

# The Role and use of brain MRI in intracranial alterations, **A NEUROSURGEON'S** perspective

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# Focus of this lecture

- ▶ Az MR szerepe a **traumás**, **tumoros** és **gyulladásos** eredetű koponyaűri elváltozásokban mikor mellőzhető és mikor kihagyhatatlan, a felvételek tanácsolt kiterjesztése, esetleg **ismétlése** és az **ajánlott szekvenciák**

# Diagnosis of different pathologies

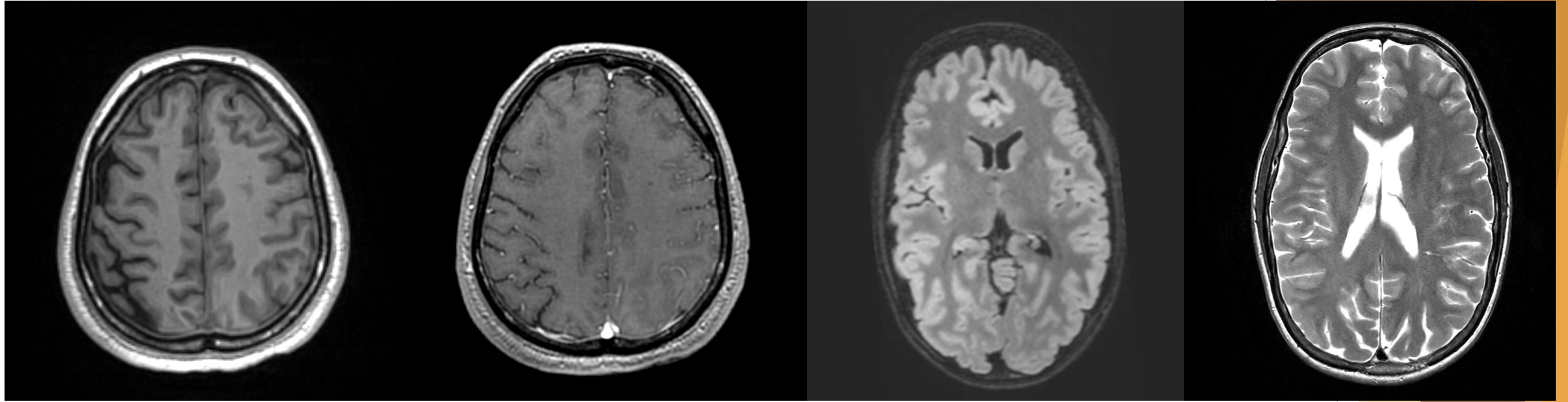
- ▶ Tumor
- ▶ Inflammatory alterations
- ▶ Congenital abnormalities
- ▶ Neurodegenerative alterations
- ▶ CSF flow
- ▶ Neuralgias and compressions
- ▶ Vascular Malformations
- ▶ Trauma

# Basic Sequences

- ▶ Different Sequences have different properties
- ▶ Proper Sequences for proper diagnosis
- ▶ Understanding the differences
- ▶ T1,T2,DWI,SWAN,FLAIR,DTI,ADC etc. etc.
- ▶ Native Vs Contrast enhanced
- ▶ MR Angiography

# Ground Rules of Main Sequences

- ▶ On T2 White matter is hyper and gray matter is hypointense
- ▶ On T1 images Gray matter is hyper and white matter is hypo intense (Intensity is compared to each other and not CSF)
- ▶ T2 FLAIR for attenuation of Water (CSF) therefore T2 intense lesions become more visible and differentiable from CSF
- ▶ Gadolinium as contrast agent , used with T1W sequences
- ▶ All cells pick up contrast material, cells with higher metabolic activity pick more contrast material thus, tumor cells pick more contrast and become hyperintense on T1W
- ▶ DWI basically shows us diffusion restriction in tissues



T1W

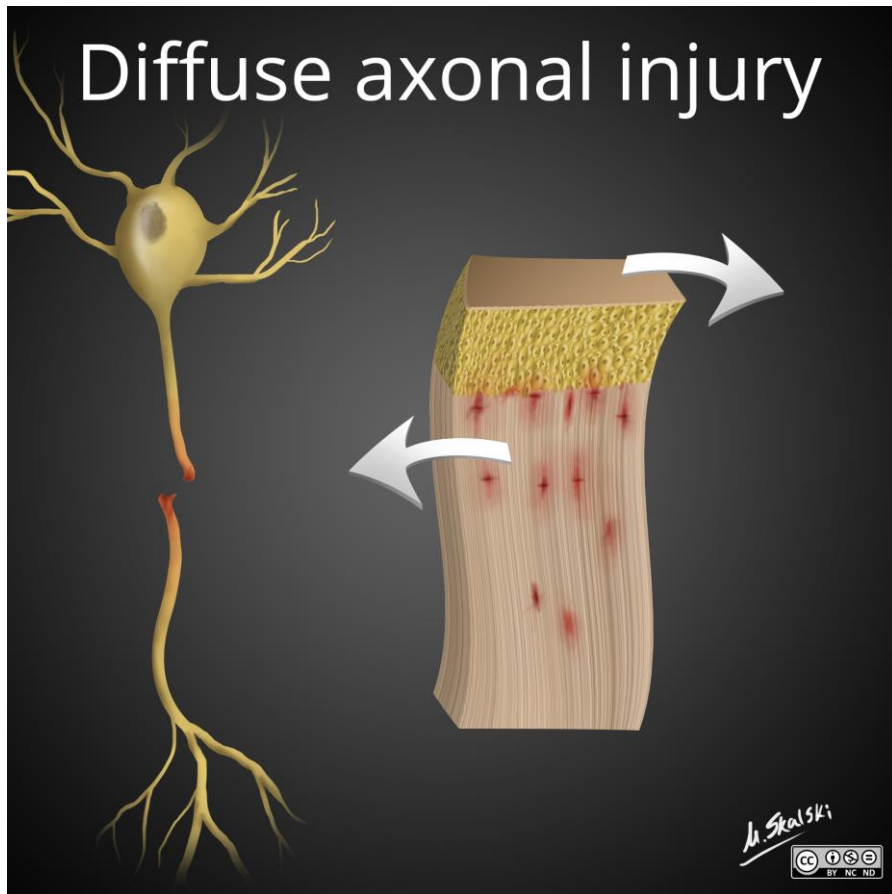
T1WC+

T2WFLAIR

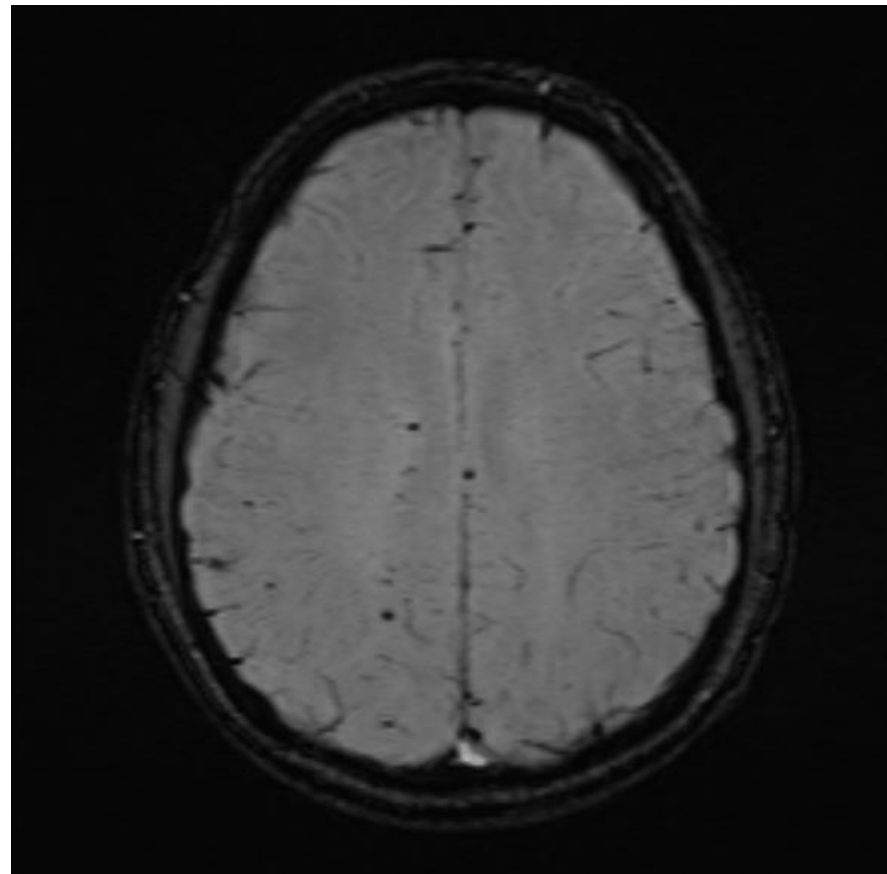
T2W

# TBI And role of MRI

- ▶ Main diagnostic modality is CT
- ▶ For Brain Trauma **NEVER** use skull **X-rays** as they are **inconclusive** and **misleading**
- ▶ MRI is used for dedicated cases
  - ▶ DAD
  - ▶ Injuries to Brainstem, extent of ischemic damage
  - ▶ Follow up of trauma in children
  - ▶ If suspicion of non accidental trauma rises (**DTI** can detect small injuries)
  - ▶ In case of spine trauma, it has more use
- ▶ Study that TBI patients with MRI had better outcome
  - ▶ There were other studies that did not show any difference
  - ▶ Inconclusive studies,
  - ▶ Severe moderate or mild TBI patients ?
- ▶ Use of Magnetic Resonance Imaging in Acute Traumatic Brain Injury Patients is Associated with Lower Inpatient Mortality



