

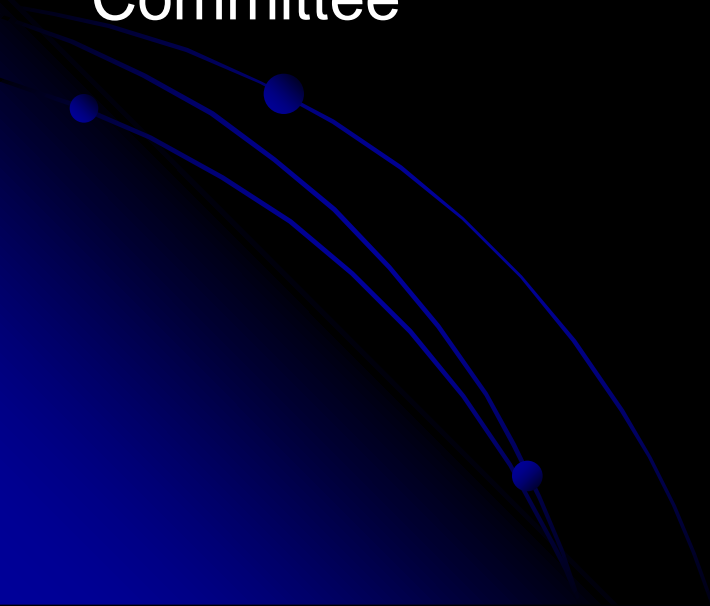
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ASN 2021

***The Role of Neuroimaging in
Secondary Headaches***

**Laszlo Mechtler MD, FAAN
Director, Dent Headache Center
Professor of Neurology and Oncology, SUNY at Buffalo
Chief of Neuro-oncology , Roswell Park Cancer Institute**

Disclosure

- Director of Neuro-imaging, DNI
- Neuro expert panel , American College of Radiology
- Past-President of American Society of Neuro-imaging (ASN)
- Past Associate Editor of Neuro-imaging, Continuum
- National Quality Forum Imaging Efficiency Steering Committee



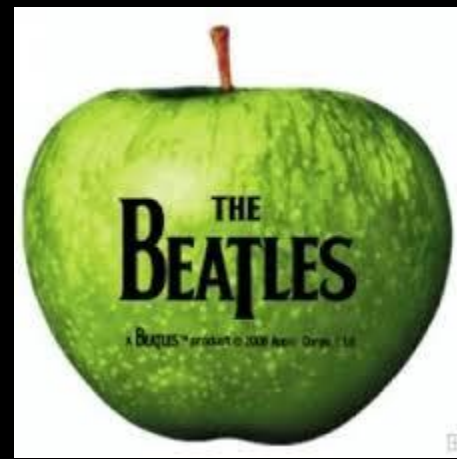
Future of Imaging

- *Anatomic*

1. CT
2. MRI
3. CTA/MRA
4. DWI/DTI
5. SWI
6. Volumetric

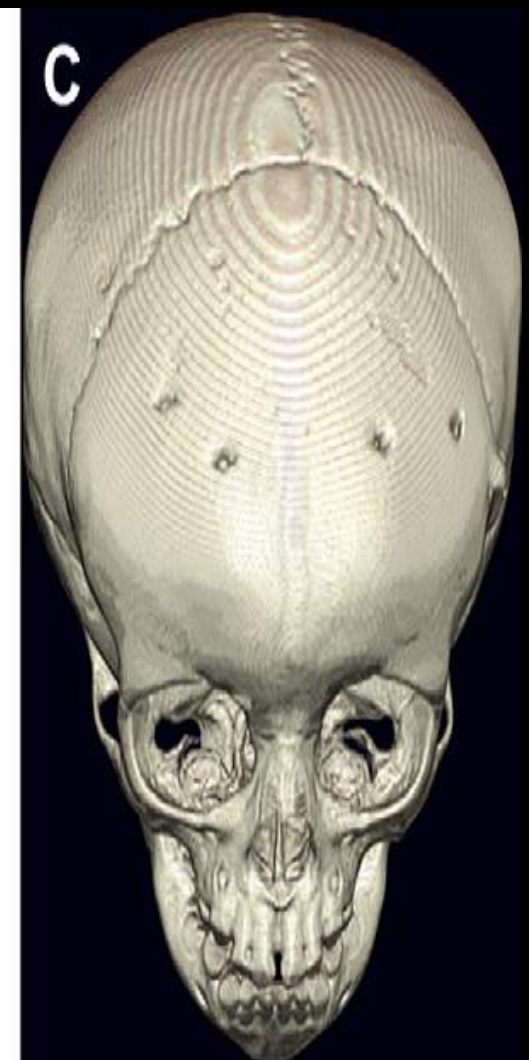
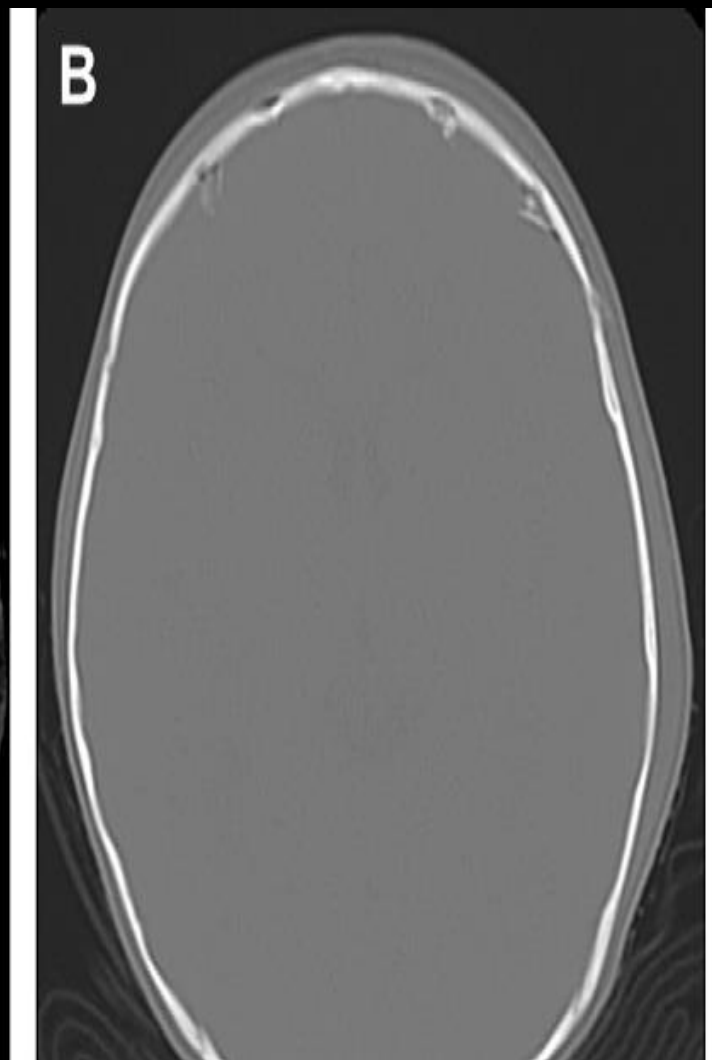
- *Functional*

