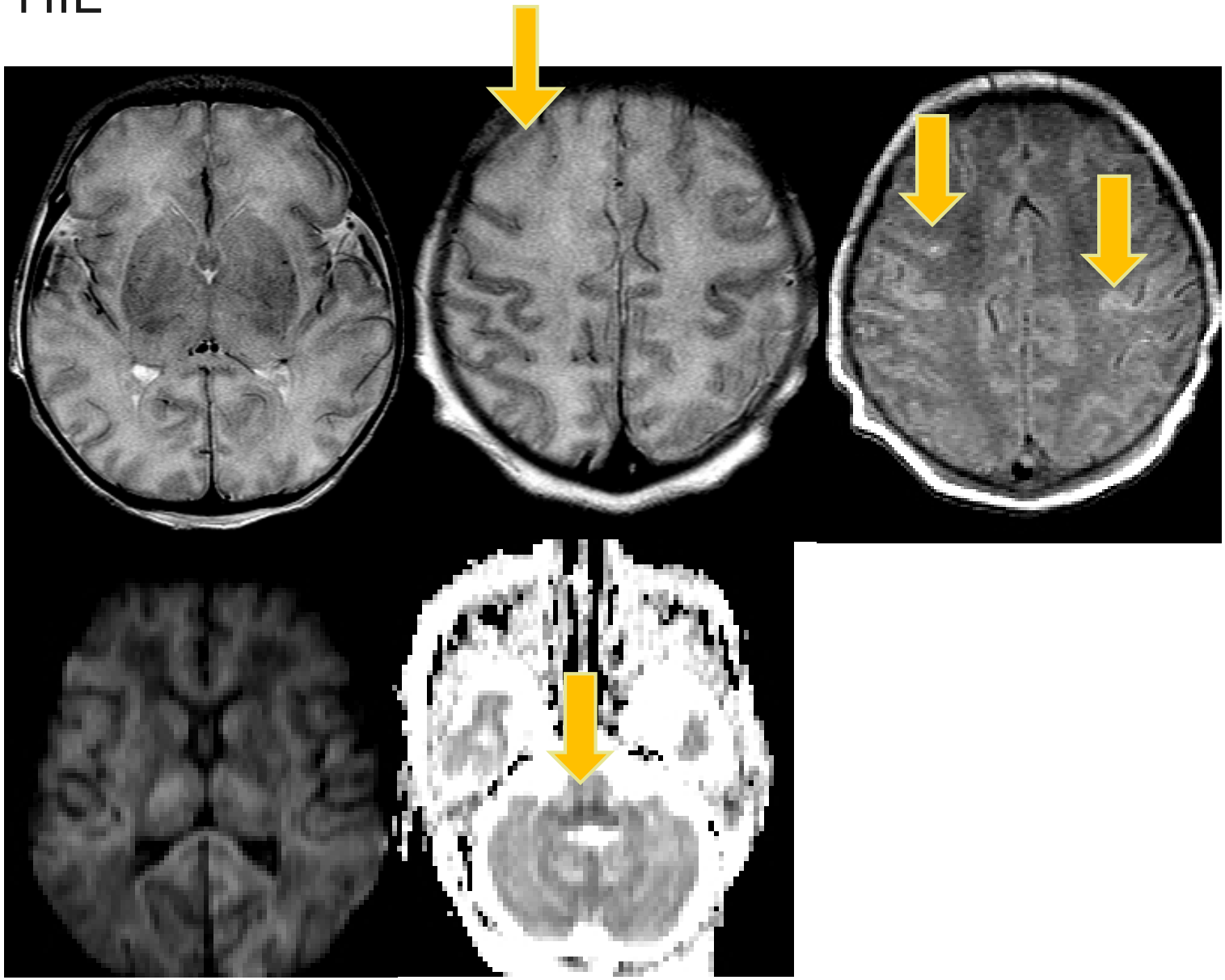


PITFALLS

Dual pathology



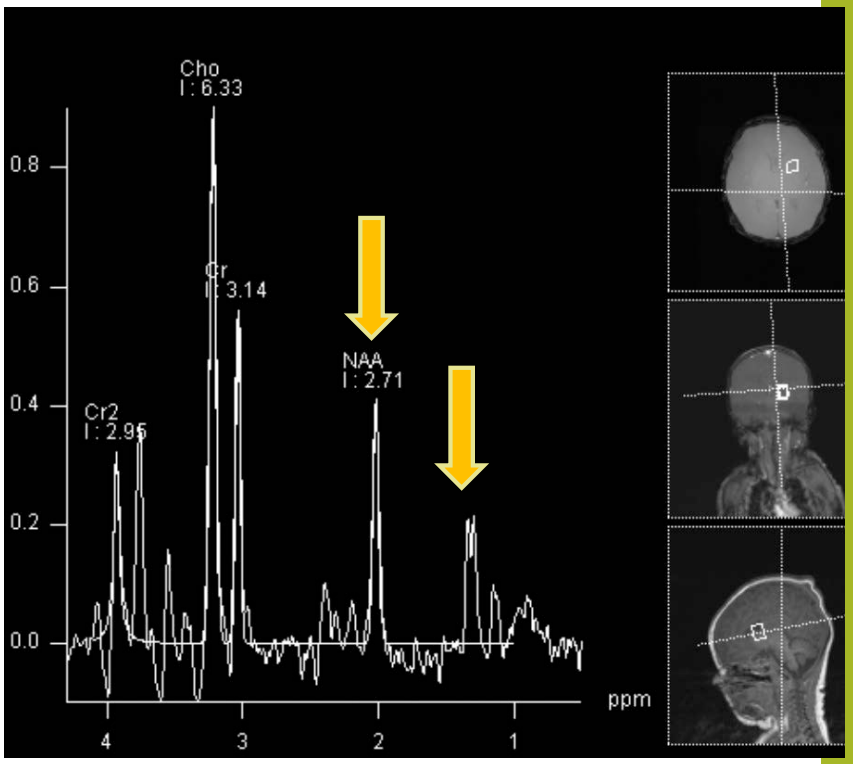
HIE



3 day old, full term male, with status epilepticus

Hypoxic-Ischemic encephalopathy

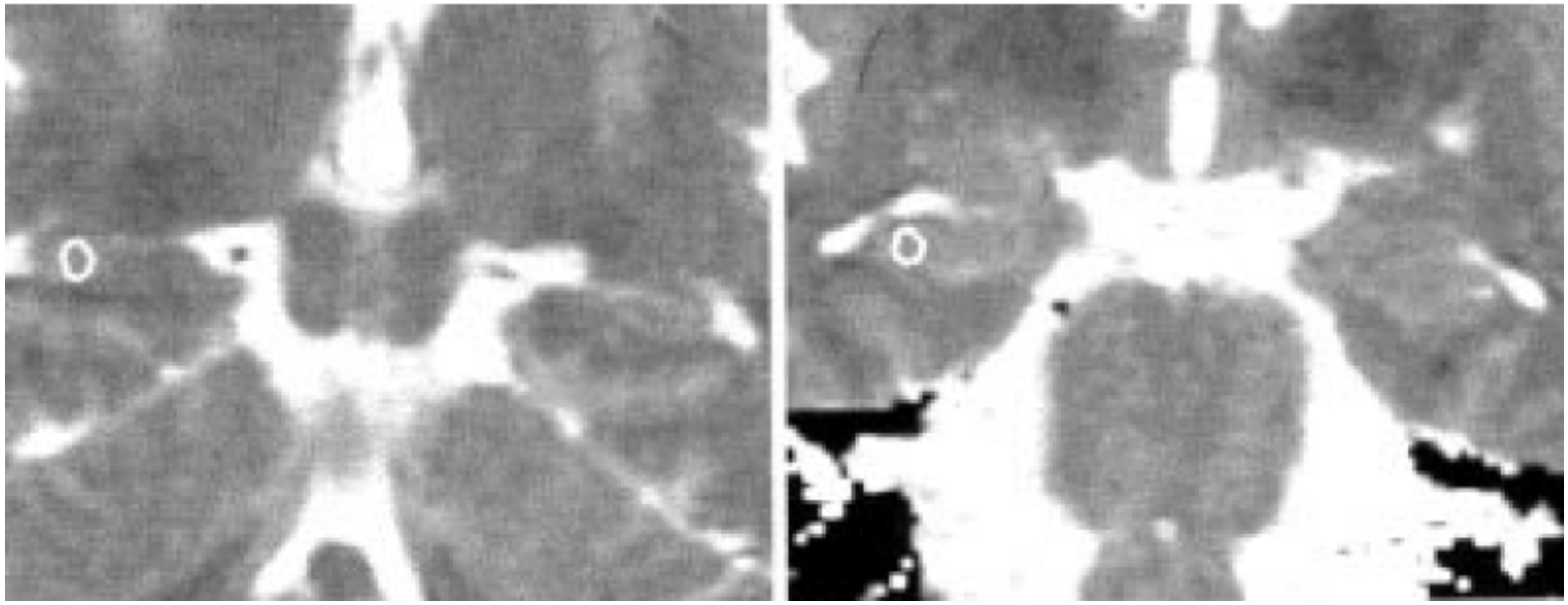
- Lactate: within hours after injury before abnormal signal intensity seen on convention MRI -> early detection
- Glutamine/glutamate
- Decreased NAA: later
- Persistence of lactate after 24 hours may indicate permanent injury