Case courtesy of  
Matt Skalski,  
Radiopaedia.org, rID: 38437



Case courtesy of  
Mostafa El-Feky,  
Radiopaedia.org, rID: 77668



# CSF Flow

- ▶ Precise diagnosis of Hydrocephalus in challenging cases
  - ▶ Aqueduct stenosis
  - ▶ Occlusion of foramen of Monroe
  - ▶ Intraventricular masses
    - ▶ Colloid cyst
    - ▶ Papilloma
    - ▶ Or any space occupying lesion in the ventricles in general (Fluid Attenuated sequences)
- ▶ Arachnoid cysts or lesions involving CSF flow
- ▶ Neuro-enteric cysts (Not directly originating from CSF flow problems, but they can have direct impact on CSF flow and impair CSF circulation)
  - ▶ Investigation of the CSF flow and its dynamics
  - ▶ Checking the patency of ventriculostomies

# Neurodegenerative diseases

- ▶ In general, for confirmation of diagnosis of ND disease along with clinical findings
  - ▶ Alzheimer's disease
  - ▶ Parkinson disease
  - ▶ MS, NMO
  - ▶ FTD
  - ▶ etc. etc.
- ▶ These diseases can not be diagnosed only by MRI or clinical findings, it's a combination of both !

**Mainly not Neurosurgical problems, but we need to recognize these and differentiate them from malignancies**

# Neuralgias and compression of CNs

- ▶ Requires high quality MRI pictures
- ▶ Correct understanding of brain anatomy on MRI scans
- ▶ Sequences that are useful (mainly for V and IX neuralgias)
  - ▶ FLAIR (fluid-attenuated inversion recovery) for recognizing demyelination IR
  - ▶ FIESTA (fast imaging employing steady-state acquisition) GRE
  - ▶ 3D TOF (time of flight) MRA
  - ▶ T1 T2 weighted images
  - ▶ CISS (MRA + Thin T2 co-registration- constructive interference in steady-state) GRE
- ▶ IR = Inversion recovery      GRE = Gradient echo sequences

# Congenital Abnormalities

- ▶ Diagnosing congenital diseases in children and even in adults
  - ▶ Dandy walker
  - ▶ Chiari malformations
  - ▶ Polymicrogyria
  - ▶ Lissencephaly
  - ▶ Schizencephaly
  - ▶ Holoprosencephaly
  - ▶ etc. etc.
- ▶ For these anomalies MRI is mainly used for **Diagnosis**, generally these pathologies do not require **regular follow ups**. If surgery is done for treatment of these cases (i.e Chiari malformation) follow ups can be done by MRI based on **clinical presentation** of the patient.

# Tumors

- ▶ Gold standard for diagnosing is Contrast enhanced MRI
- ▶ Different tumors have different properties on different sequences
- ▶ These properties are used for Differential diagnosis
- ▶ The final diagnosis **MUST** be given only after **histopathological confirmation!!**
- ▶ General sequences used:
  - ▶ T1W T2W DWI FLAIR C+T1W SWAN (other sequences such as Spectroscopy or perfusion can be used as well)
- ▶ Multiplanar MRI
  - ▶ Axial
  - ▶ Sagittal
  - ▶ Coronal

# LGGs

- ▶ Low grade Gliomas do not enhance contrast material, the reason is their low metabolic activity
  - ▶ FLAIR sequences are very useful for determining the borders and extent of infiltration
  - ▶ Stroke, cerebritis, Herpes encephalitis, brain edema or simply any alteration mimicking LGGs must be ruled out
  - ▶ T1W Hypointense T2W and FLAIR hyperintense
  - ▶ Can be cystic or calcified, intra-tumoral bleeds are not often but can be present
  - ▶ If contrast enhancement is present, transformation to high grade has happened
  - ▶ DWI has no diffusion restriction

As of 2021 Secondary GBM is referred as WHO Grade IV Astrocytoma !!

# High Grade tumors

- ▶ They enhance contrast
- ▶ T1W shows irregular iso or hypointense mass
- ▶ Necrosis and cysts are common
- ▶ T2W And FLAIR shows hyperintense signals, vasogenic edema and infiltration
- ▶ DWI does not show diffusion restriction, but ADC values are lower than of LGGs
- ▶ Differential diagnosis
  - ▶ CNS Lymphoma
  - ▶ Abscess
  - ▶ Subacute ischemia (luxurious perfusion)
  - ▶ Metastasis
  - ▶ AVMs
  - ▶ **Status Epilepticus\*\*\*** (they can cause contrast enhancement and signal alterations)
  - ▶ Etc. etc.

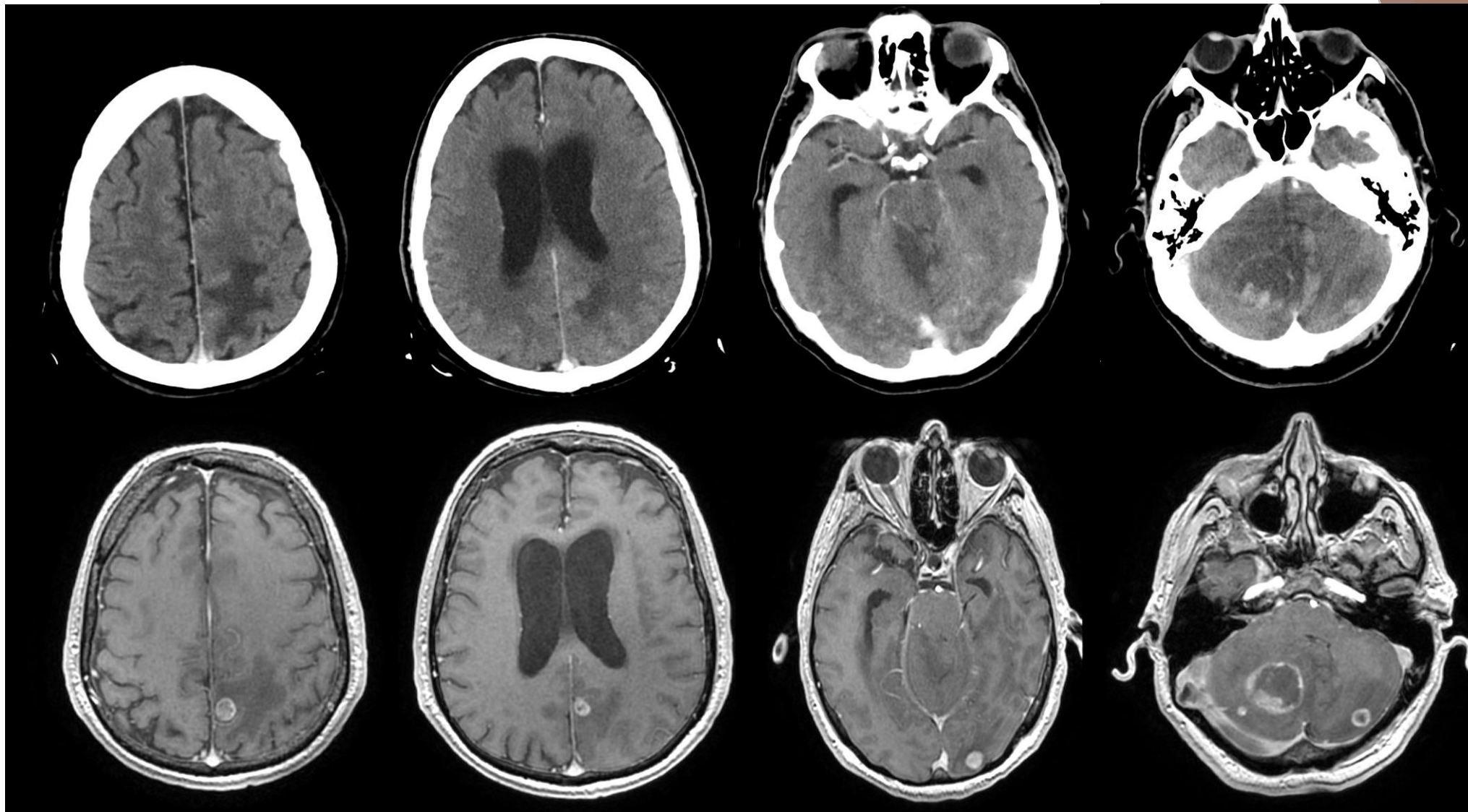
# Properties

- ▶ Enhancement of contrast material by tumor
- ▶ Perifocal edema
- ▶ On T1C+ sequences the contrast enhanced tumor is hyperintense
- ▶ Perifocal edema is best seen on T2 T2FLAIR sequences
- ▶ DWI has an important role for differential diagnosis (Inflammatory alterations)