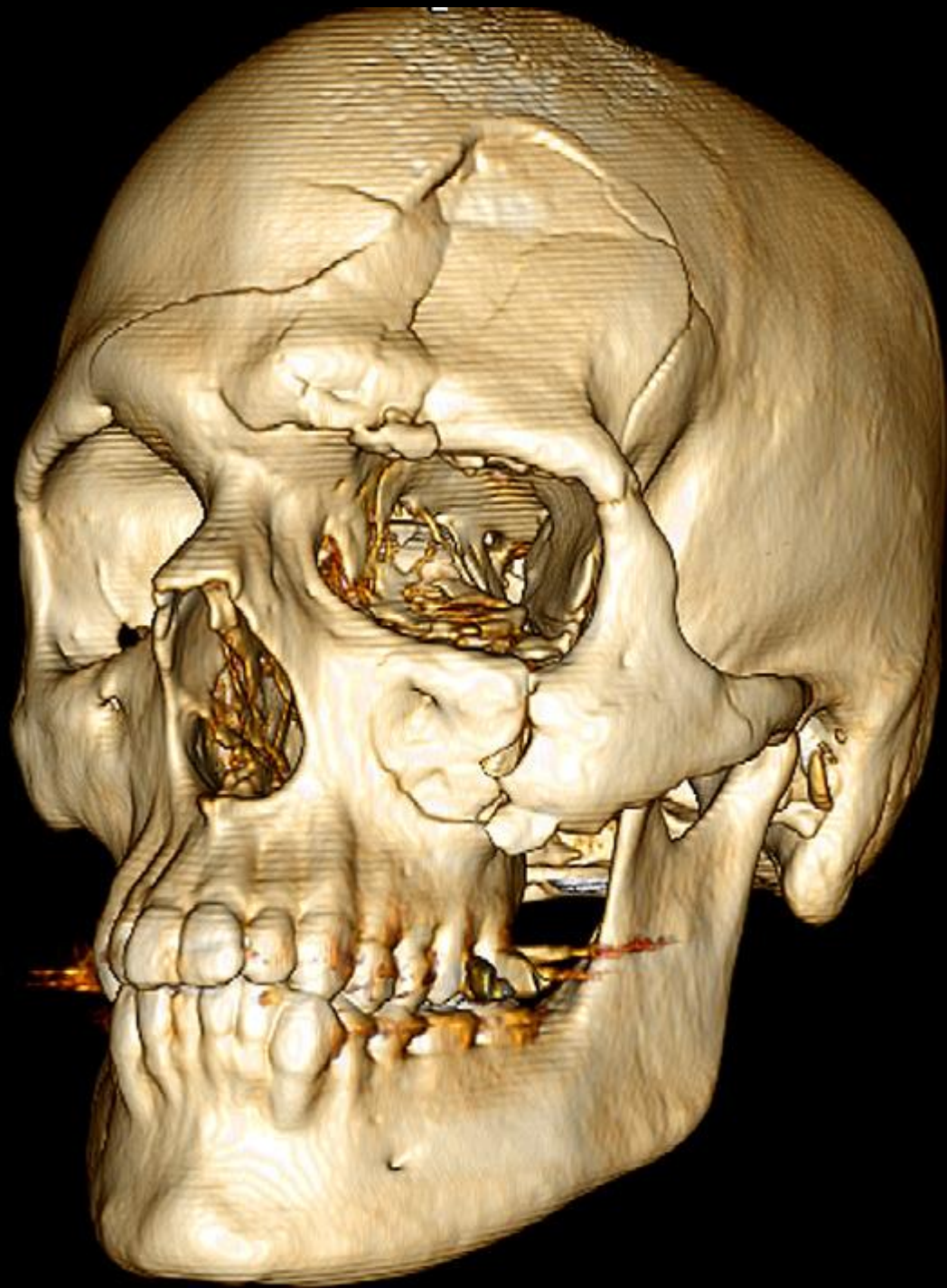
1. MRS
2. PWI
3. fMRI
4. PET



Houndsfield develops CT scanner

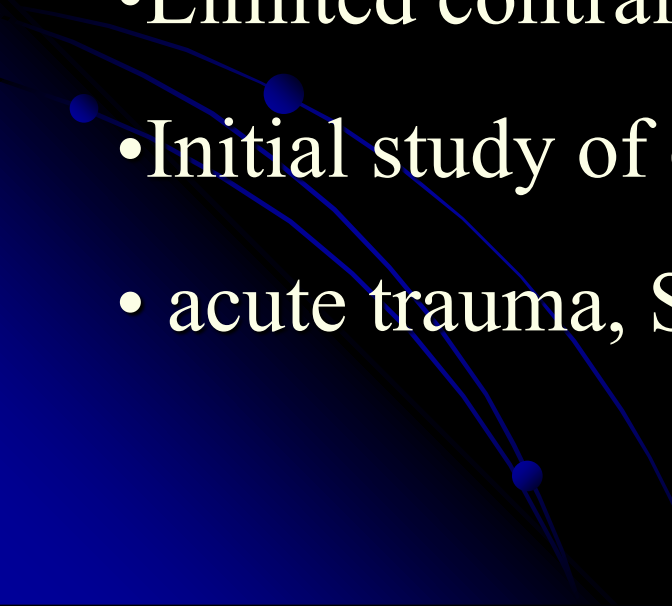
3-D reformatted images can be useful in defining skull and facial fractures.





Depressed
frontal fracture.

CT Scan

- Sensitive for acute intracranial hemorrhage
 - Excellent cortical bone detail
 - Quick and relatively inexpensive
 - Limited contraindications (pregnancy)
 - Initial study of choice for head trauma
 - acute trauma, SAH, MR contraindications
- 

Research Submissions

Neuroimaging for Migraine: The American Headache Society Systematic Review and Evidence-Based Guideline

Randolph W. Evans, MD; Rebecca C. Burch, MD; Benjamin M. Frishberg, MD; Michael J. Marmura, MD; Laszlo L. Mechtler, MD; Stephen D. Silberstein, MD; Dana P. Turner, MSPH, Ph. *Headache* 2020;60:318-336

1. There is no necessity to do neuroimaging in patients with headaches consistent with migraine who have a normal neurologic examination, and there are no atypical features or red flags present

Neuroimaging for Migraine: The American Headache Society Systematic Review and Evidence-Based Guideline

Randolph W. Evans, MD; Rebecca C. Burch, MD; Benjamin M. Frishberg, MD; Michael J. Marmura, MD; Laszlo L. Mechtler, MD; Stephen D. Silberstein, MD; Dana P. Turner, MSPH, Ph. Headache 2020;60:318-336

2. Neuroimaging may be considered for presumed migraine for the following reasons:

- ✓ unusual, pro-longed, or persistent aura;
- ✓ increasing frequency, severity, or change in migraine clinical features, first or worst migraine,
- ✓ migraine with brainstem aura,
- ✓ confusional migraine,
- ✓ hemiplegic migraine,
- ✓ late-life migrainous accompaniments,
- ✓ migraine aura without headache,
- ✓ side-locked migraine, and posttraumatic migraine.

Most of these are consensus based with little or no literature support. Grade C (strong recommendation, low quality evidence)



Headache Classification

Part 1:

Primary headache disorders

Part 2:

Secondary headache disorders

Part 3:

Cranial neuralgias, central and primary facial pain and other headaches

Normal Anatomic Variant

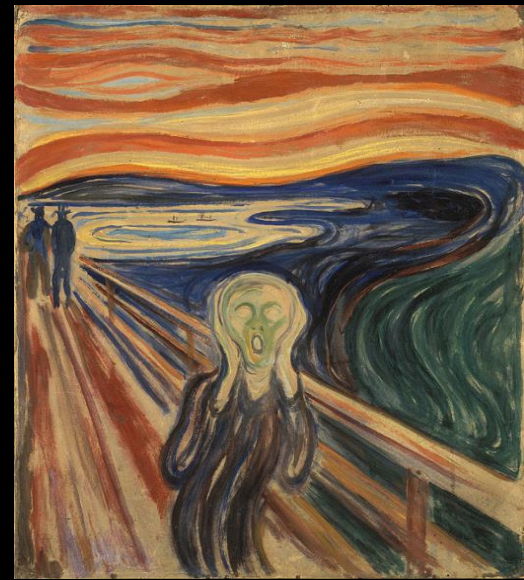
- Ventricular asymmetry
- Cavum septi pellucidi/Cavum vergae
- Cavum veli interpositum
- Arachnoid granulations
- Mega cisterna magna
- Enlarged Meckel cave
- Transverse sinus asymmetry

Parenchymal

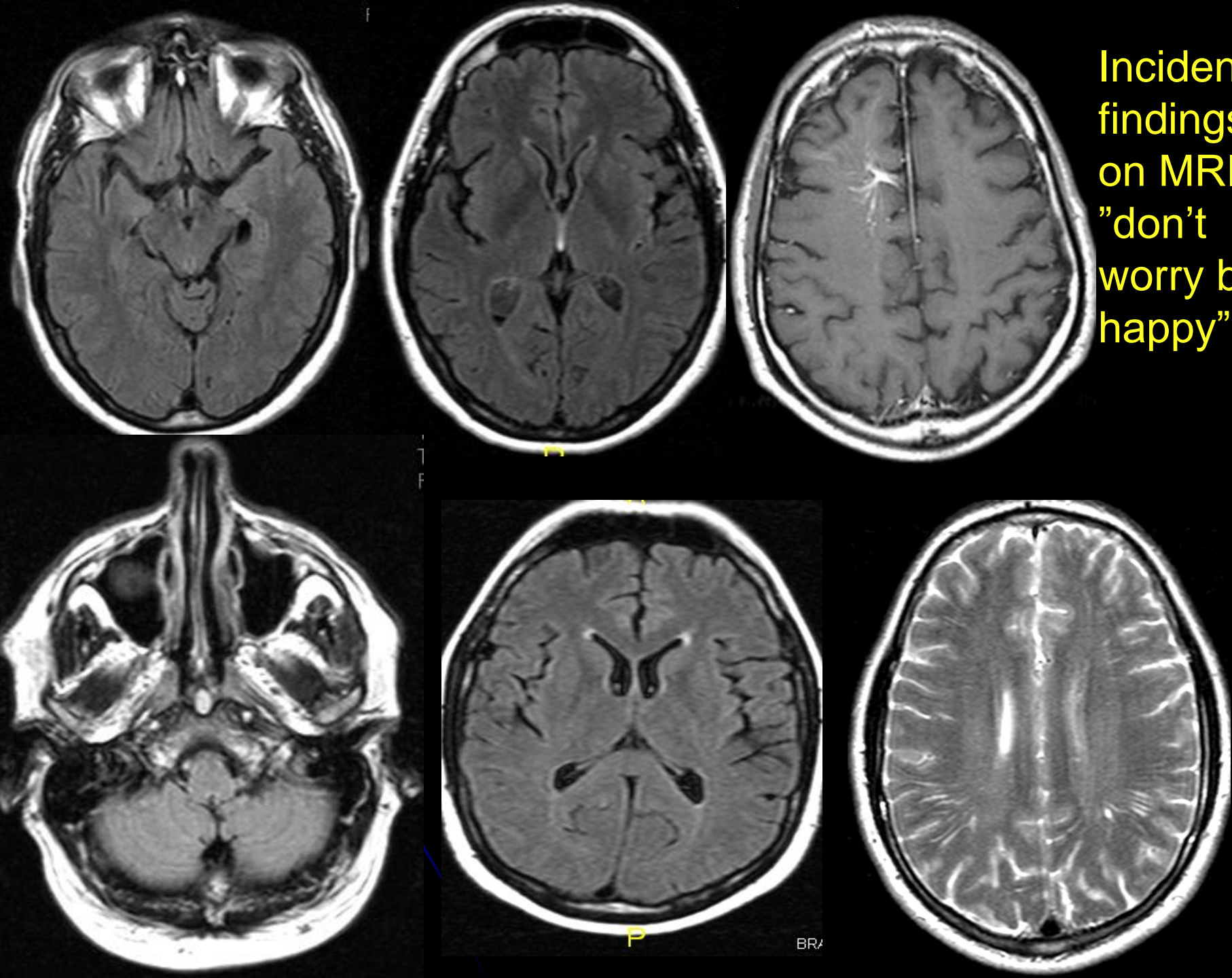
- White matter lesions
- Developmental venous anomaly
- Capillary telangiectasia
- Lipoma
- Low-lying cerebellar tonsils
- Prominent perivascular spaces
- Ependymitis granularis