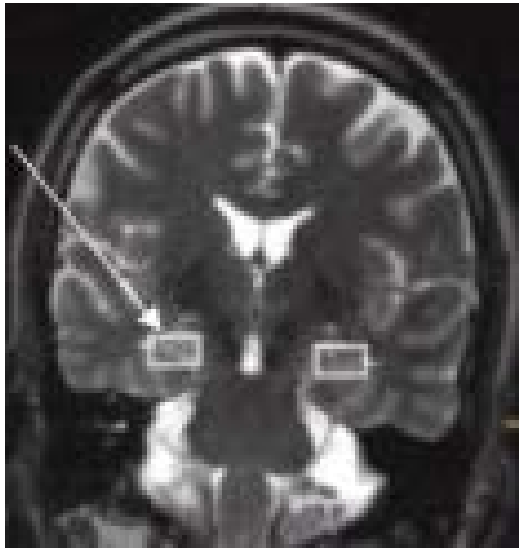
Courtesy of Dr. Robert A. Zimmerman MD. The Children's hospital of Philadelphia

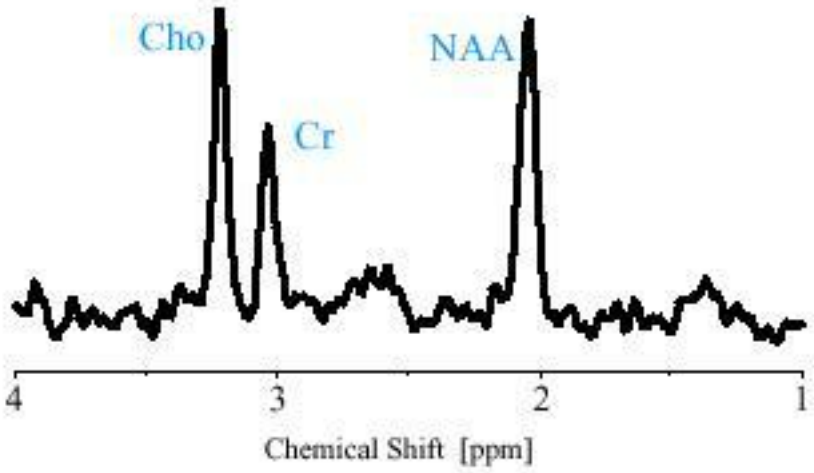
Bilateral MTS/Equivocal MTS

T2 Relaxometry: Objective Measurement of T2 relaxation



1-H MRS





NAA (2.0 ppm): Neuronal marker

Creatine (3.0 ppm): Cellular energy

Choline (3.2 ppm): Cell membrane

mI (3.5 ppm): Astrocyte/glial cell marker

Lactate (1.3 ppm): Anaerobic metabolism

Emerging Imaging Techniques

1-H MR Spectroscopy (MRS) in Epilepsy Imaging

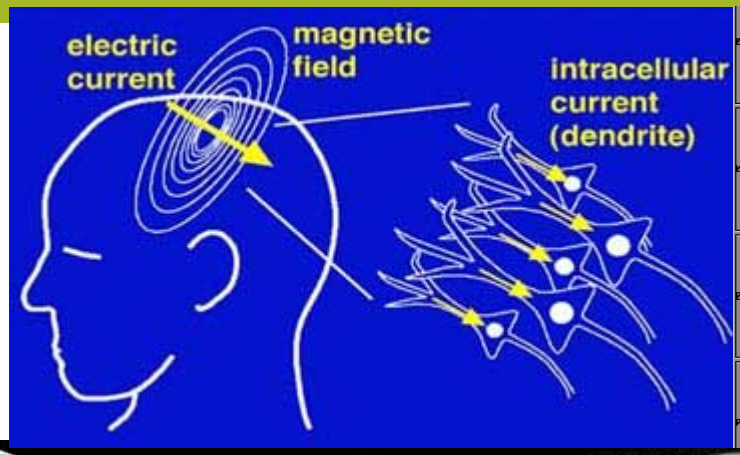
- Lateralization in TLE

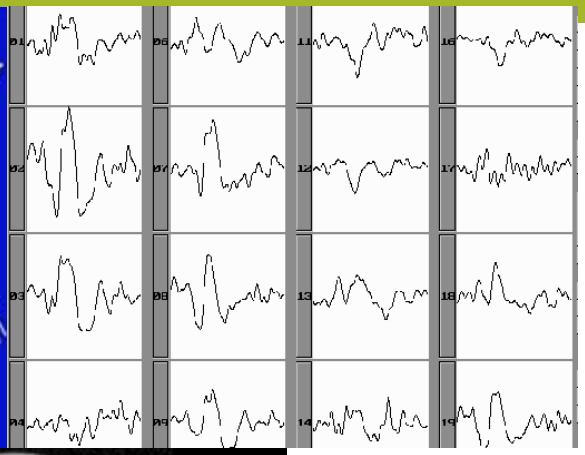
  Decreased absolute NAA, Decreased NAA/Choline, NAA/Creatine,NAA/Choline+Creatine ratios