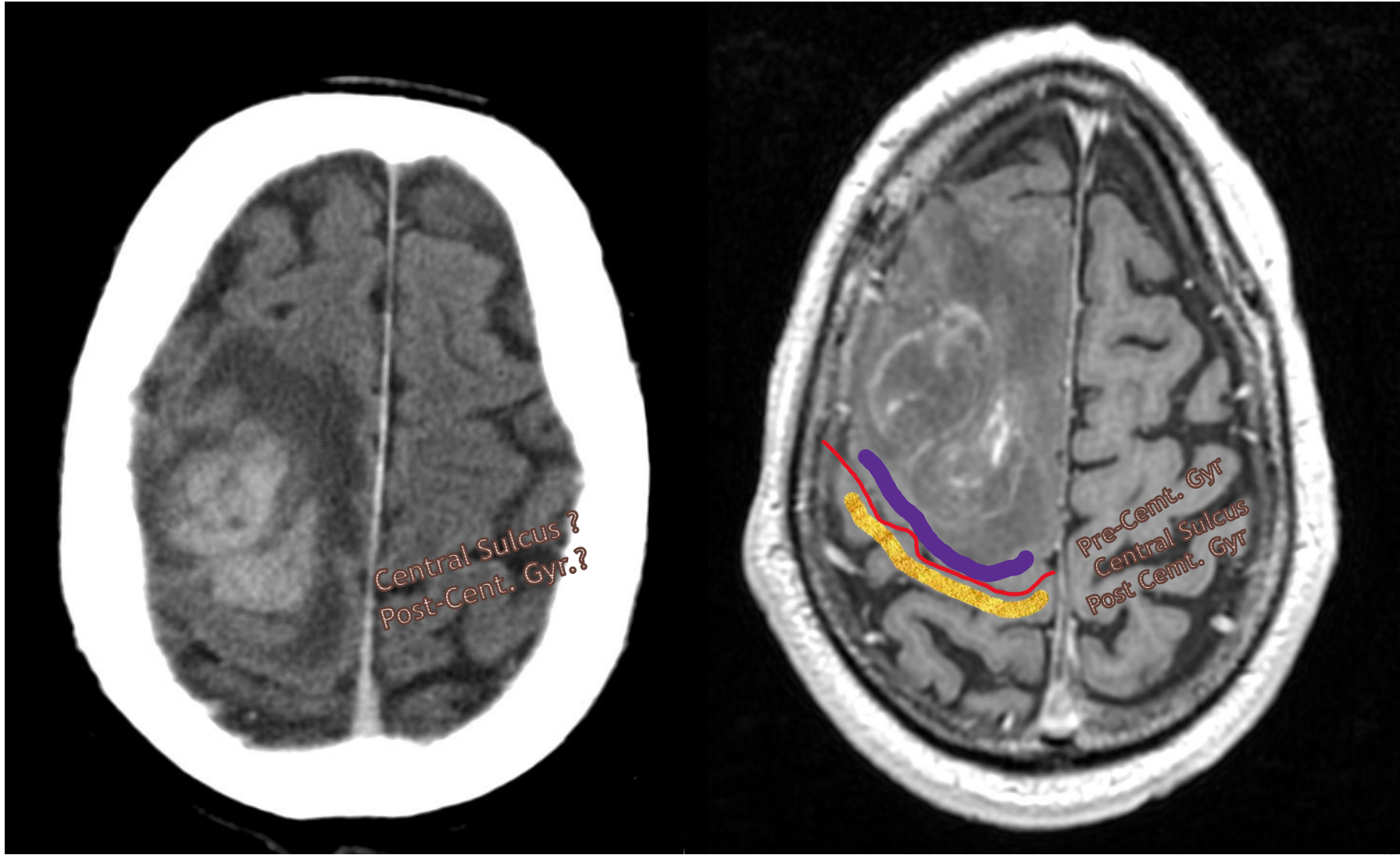


# Importance of MRI in diagnosis of tumoral alterations

- ▶ Solidarity vs Multiplicity
- ▶ Precise determination of location
- ▶ Involvement of important vessels and structures
- ▶ Planning of the surgery (Neuronavigation)
- ▶ Post-operative control, determination of residual tumor
- ▶ Administration of C+ is needed for tumor detection



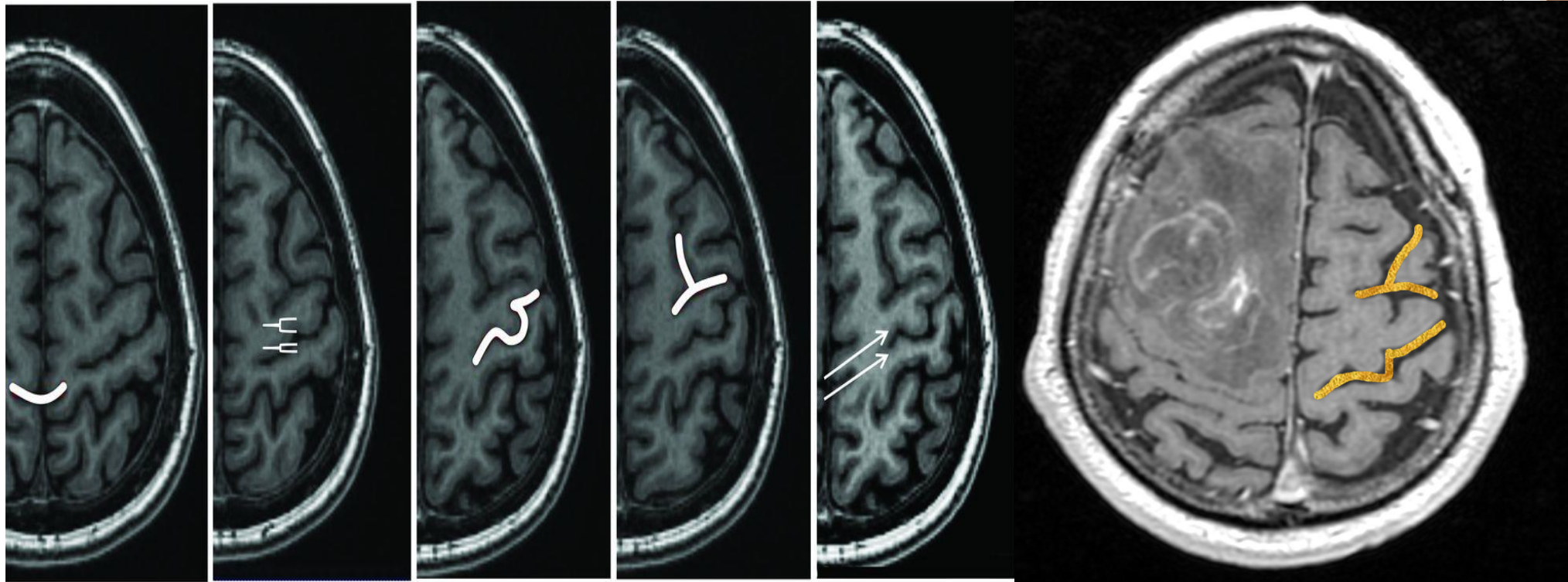
Corresponding Slices of MRI C+ Vs CT C+



Central Sulcus?  
Post-Cent. Gyr.?