Cysts

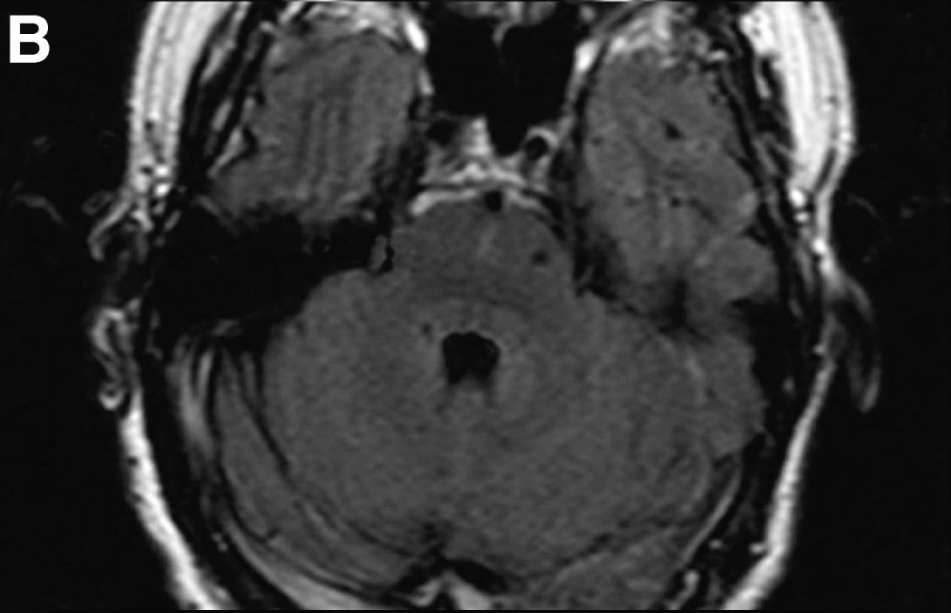
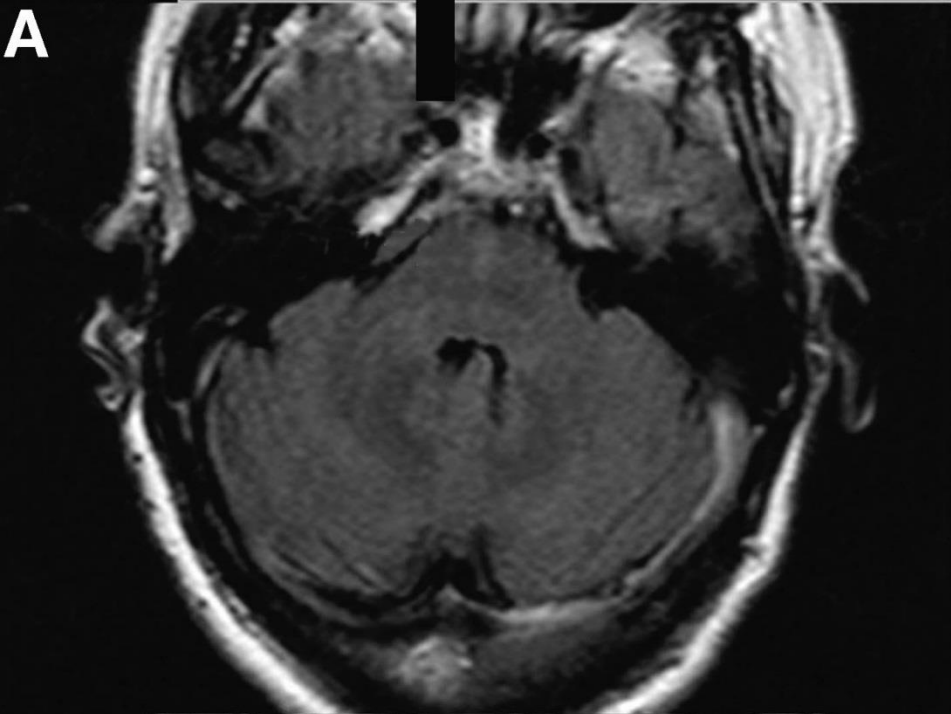
- Pineal cyst
- Arachnoid cyst
- Choroid plexus cyst
- Choroidal fissure cyst
- Tornwaldt cyst
- Sinus retention cyst



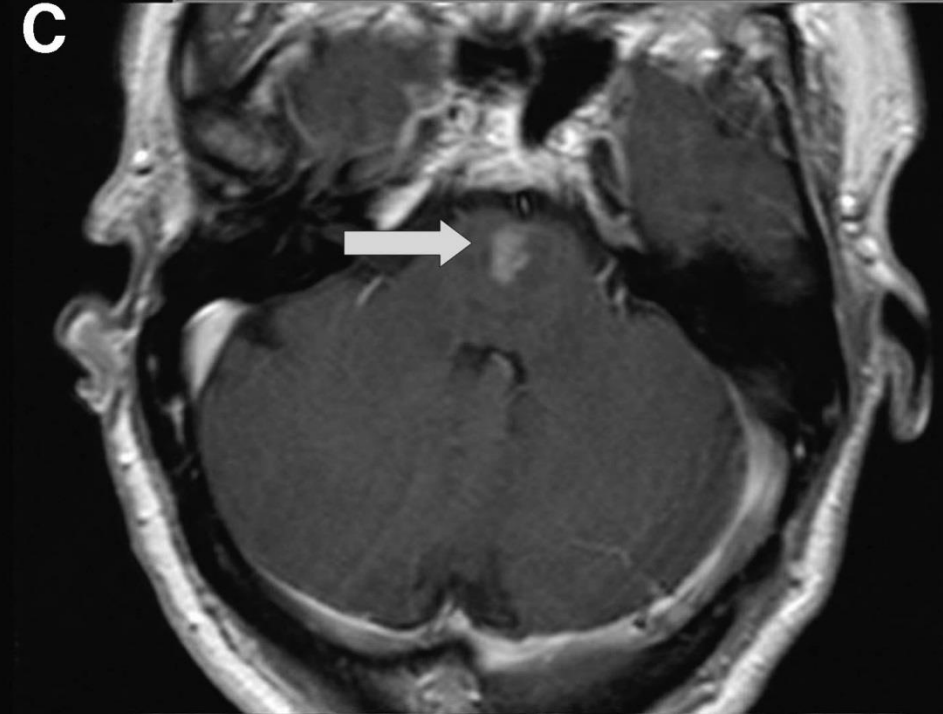
Incidental Findings Seen on MRI



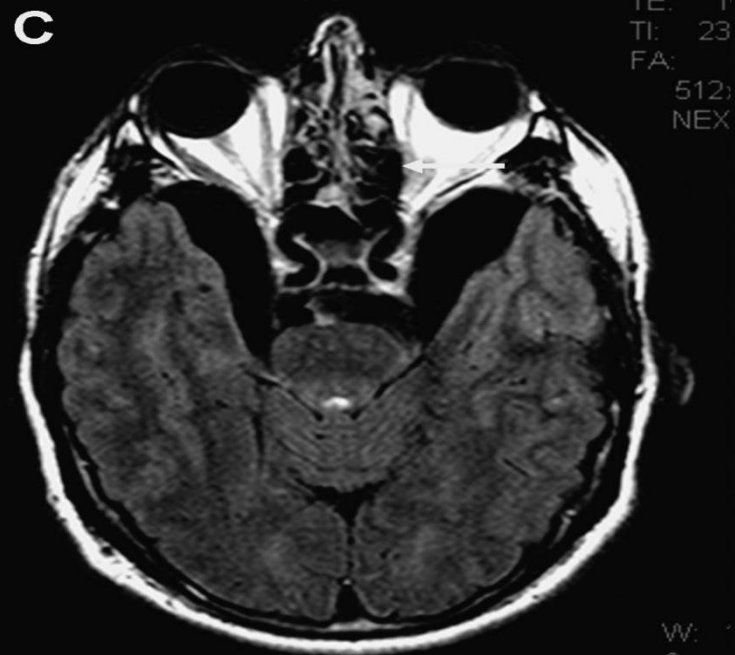
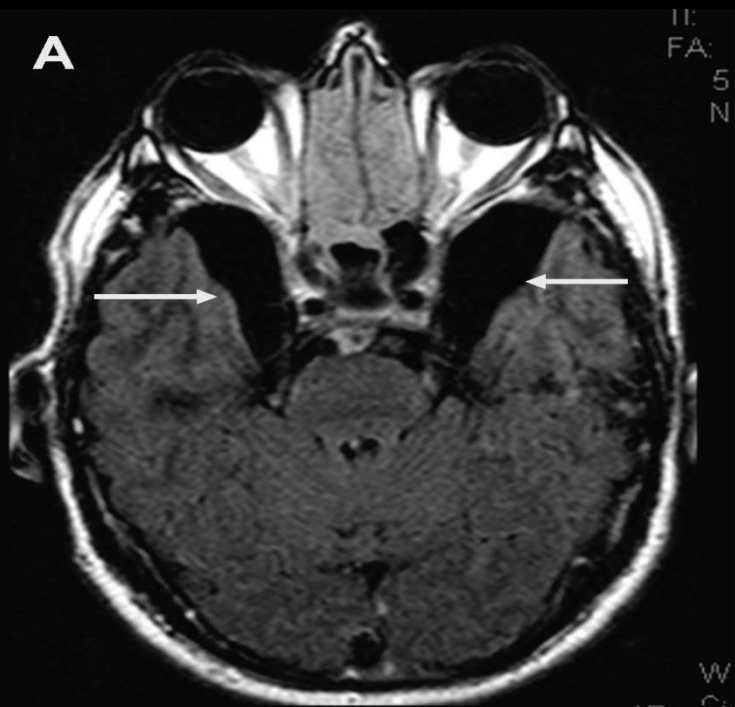
Incidental findings on MRI...
"don't worry be happy"