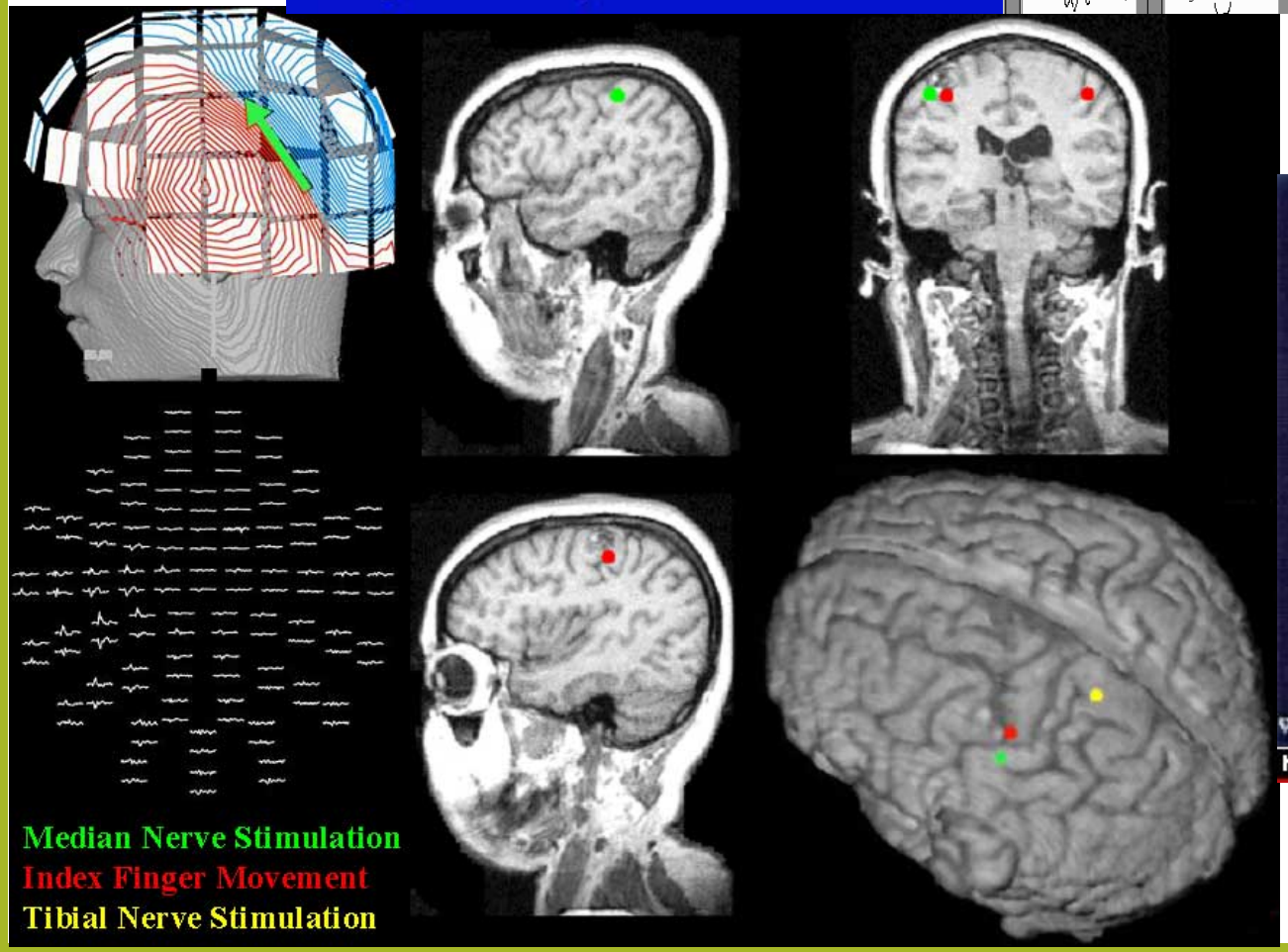
  Ipsilateral to lesion

Emerging Imaging Techniques

- MEG
- DTI
- fMRI
- MRS
- MR/CT Perfusion Imaging


electric current
magnetic field
intracellular current (dendrite)




Median Nerve Stimulation