Pre-Cent. Gyr  
Central Sulcus  
Post Cent. Gyr

# Finding Central Sulcus



bracket sign

cortical thickness sign

omega sign

T sign

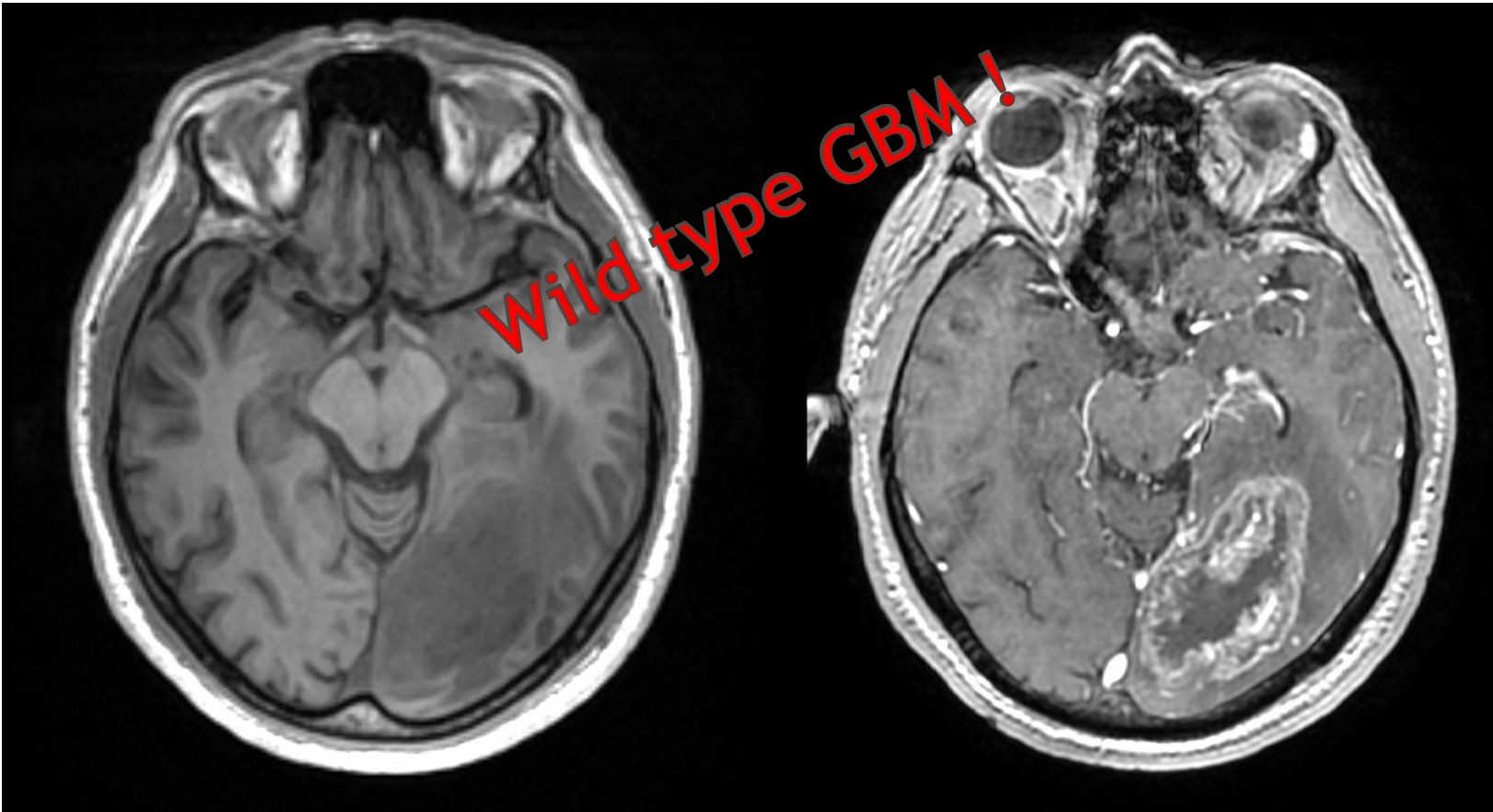
white gray sign

# Other Tumors +/- Malignancies

- ▶ In general tumors of The CNS (Primary and secondary) they can have different patterns of contrast material enhancement.
- ▶ Main sequences used for diagnosis are:
  - ▶ T1W T1W C+
  - ▶ T2W
  - ▶ DWI/ADC
  - ▶ FLAIR
  - ▶ SWAN (Intra-tumoral bleeds) and differential diagnosis (**vascular malformations**)
    - ▶ Cavernomas ( hemosiderin ring)
    - ▶ Hemangiomas
    - ▶ AV malformations
    - ▶ Etc. etc.
  - ▶ DTI (**for tractography**)
  - ▶ Perfusion MRI (**not necessary always**)
- ▶ T2W displays peri-tumoral edema and in high grade tumors T2FLAIR can show extension of tumor infiltration as well

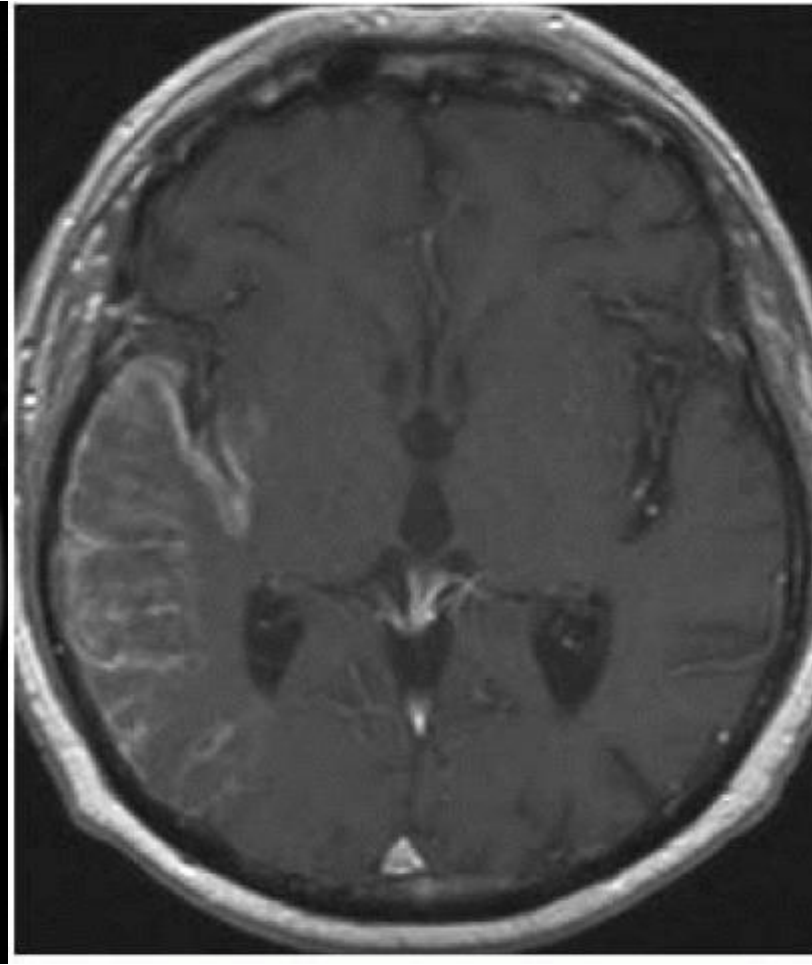
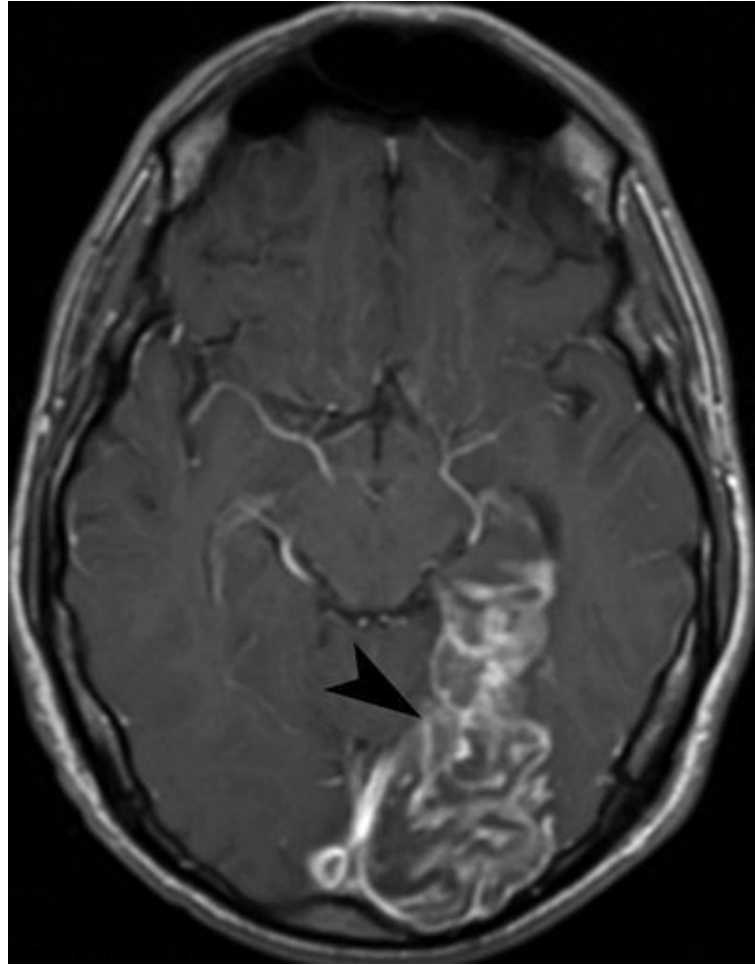
# Differential diagnosis

- ▶ Very important to have a solid diagnosis before planning a surgery
- ▶ GBM/Luxurious perfusion/Inflammatory alterations/Radio necrosis
- ▶ Cystic tumors/Septic emboli/Cysticercosis/Hydatid cysts/Arachnoid or neurenteric cysts/ Abscess
- ▶ LGGs/Stroke/status epilepticus/cerebritis
- ▶ Sellar tumors vs Apoplexia or tumors with bleeding
- ▶ Vascular malformations Vs cystic tumors (hemosiderin stain , localization)
- ▶ Most important part of ddx is hidden within patient's history and the nature of the disease



T1W

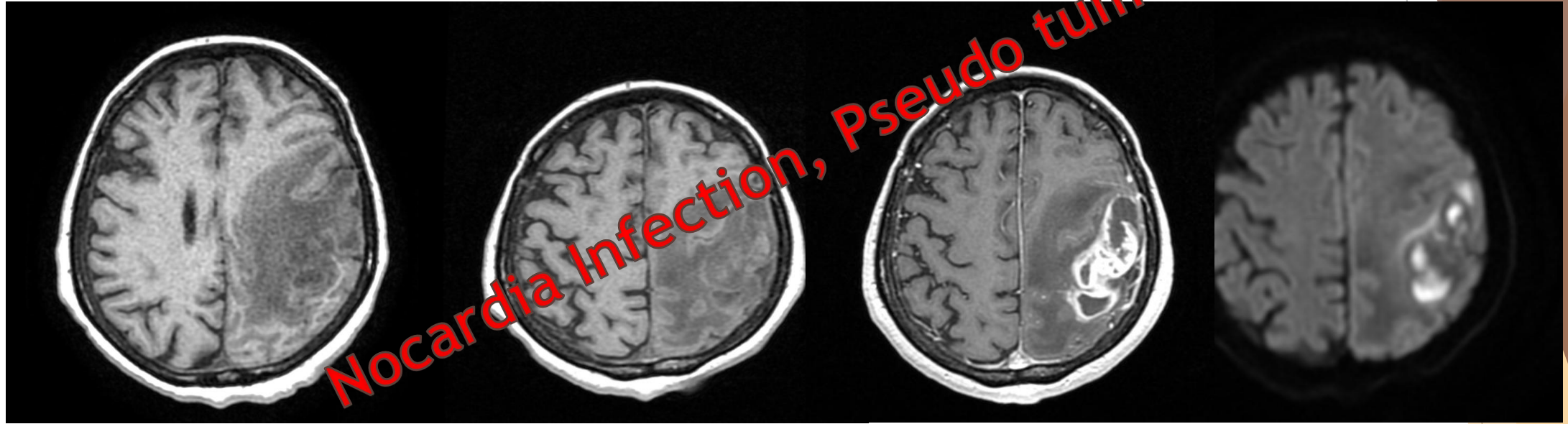
T1WC+



GBM ?