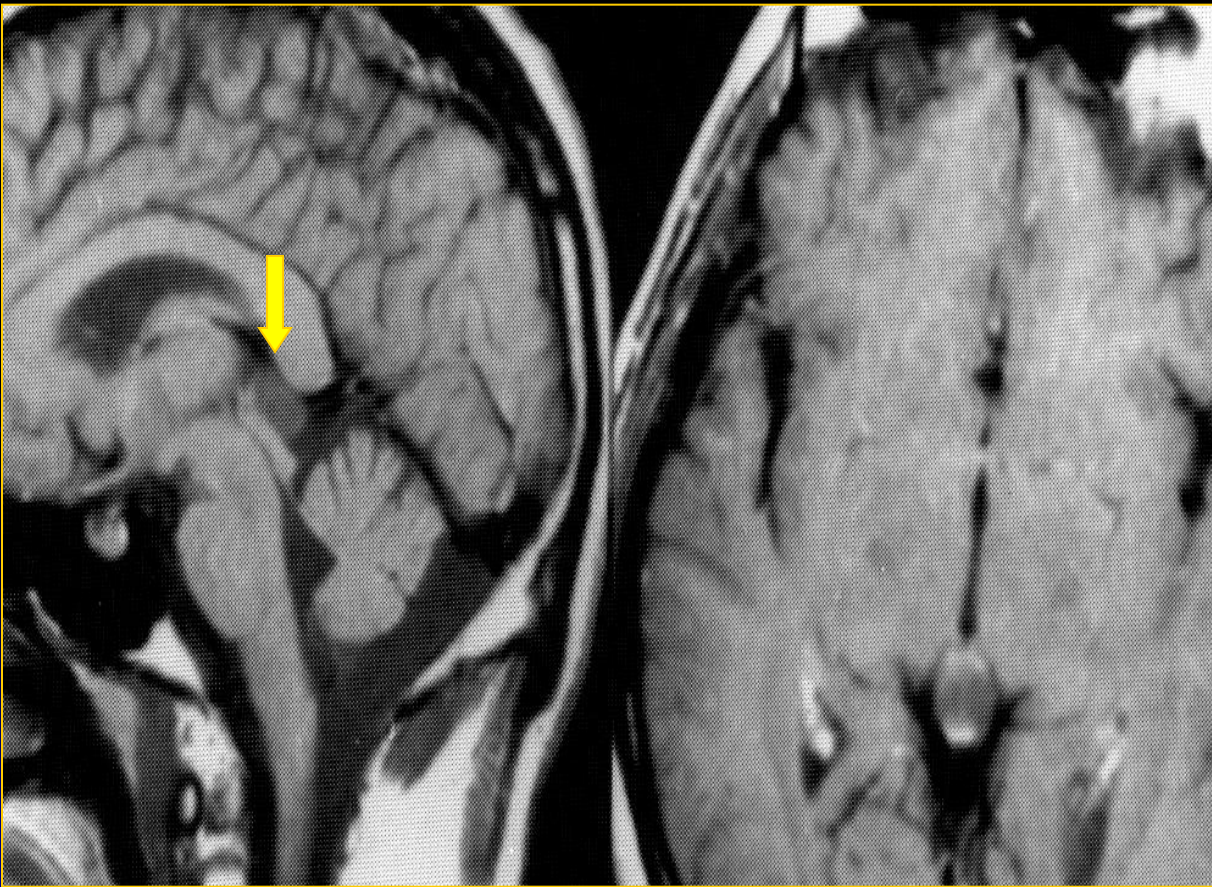
Subtle FLAIR hyperintensity



Contrast enhancement



PINEAL CYST-ASYMPTOMATIC



**Cyst is ovoid
sl.hyperintense to
CSF**

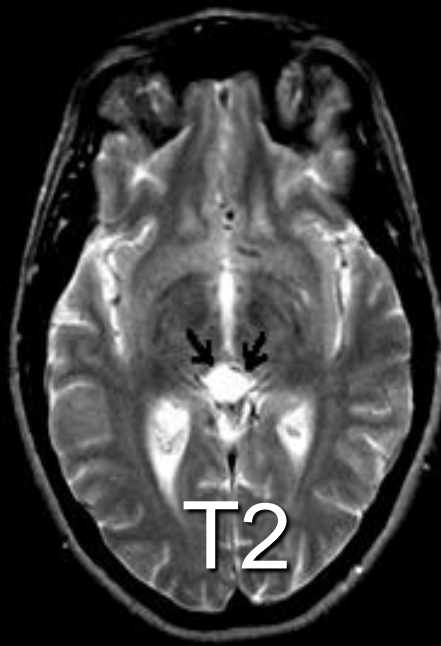
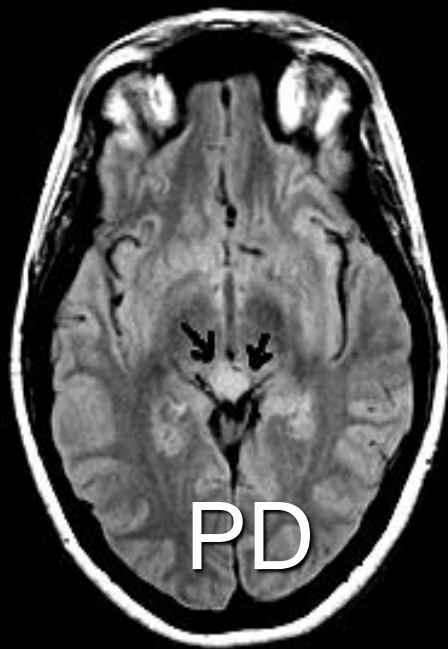
**Cyst wall enhances
minimally.**

**No distortion of the
tectum**

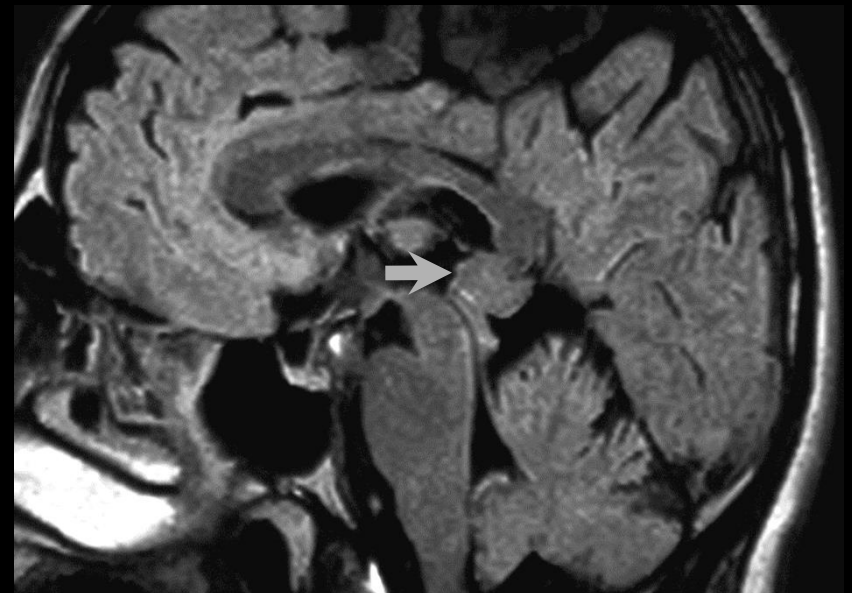
Non-contrast sagittal and Post-contrast Axial

Pineal Cyst

- 60% hyperintense to CSF on T1W1
- 90% hyperintense on PD/FLAIR
- 60% enhance
- 1-4% prevalence
- 80% less than 1 cm
- F:M = 3:1
- Clinical profile: Young female with non-focal headache



Pineal Cyst



RED FLAGS



- The “first or worst” headache (“thunderclap”)
- Subacute headaches with increasing frequency and severity
- Progressive or new daily persistent headache
- Chronic daily headache
- Headaches always on the same side
- Headaches resistant to treatment
- New onset of headaches in high-risk population
 - Patients with cancer
 - Patients who are HIV positive
 - Patients with dementia
 - Patients who are taking an anticoagulants
 - Patients with neurocutaneous syndrome
- New onset of headaches after age 50
- Patients with headaches and seizures
- Headaches associated with symptoms such as fever, neck stiffness, nausea, and vomiting
- Headaches with focal neurologic deficits not meeting the International Headache Society criteria of migraine with aura
- Headaches associated with papilledema, cognitive impairment, or personality change
- Headaches precipitated by exertion, Valsalva maneuver, or positional changes
- Atypical cranial neuralgias poorly responsive to treatment