Index Finger Movement
Tibial Nerve Stimulation


R 18.00 mm
LToe2
W: 392 L: 148
F
Slice 28 / 46
Medscape ®
http://www.medscape.com

Emerging Imaging Techniques

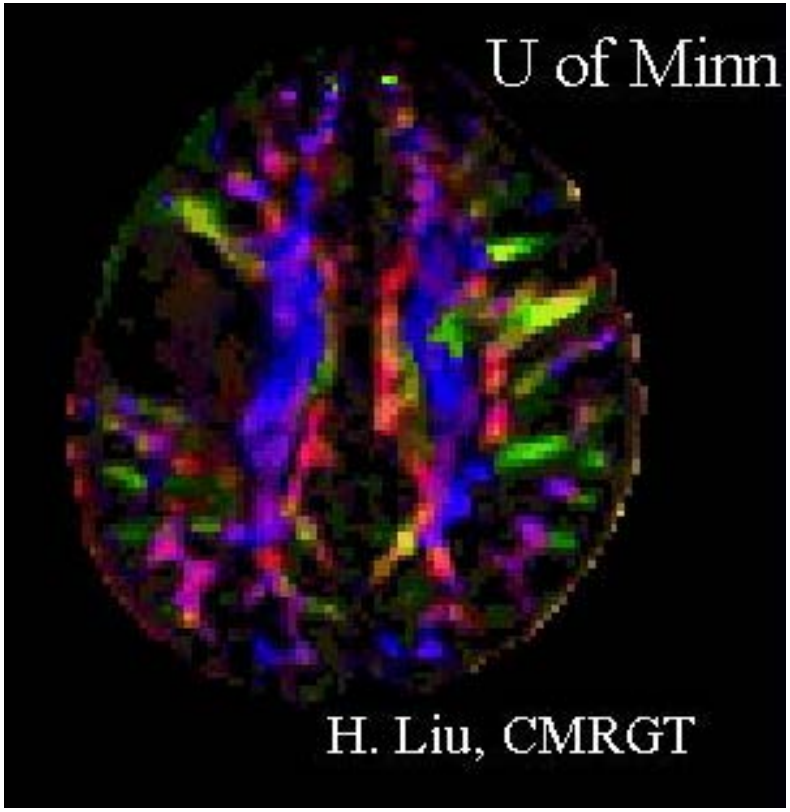
MEG (MagnetoEncephaloGraphy) & MSI (Magnetic Source Imaging)