**Subacute Stroke**  
Luxury Perfusion  
WithPial Enhancement



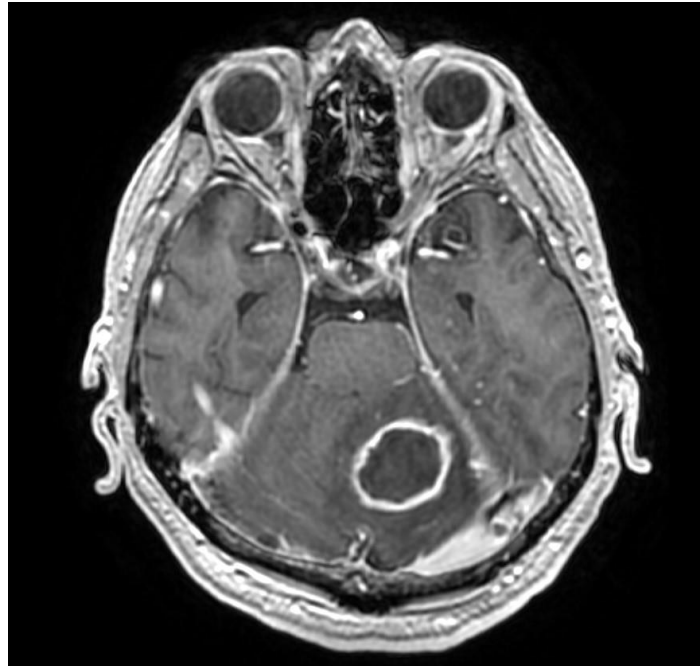


T1W    T1WC+    T1WC+    DWI

GBM ? Ruptured Abscess? Gliosarcoma?

# Importance of History taking

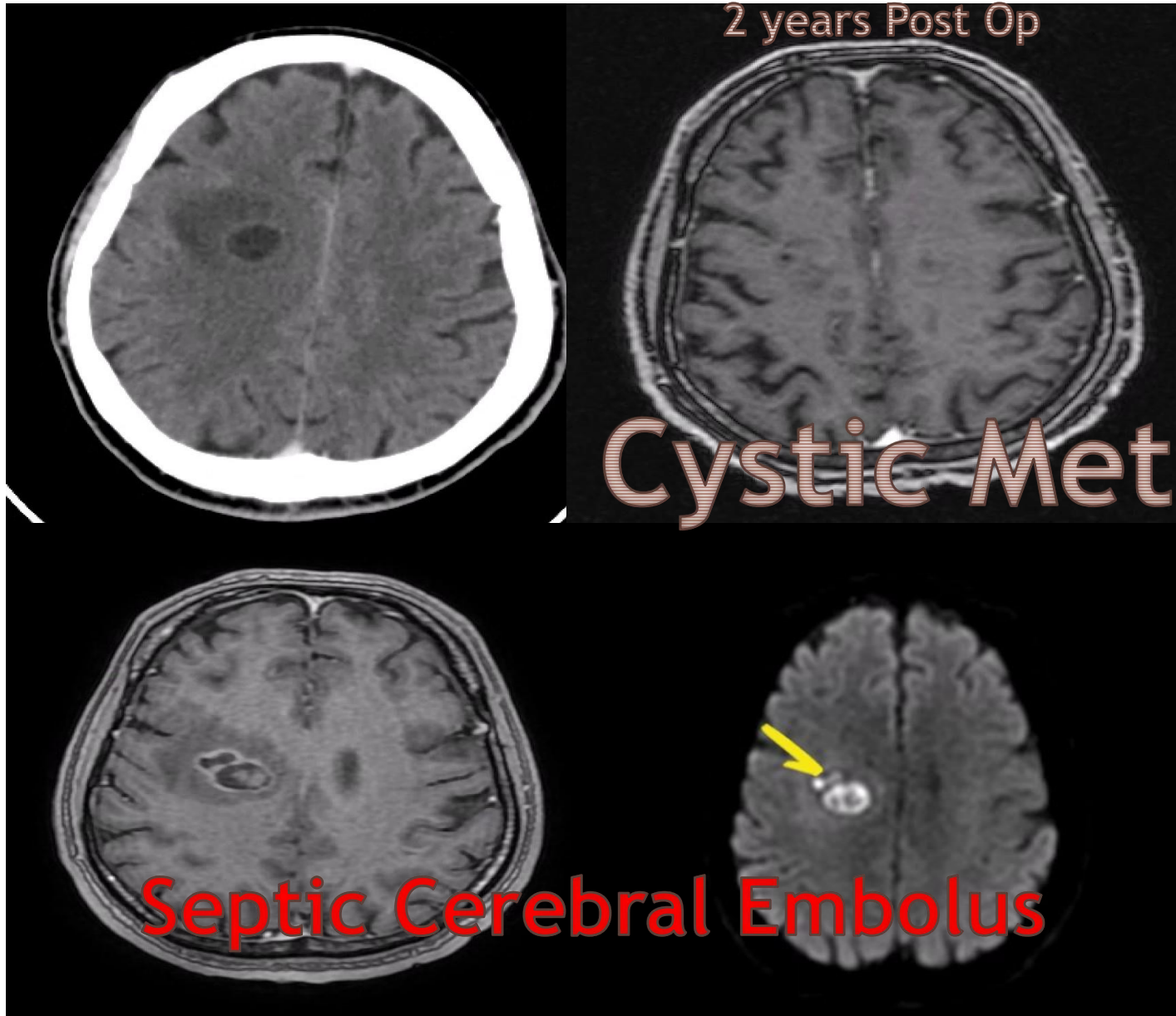
- ▶ Patient was referred due to headaches and vertigo
- ▶ In 2017 he underwent pulmonary lobectomy due to malignancy (tumor)



- ▶ Based on MRI, possibility of a pulmonary Met is very high
- ▶ Further investigation reveals that in 2017 the histopathology report confirmed an **actinomyces pseudotumor** alteration !!
- ▶ Therefore, possibility of an abscess and an inflammatory alteration rises
- ▶ CRP WBC were all within normal range !



- ▶ 65 years old male,
- ▶ type 1 DM on metformin, **Was not taking the medicine for 3 months !**
- ▶ sudden LOC,
- ▶ Blood glucose level 39mmol/L ,
- ▶ ketoacidosis coma,
- ▶ after 4 days a sudden right sided hemiparesis developed
- ▶ CRP was elevated
- ▶ Head CT + MRI



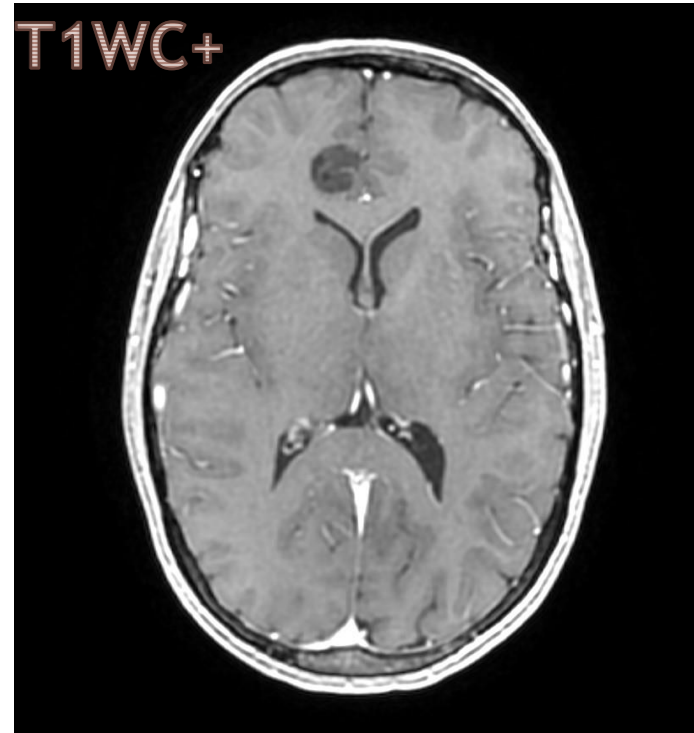
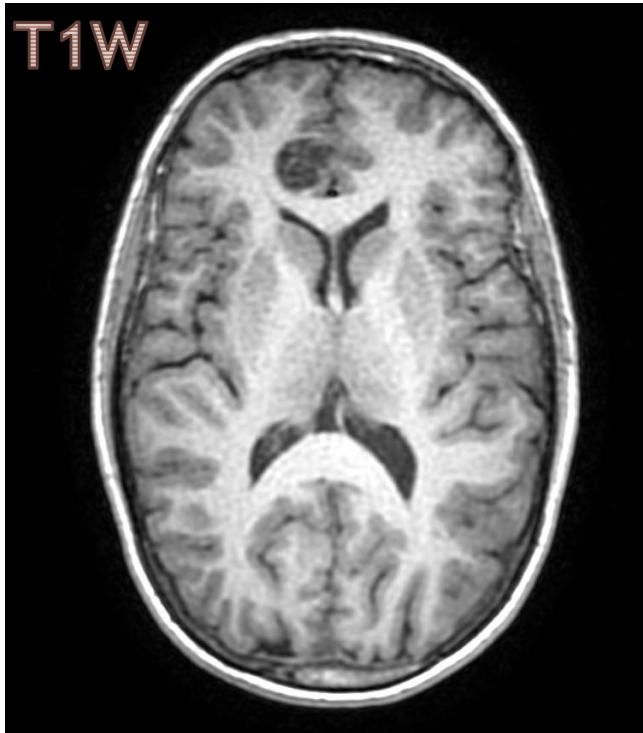
2 years Post Op

Cystic Metastasis ?