Subarachnoid Hemorrhage

Subarachnoid Hemorrhage at 24h

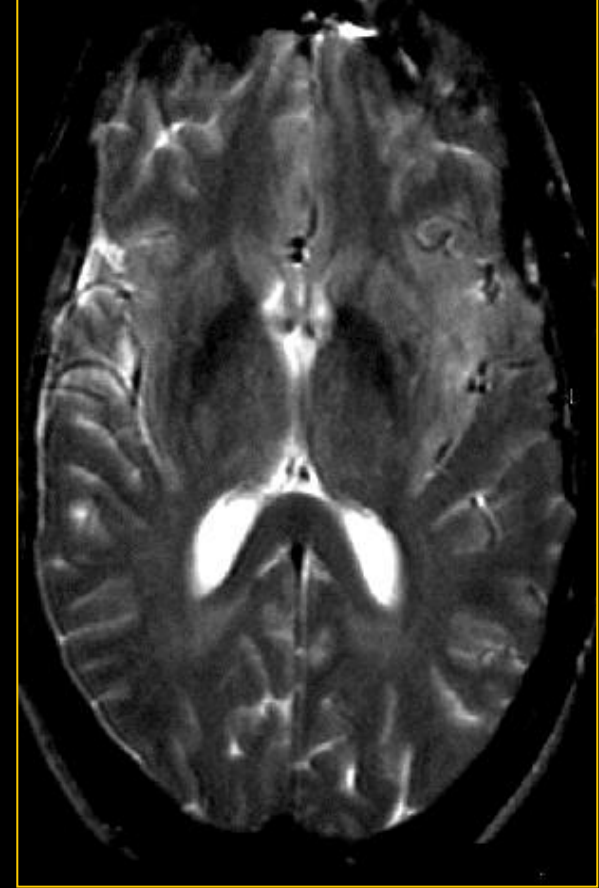
CT vs. Conventional MRI



CT



T1-non



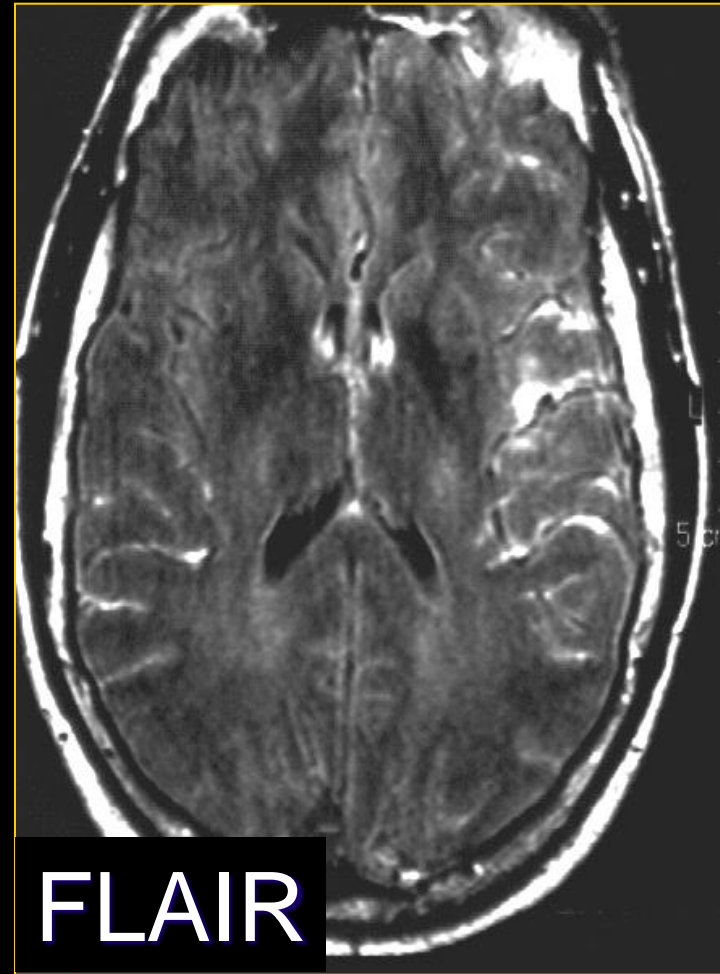
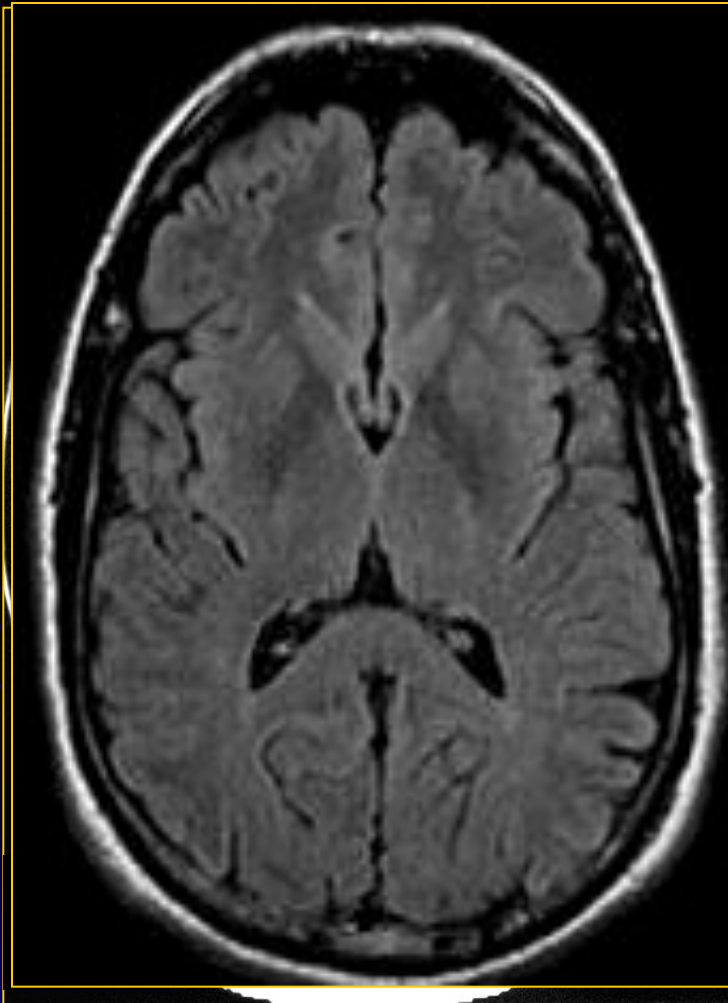
T2

Approximate probability of recognizing an aneurysmal subarachnoid hemorrhage on CT scan after the initial event

<u>Time</u>	<u>Probability (%)</u>
Day 0	95 (Adams et al., 1983)
Day 3	74 (Adams et al., 1983)
1 week	50 (van Gijn and van Dongen, 1982)
2 weeks	30 (van Gijn and van Dongen, 1982)
3 weeks	Almost 0 (van Gijn and van Dongen 1982)

Reproduced with permission from Evans, R.W. (1999). Headaches. In *Diagnostic Testing in Neurology* (R.W. Evans, ed.), p. 9. W.B. Saunders, Philadelphia.

Subarachnoid Hemorrhage at 24h



SENTINEL HEADACHES

- 50% of SAH
- 40-75% of pts seek medical attention
- Neck stiffness 30%
- N/V 20%
- Visual disturbances 15%
- Last 1 to 2 days, maybe as long as 2 wks