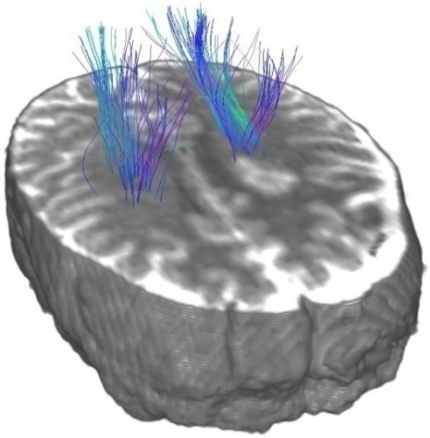
- Localize epileptogenic substrate
- Evaluate functioning cortex

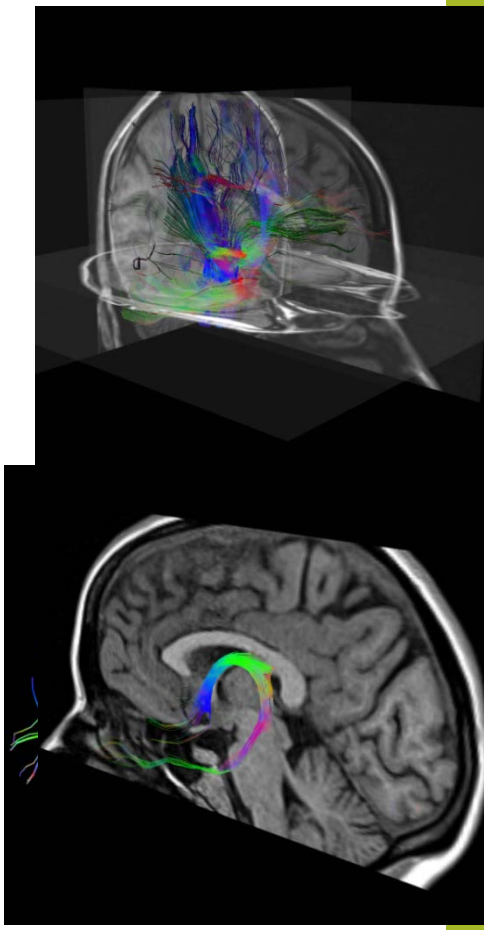
Emerging Imaging Techniques

- MEG
- DTI: Diffusion Tensor Imaging
- fMRI
- MRS
- MR/CT Perfusion Imaging

DTI &TRACTOGRAPHY







Emerging Imaging Techniques

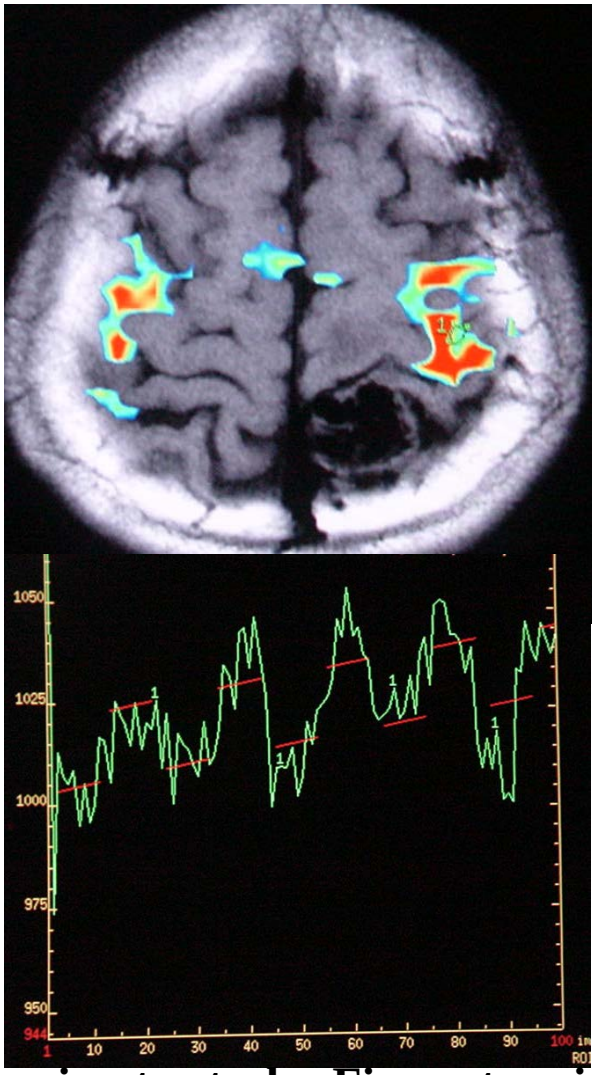
DTI in Epilepsy Imaging

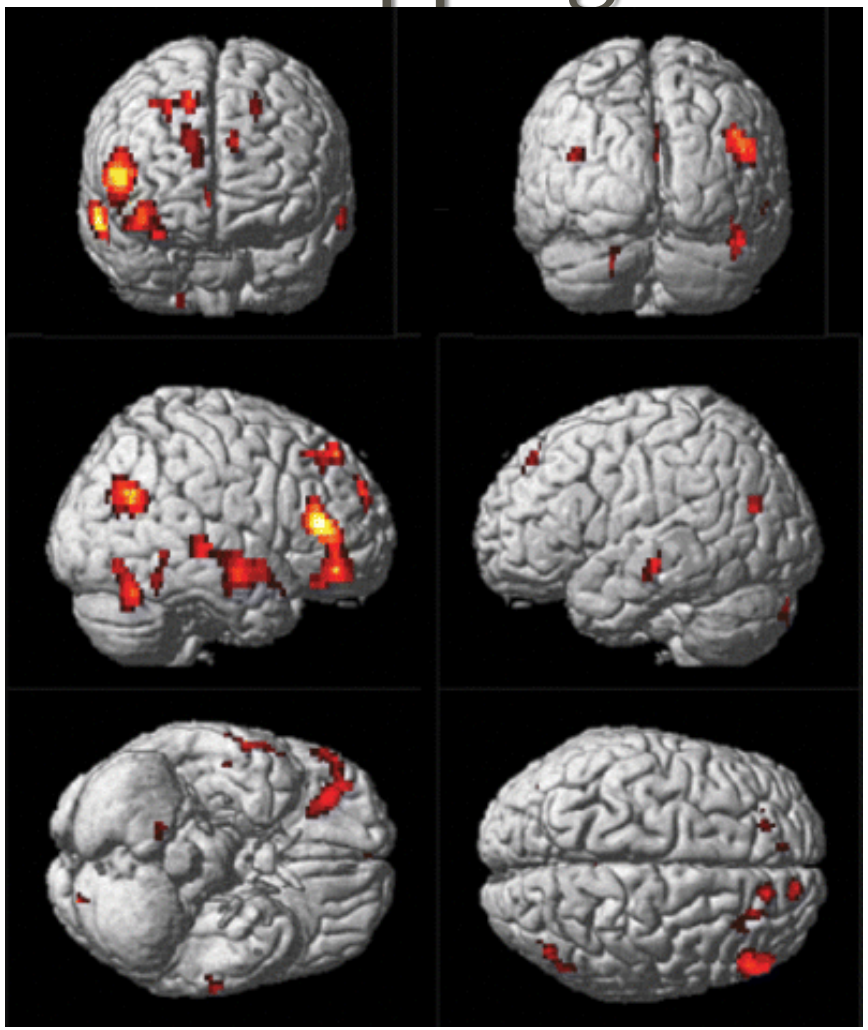
- Plan for surgery evaluation

Research

- Assess epileptogenic zone in LRE
- DTI abnormality (Decreased FA) in TLE in ipsilateral brain

BOLD fMRI: cortical mapping





Sensorimotor task : Finger tapping

Emerging Imaging Techniques

fMRI in Epilepsy Imaging

- Evaluate functioning cortex/eloquent area: Motor cortex, Language lateralization, Memory

Summary: Role of Imaging

- **Pre-surgery**
  - Identify structural abnormality
  - Localize
- **Plan for surgery**
  - Help confirm epileptogenicity
  - Relationship with eloquent areas
  - Predict resectivity and Prognostication
- **Post-surgery**
  - Evaluate residual lesion
  - Surveillance

Emergency	**CT**		
General -Identify obvious epileptogenic substrates -Follow up	**Conventional MRI (Standard protocol)**		
Special Attention -Identify subtle epileptogenic substrates -Lateralization	**Conventional MRI** **- Special Protocol** **- Experienced radiologist** **- 3T > 1.5T** - Special coil	MRS DWI	**SPECT** **PET** **MEG + MSI**
Specific Attention - Pre-surgical evaluation of risk, potential complication - Research	**fMRI** DTI DWI MRS		

THANK YOU