Septic Cerebral Embolus

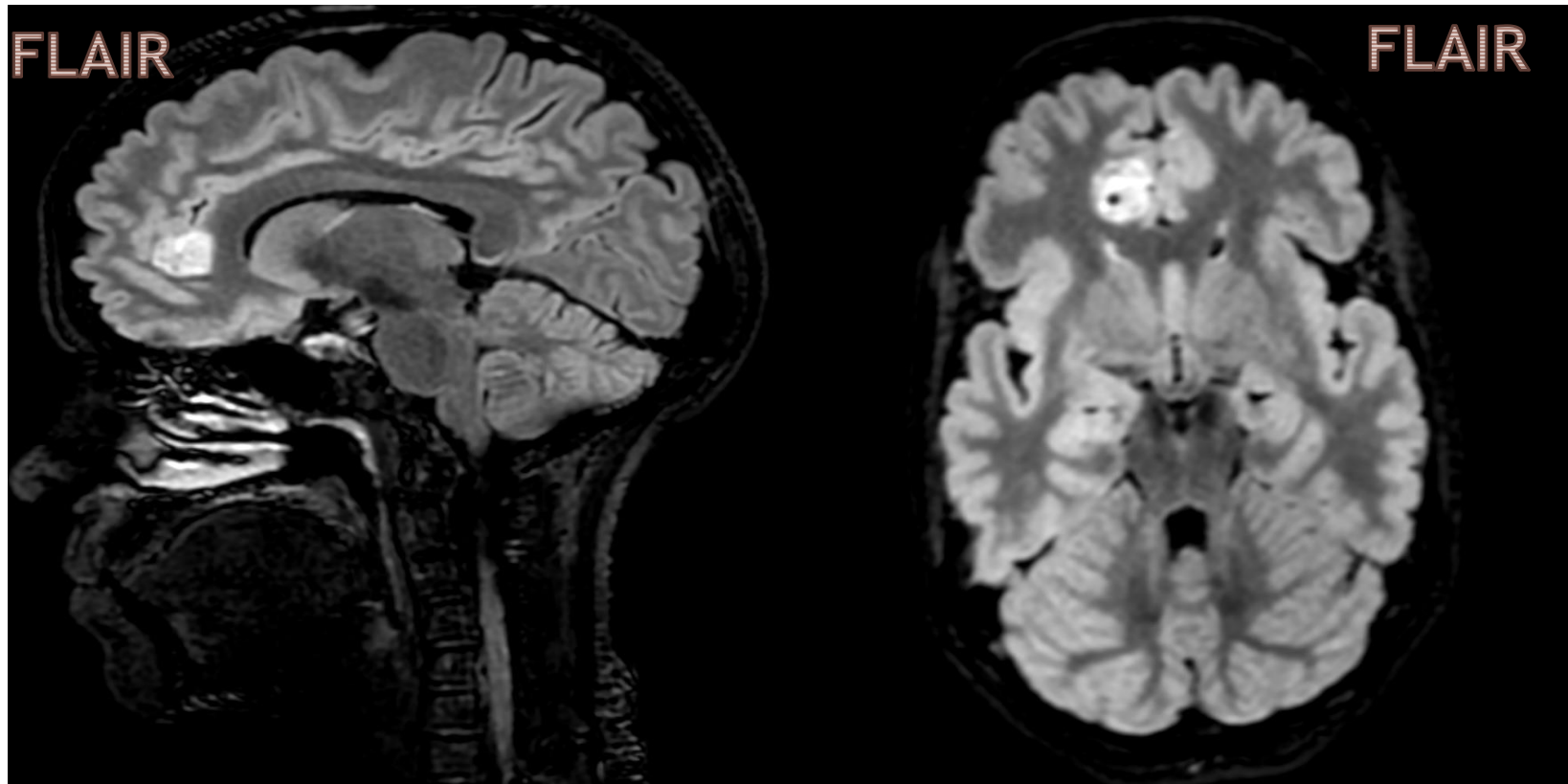
# Importance of proper Sequencing

- ▶ Young female, no comorbidities, first epileptic seizure in life



LGG ? Gliependymal cyst ?  
Arachnoid cyst ? Malignancy at all ?

# Proper Sequencing



Fluid suppression gives a better idea of this lesion, most probably a LGG !  
**A closer follow up needed !!**

# Similar cystic lesions

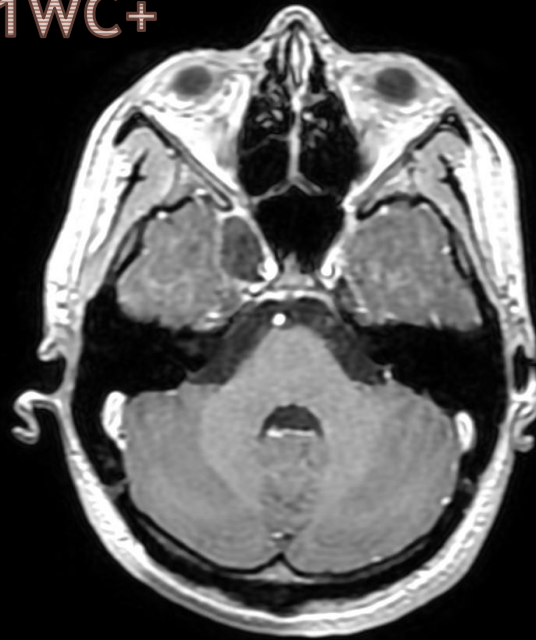
- ▶ Dermoid, Epidermoid, Neurenteric cyst, Arachnoid cyst, Porencephalic cyst, Colloid cyst, Pineal cyst, Ependymal cyst etc. etc.
- ▶ They are very similar in terms of MRI properties
- ▶ Location of the cysts are crucial in terms of radiological diagnosis
- ▶ Some have distinguished properties on some MRI sequences
- ▶ Dermoid cysts
  - ▶ Fat content , **Fat suppression sequencing** are useful
  - ▶ IF ruptured fat droplets can be found in SA space or even in ventricles
  - ▶ On T1W hyperintense on T2W iso-hyperintense
  - ▶ T1WC+ Mild enhancement of capsule
- ▶ Epidermoid
  - ▶ On native sequencing can mimic Arachnoid cysts, since they appear mainly around cisterns
  - ▶ FLAIR does not suppress
  - ▶ **DWI hyperintensity** definitely distinguishes from Arachnoid cysts
- ▶ Colloid Cysts
  - ▶ Usually occurs at the level of foramen of Monroe
  - ▶ On T2W signals can vary !!
  - ▶ On T1W about 2/3 is hyperintense and 1/3 isointense (depending on cholesterol content)
  - ▶ FLAIR does not suppress
  - ▶ DWI does not restrict



T2W

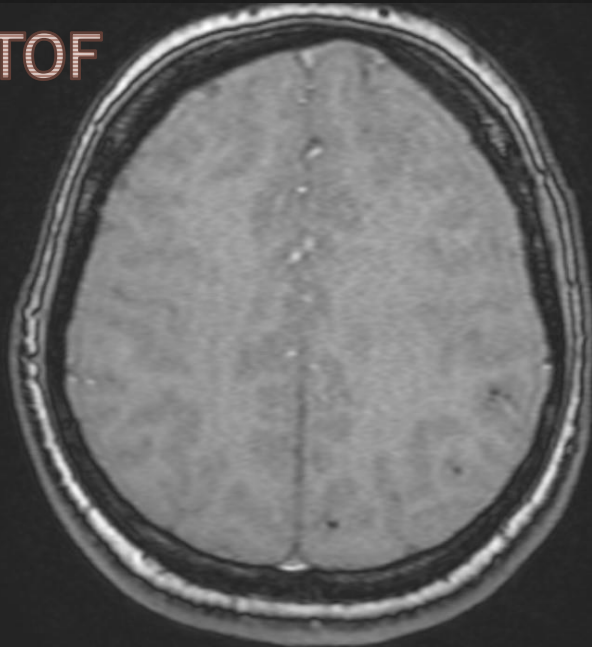


T1WC+

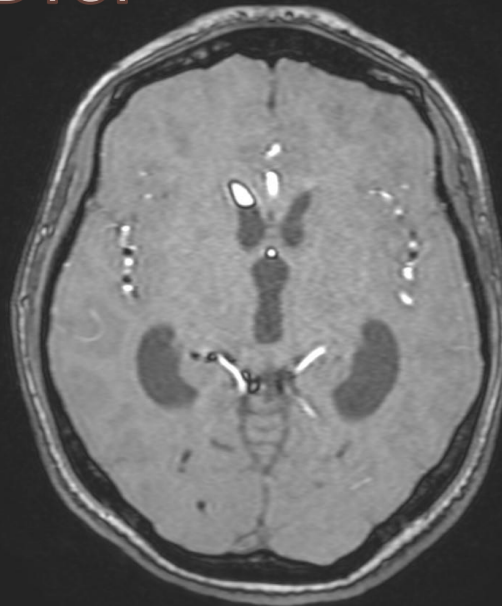


Arachnoid cyst ?