2 +c
IP No cut

14,5 cm
DARD
2

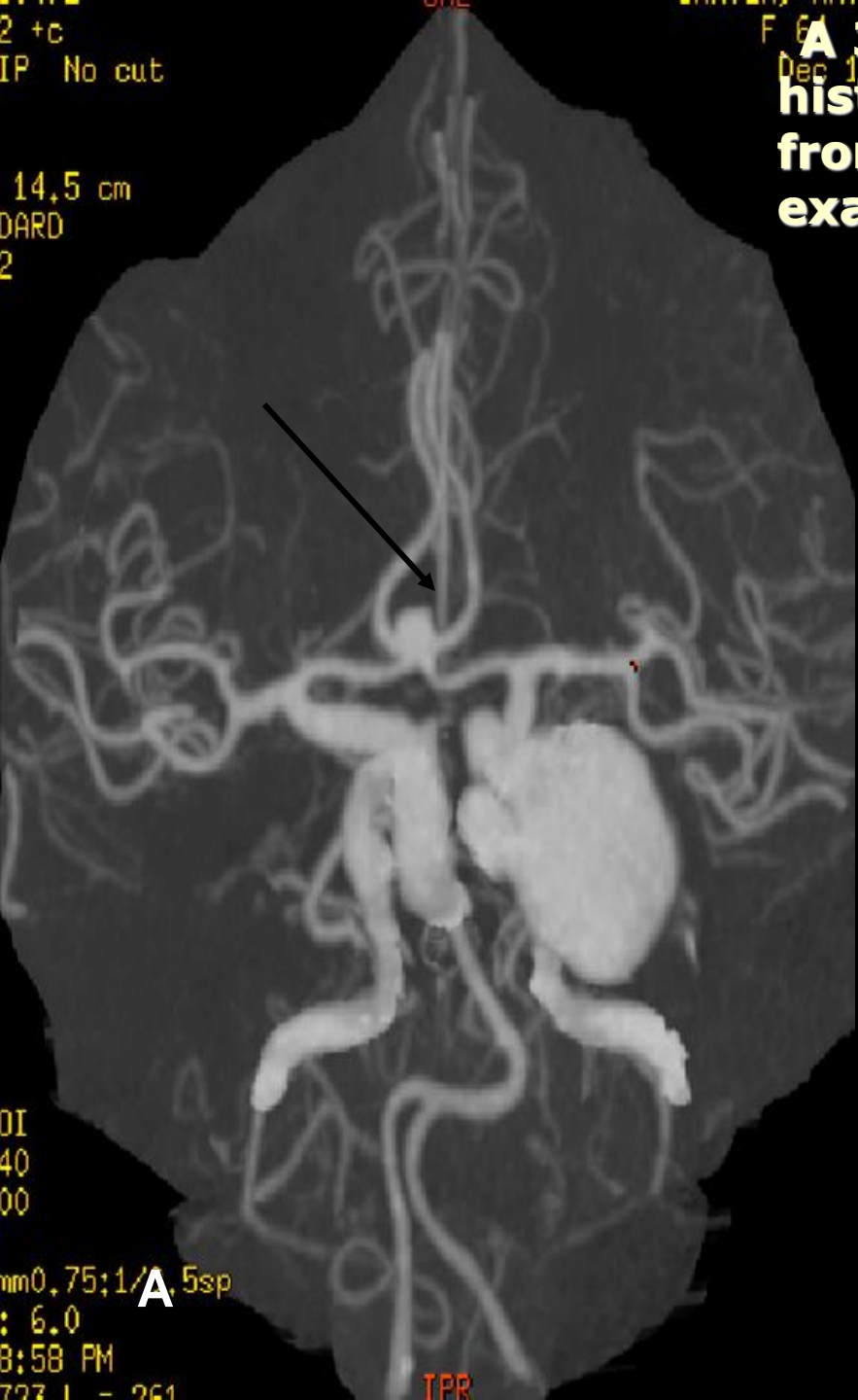
DI
40
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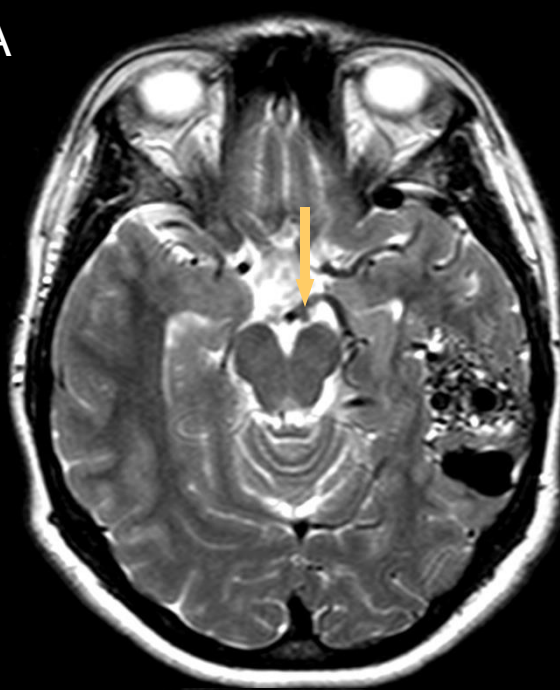
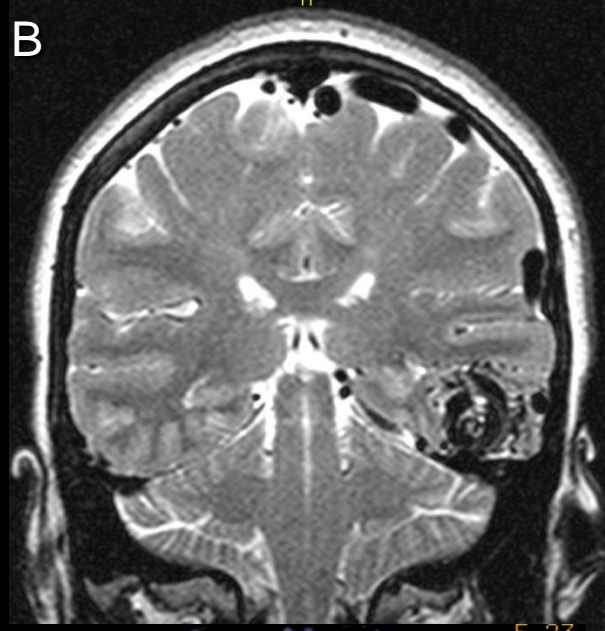
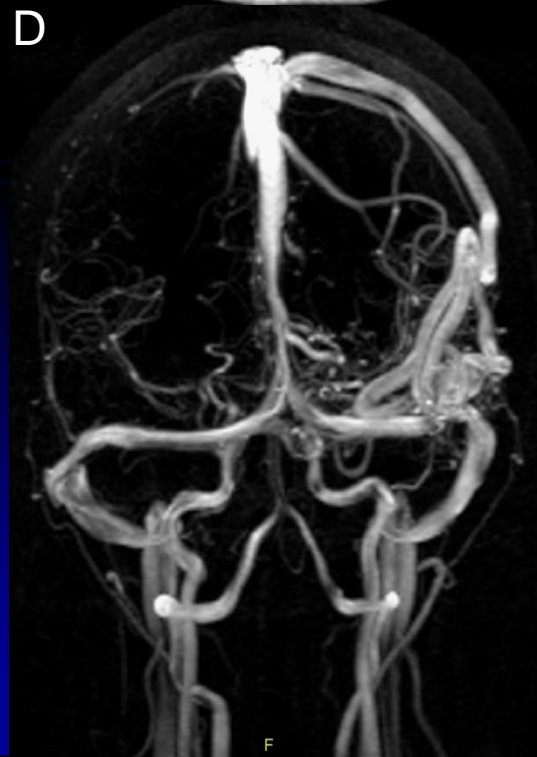
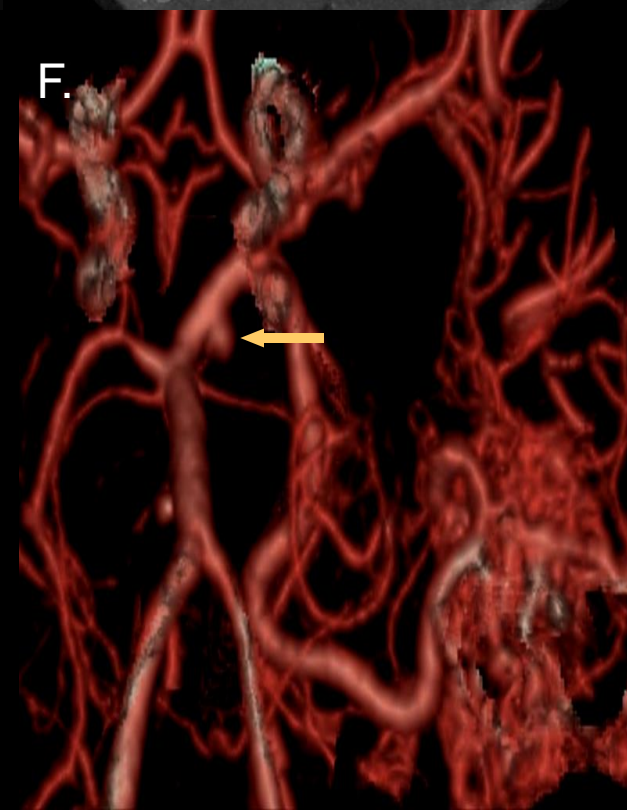
mm0,75;1/A,5sp
: 6.0
8:58 PM
727 L - 261

TPR

F 6
Dec 1

A 32-year-old woman with a 6 month history of intermittent disabling left frontal-orbital headaches and a normal exam



A**B****C****D****E****F**

F 23
ring Focus No out
C

EX: 11999
Se: 2 +c
Volume Rendering No cut

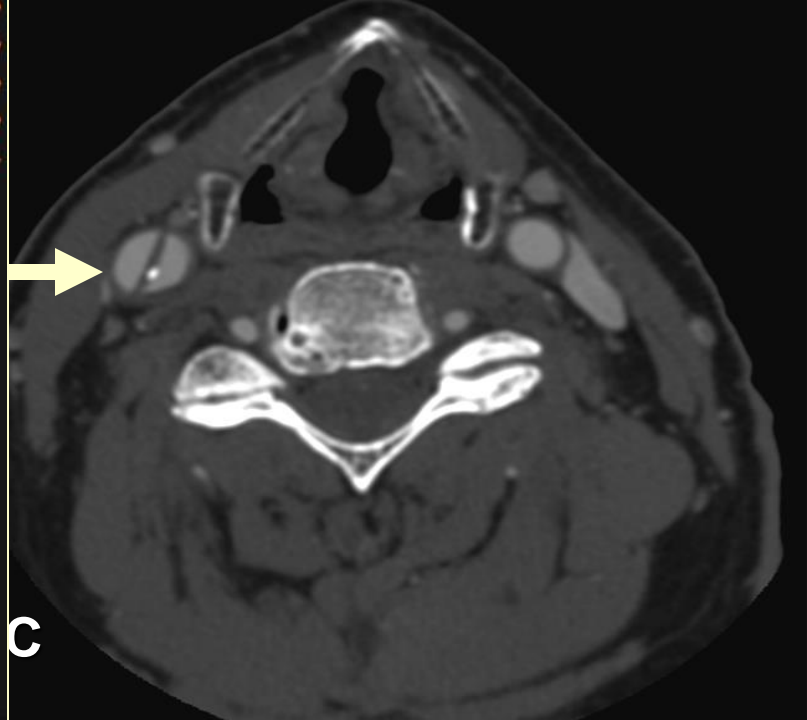
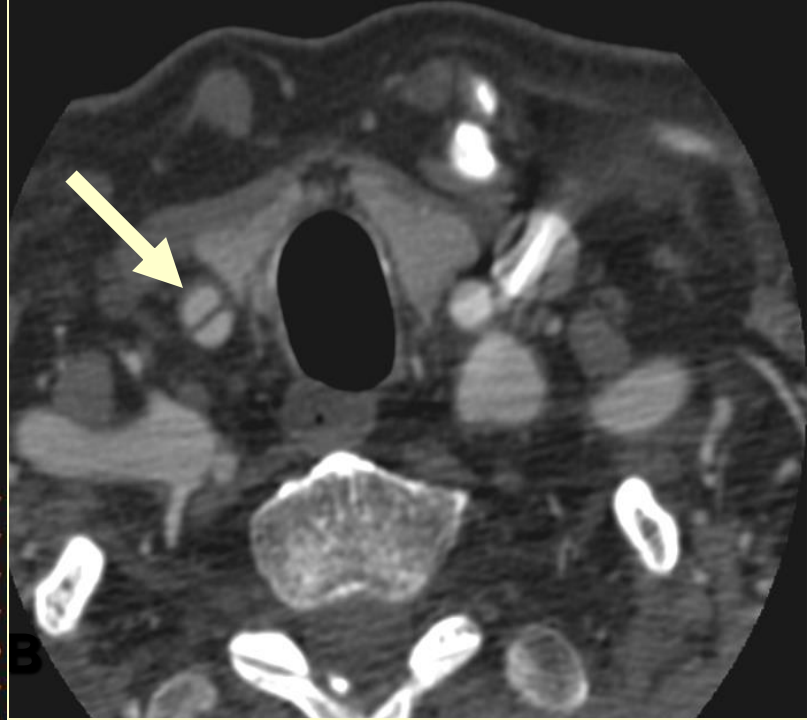
BECKER, HENRY
M 70 294803
Mar 16 2004

DFOW 20,5 cm
STANDARD
433/7

L
A
S

H
I
P

No VOI
kv 120
mA 315
1,4
1,2 mm 0,75:1/0,8sp
Tilt: -18.5
11:43:18 AM
W = 644 L = 324



Carotid / Vertebral Arterial Dissection

- Carotid: 3 / 100,000
- Vertebral 1.5 / 100,000
- 2% of all ischemic strokes
- 10-25% of ischemic strokes in young / middle-age patients
- Affects all ages; peak in 5th decade
- Male to female ratio 1.5:1

CVAD: Etiology

- Underlying arteriopathy (20%)
 - Ehlers-Danlos, Marfan's
- Fibromuscular dysplasia (15%)
- Minor trauma / hyperextension or rotation of neck
 - Yoga, coughing, vomiting, painting a ceiling, roller coasters
- Major trauma / sports injuries
- Chiropractic manipulations
 - 1 / 20,000
 - Chicken or the egg?

Carotid Dissection: Classic Triad

<u>Pain</u>	<u>Partial Horners</u>	<u>Cranial nerve palsy</u> 2-8%
<p>Unilateral neck 25%</p> <p>Unilateral facial/orbital 50%</p> <p>Headache 66%</p> <p>-<i>classic</i>: frontotemporal, gradual, constant, aching</p> <p>-<i>variant</i>: thunderclap, occipital, hemicranial, throbbing, sharp</p> <p>Pain precedes other sx by average of 4 days</p>	<p>“Oculosympathetic crisis”</p> <p><50%</p> <p>Miosis / ptosis</p> <p>-anhidrosis absent as facial sweat glands innervated by sympathetic plexus on external carotid artery</p>	<p>TIA</p> <p>Amaurosis fugax</p> <p>Unheralded ischemic stroke in 20%</p> <p>Blindness from ischemic optic neuropathy <u>Ischemia</u></p> <p>50 – 95%</p> <p>rare</p>

Vertebral Dissection: Presentation

Initial manifestations less distinct than carotid dissection, often attributed to musculoskeletal pain

Local symptoms

- **Neck pain (50%)**
 - Precedes other sx by 2 wks
- **Headache (66%)**
 - Non-specific in nature
 - Precedes other sx by 15 hrs
- **Radicular pain**

Ischemic Symptoms

- **>90% of all patients**
- **Brainstem, thalamic, cerebral or cerebellar infarcts**
- **TIAs less common**

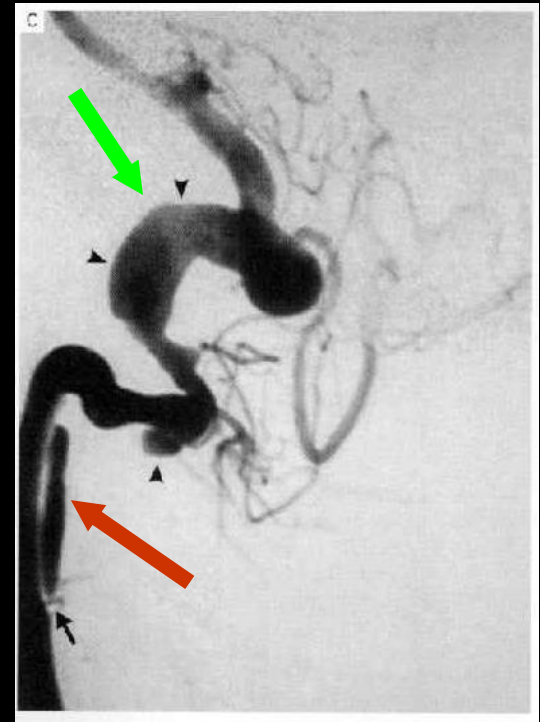
CVAD: Conventional Angiography



Carotid occlusion

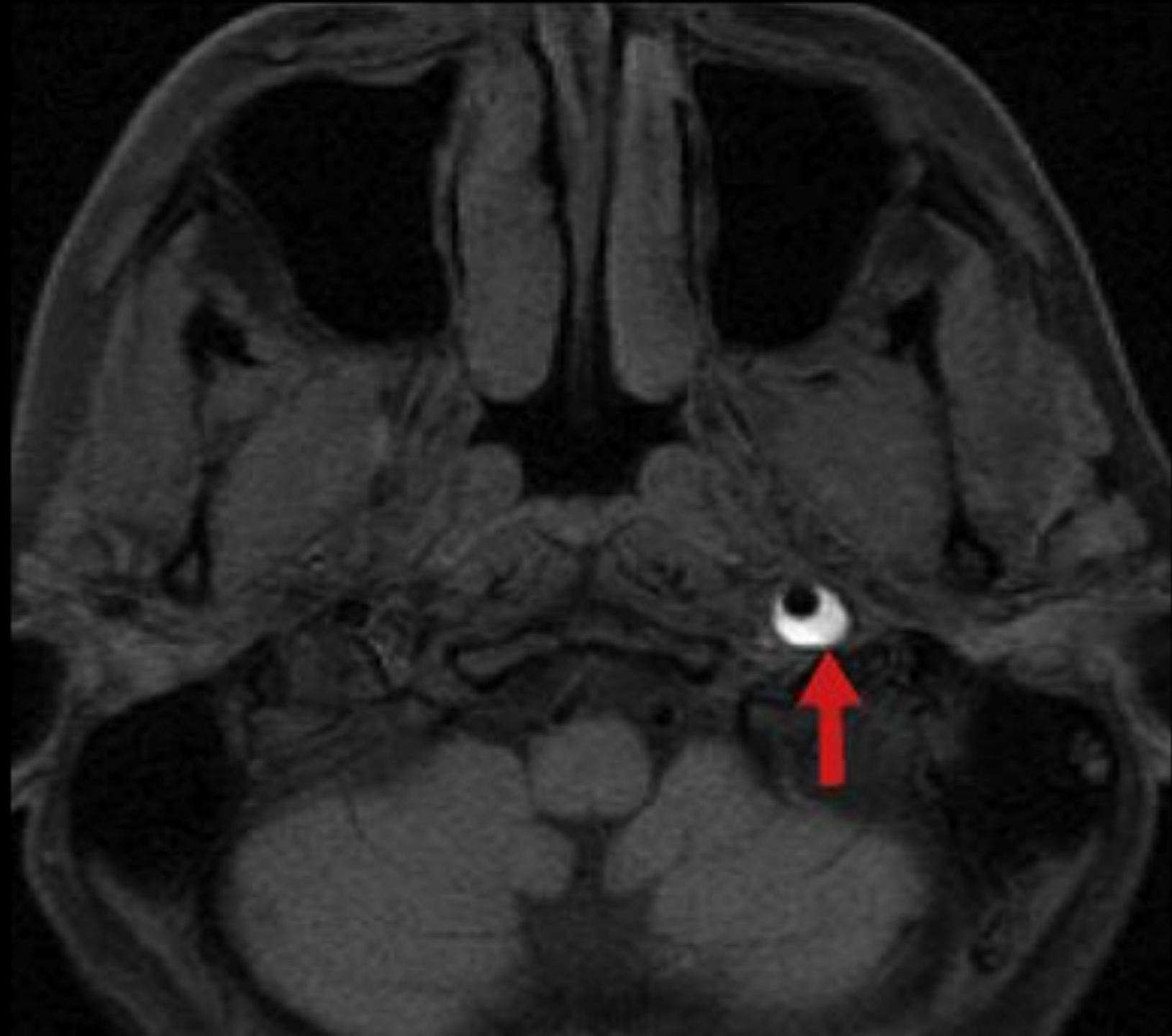


Carotid aneurysm



Vertebral double lumen

Vertebral aneurysm

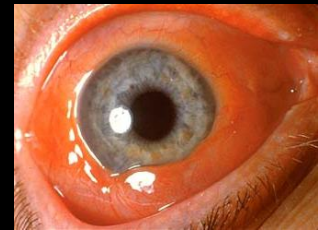


Cerebral Venous Thrombosis (CVT)


- Incidence difficult to estimate
 - $\approx 8 / 1,000,000$ general population
 - $11.6 / 100,000$ deliveries
- Female $>$ male (1.3 : 1)
- 3rd – 4th decade