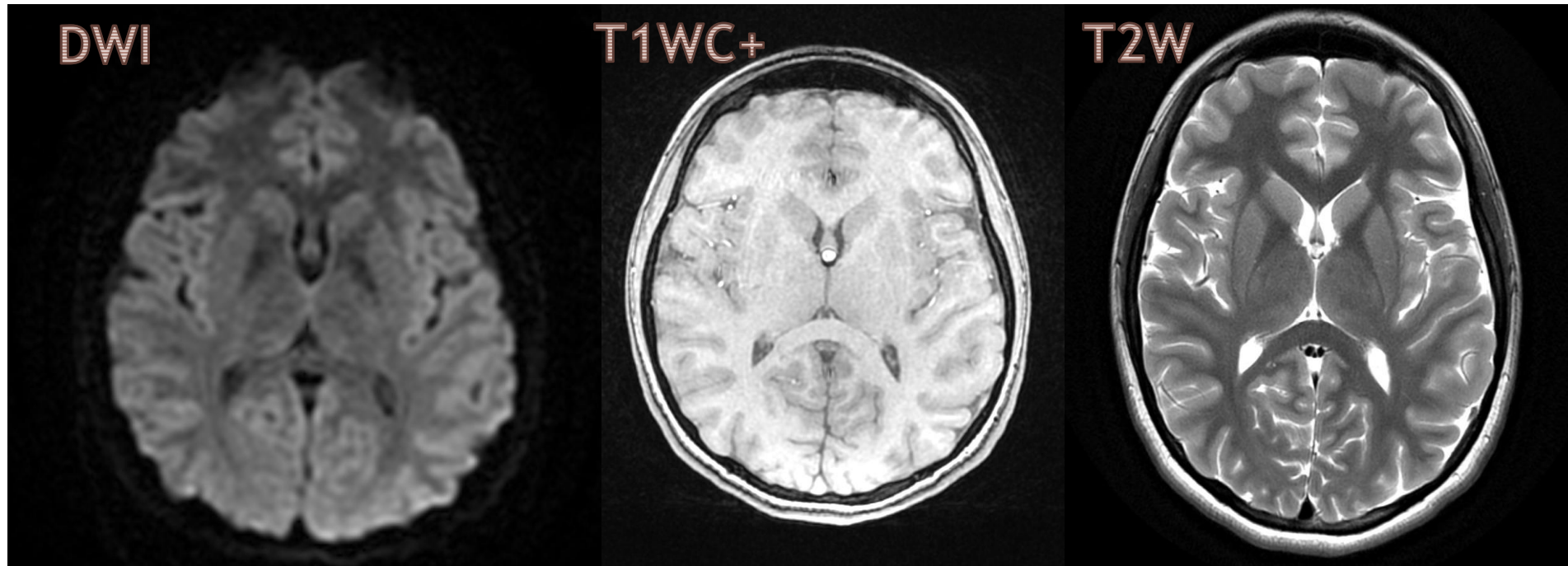
3DTOF



3DTOF



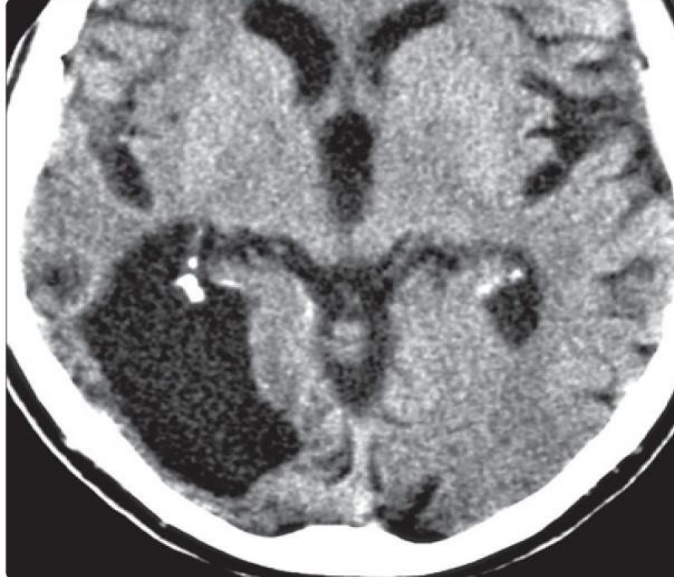
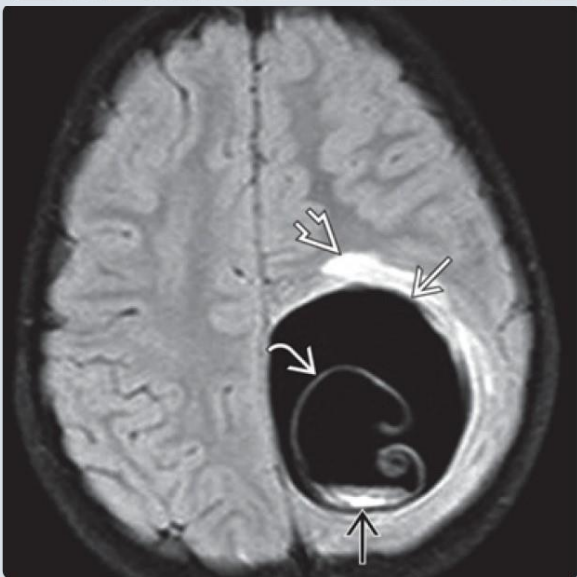
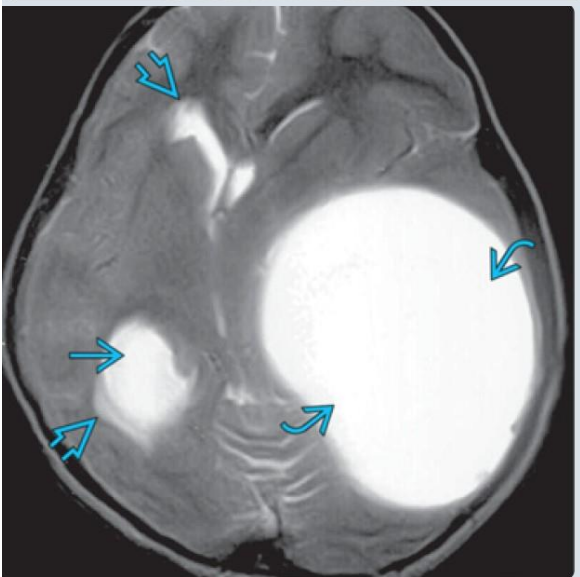
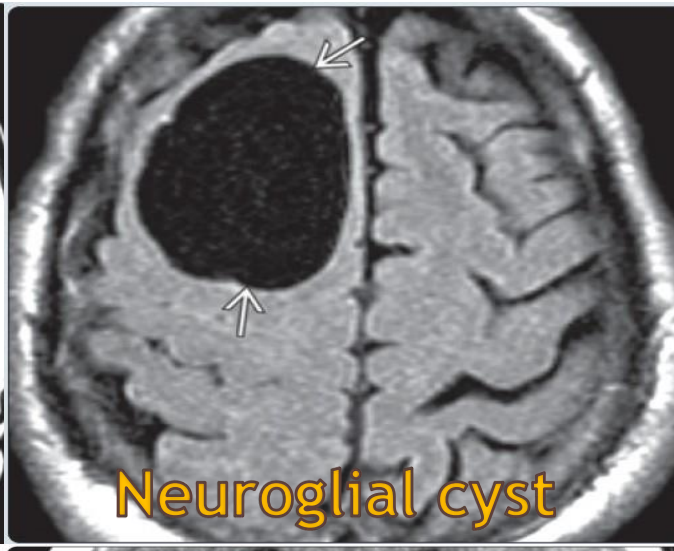
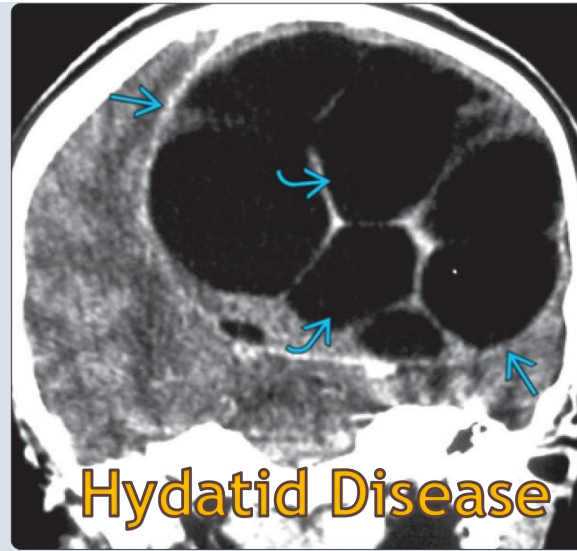
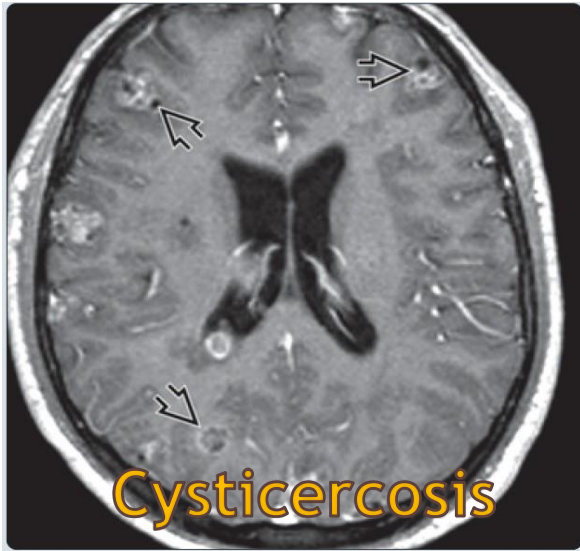
**Ruptured Dermoid !**



Classic Colloid Cyst

# Infectious cystic alterations

- ▶ Hydatid cysts
  - ▶ Usually, one solid large cyst
- ▶ Neurocysticercosis
  - ▶ Multiplex smaller caliber cystic alterations
- ▶ Differentiation from malignant and other benign cystic alterations
  - ▶ Pilocytic astrocytoma
  - ▶ Cystic GBMs
  - ▶ Cystic Mets
  - ▶ Other benign cystic lesions
- ▶ Congenital malformations
  - ▶ Neuroglial cysts
  - ▶ Porencephalic cyst
  - ▶ Ependymal cyst
  - ▶ Etc. etc.



# Focus of this lecture !

- ▶ When can we ignore or STOP doing MRI Scans?
  - ▶ If there is no therapeutic consequence of doing or not doing the MRI scans , i.e. infaust patient, a patient who does not consent to treatment
  - ▶ When following benign lesions and after a long period of follow up (i.e 3-4 years) the lesion does not show any sign of growth and the patient is symptoms free
  - ▶ When a benign lesion is removed, and the mid term post op follow up does not show any sign of recurrence or recidivation ! i.e. Grade I meningiomas or arachnoid or pineal cysts !!!
- ▶ When do we have to do an MR scan at any cost ?
  - ▶ When a malignant lesion is suspected whether is a primary or secondary lesion
  - ▶ After resecting an intracranial lesion (no protocol but doing a control scan is strongly recommended)
  - ▶ When a pathology clearly can not be ruled out or identified on CT scans
  - ▶ Following up benign lesions or post Op patients
  - ▶ Following traumatic cases in Children or young adults
- ▶ When to use it for follow ups?
  - ▶ Benign lesions
  - ▶ Post op Patients (tumor, inflammation .....)
  - ▶ Trauma Follow up in children and young adults
  - ▶ Effectiveness of Therapy (Chemo and radio, AB therapy etc. etc.)

- ▶ In case of tumors
  - ▶ Gold Standard for Diagnosis is C+ MRI
  - ▶ Post operative follow ups for residual or recidivating tumors
  - ▶ In case of metastasis, Solitary Vs Multiplex
    - ▶ Very important for planning of post Op chemo-radio therapy
  - ▶ In case of benign tumors
    - ▶ Small symptom free LGGs
    - ▶ Symptom free Meningiomas with no mass effect or edema
    - ▶ Schwannomas with minimal symptoms or no mass effect on brain stem
    - ▶ Etc. etc.

Follow up, can be 3 Mo, 6 Mo, 1 Year  
if no abnormal growth or deterioration  
If growth or new symptoms are present,  
then a closer follow up or even  
consideration for resecting should be done

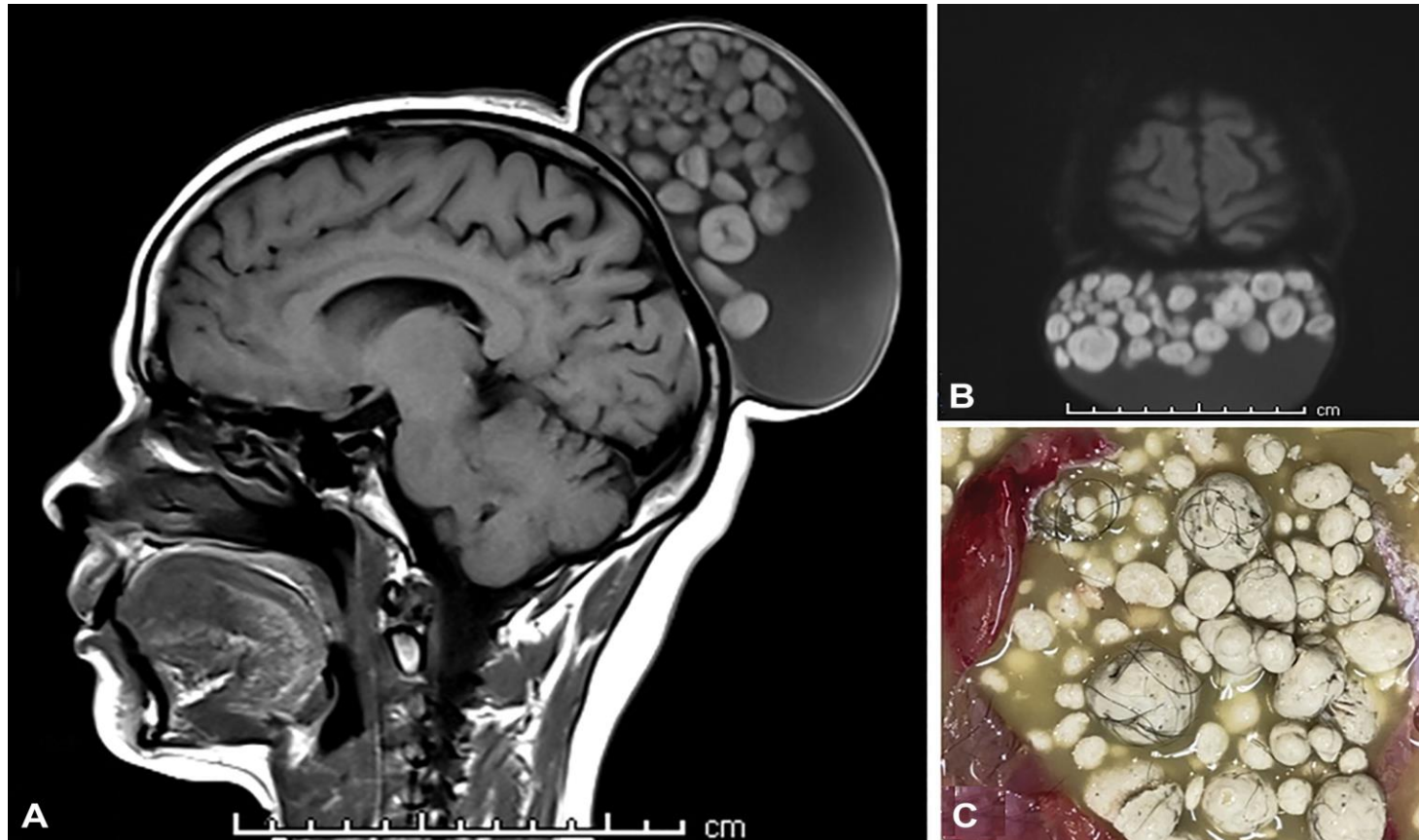
- ▶ In case of congenital abnormalities
  - ▶ Usually only diagnostic purpose
  - ▶ If An abnormality requires surgery or can progress later then follow up ( i.e Arachnoid cyst or Chiari or Lipoma etc)
- ▶ In case of Inflammatory alterations
  - ▶ Very Important for diagnosis
  - ▶ Important for surgical planning
  - ▶ Crucial for post operative control
    - ▶ If AB therapy yields, and lab results and MR scans show resolution then AB therapy can be stopped
- ▶ In case of Trauma
  - ▶ Gold standard remains CT
  - ▶ MRI is good for detecting
    - ▶ DAD
    - ▶ Brainstem involvement

# Take home message

- ▶ Sudden onset Vs slow progression
- ▶ History (infections, comorbidities etc. etc.)
- ▶ Lab results
- ▶ Known Malignancies
- ▶ Be able to use MRI scans for **differential diagnosis**, every one can **see** a **contrast enhancement**, but not everyone knows the **proper diagnosis** and the **reason for enhancement**.
- ▶ Picture modalities are there to **help** with the diagnosis and not for giving a **FINAL** diagnosis.
- ▶ Use the Picture modalities **to your benefit** in order to have a **proper diagnosis** and plan a **proper treatment plan**, let it be surgical or non-surgical !
- ▶ Think like a surgeon and not a radiologist ! At the end of the day, you **must treat the patient** and not write **radiological reports** !

# Challenge

# Teratoma



## ▶ Hints

- ▶ You can ask a dentist to assist you on this case !
- ▶ The favorite dessert of this tumor is TUTTI FRUTTI !
- ▶ You can use a hair dryer for controlling the bleeding instead of a bipolar cautery !!

**They can contain teeth**  
**They can contain anything originating from Ecto, endo or mesoderm layers**

**They can contain Hair**

• [Sumit Thakar, Pavan Vasoya](#)

• From the Department of Neurosurgery,  
Sri Sathya Sai Institute of Higher Medical Sciences,  
ITPL Rd, EPIP Area, Whitefield, Bangalore 560066, India.



# Disclamair

- ▶ Image and figure sources:

Pictures and figures used in this lecture are mainly own cases, courtesy of Dr. Arad Tahaei, as well ass cases presented in the following textbook:

- ❖ Diagnostic Imaging: Brain, Elsevier - Health Sciences Division, **Miral D. Jhaveri**