CVT: Signs

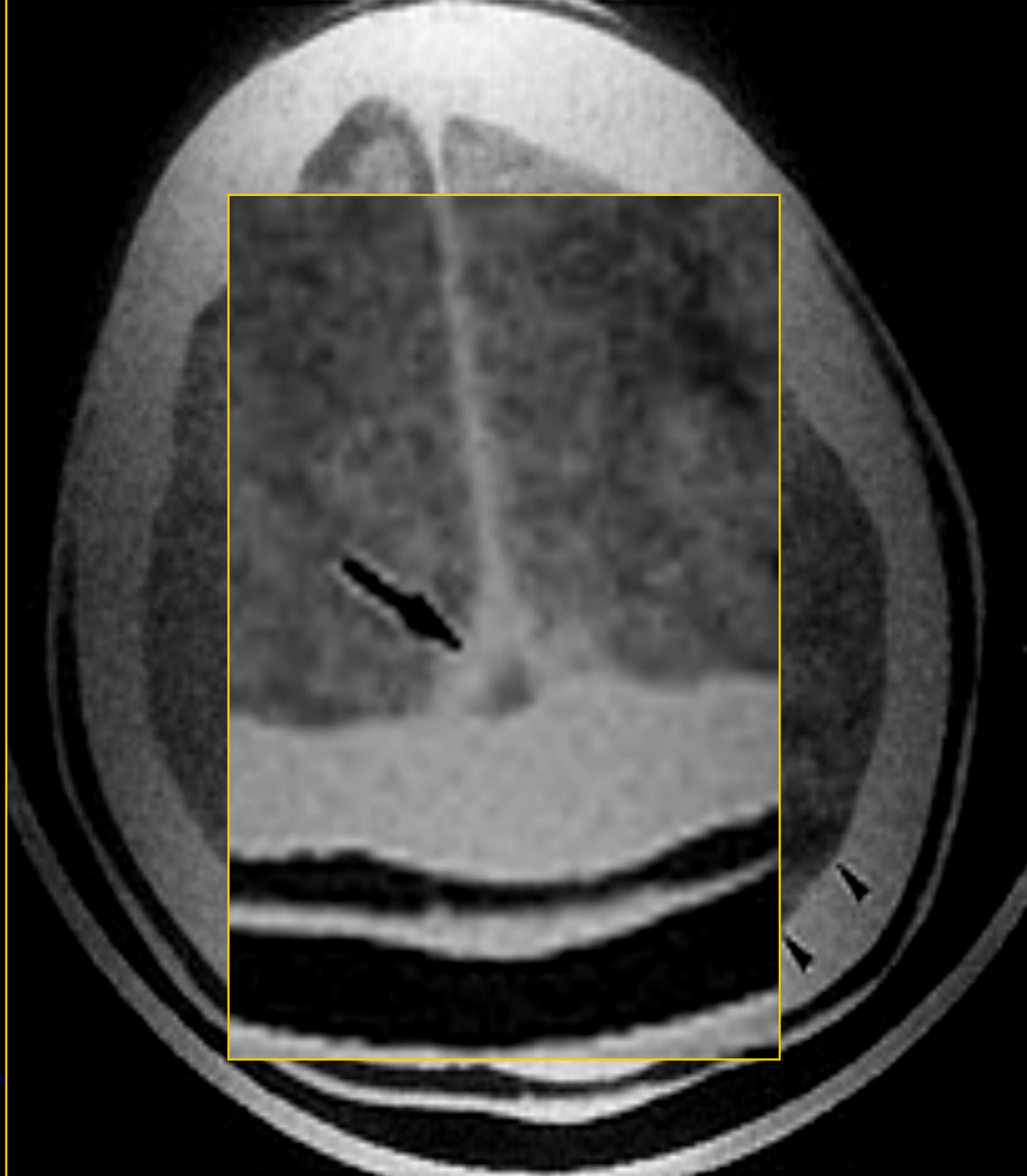
- Papilledema
- Focal motor / sensory deficit
- Seizure
- Ocular findings
 - Chemosis, proptosis, painful ophthalmoplegia
- Cranial nerve deficits
 - Cavernous sinus: 3, 4, 5, 6
 - Transverse sinus: 9, 10, 11
 - Sagittal sinus: field cuts and lower extremity monoplegia



CVT: Symptoms

- Headache present in 75-95%
 - Tremendous range of headache description
 - Classic: persistent, slowly progressive, retro-orbital
 - Variations: thunderclap, diffuse
 - Associated Symptoms
 - Any type of focal neurological deficits
 - Seizures
 - Altered mental status
- 

CVT: Empty Delta Sign

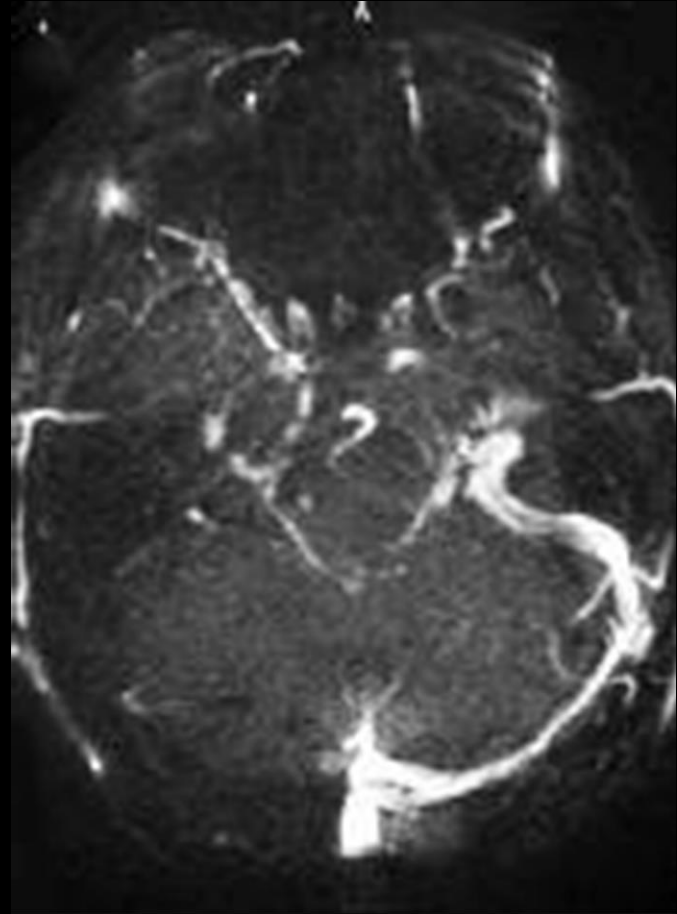


Sagittal Sinus Thrombosis & Infarct



Magnetic Resonance Venography

- Absent flow in
 - Right transverse sinus
 - Sigmoid sinus
 - Internal jugular vein

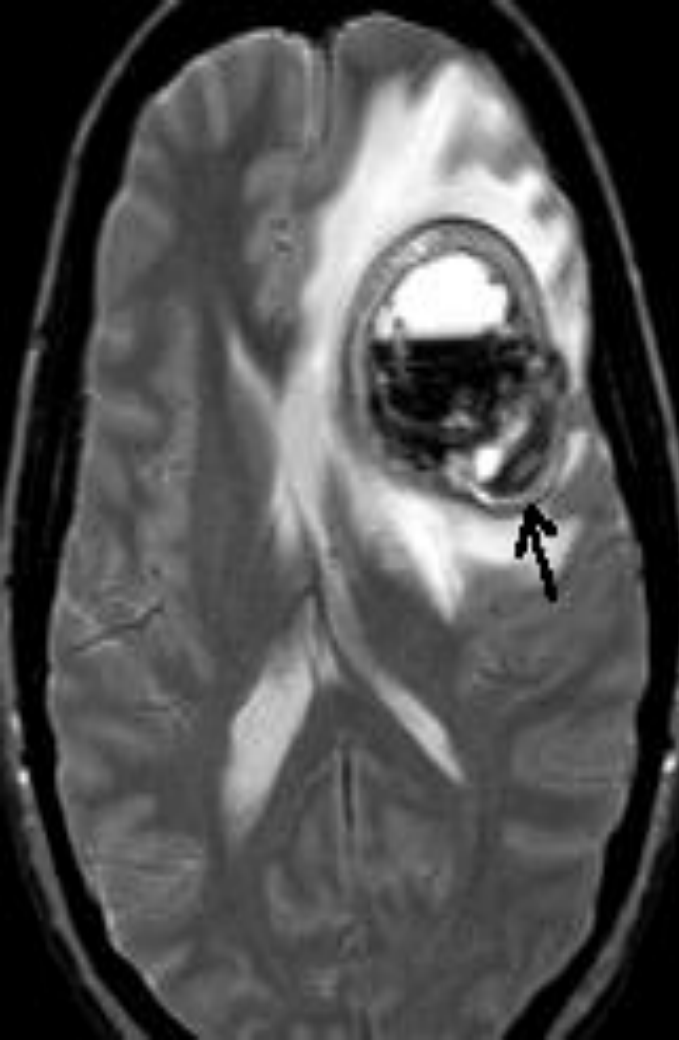


Recommended Routine Use of Gadolinium in Patients With Headache

- ◁ Patients with abnormal neurologic examination
- ◁ Patients with positional headaches
- ◁ Patients with exertional or Valsalva maneuver–exacerbated headaches
- ◁ Patients with cluster or neuralgia-type headaches or facial pain
- ◁ Patients with known history of cancer, AIDS, or infectious disease

INTRACRANIAL NEOPLASMS

- Headache present in 50%
- Worst symptom in 45%
- 77% tension type, Migraine-like 9%
- Pediatric > adult
- Classic Triad- sleep poor, severe pain and N/V occur in one-third of pts
- Focal neurologic deficit
- Seizure
- Posterior fossa mass- referred to occiput



T2W

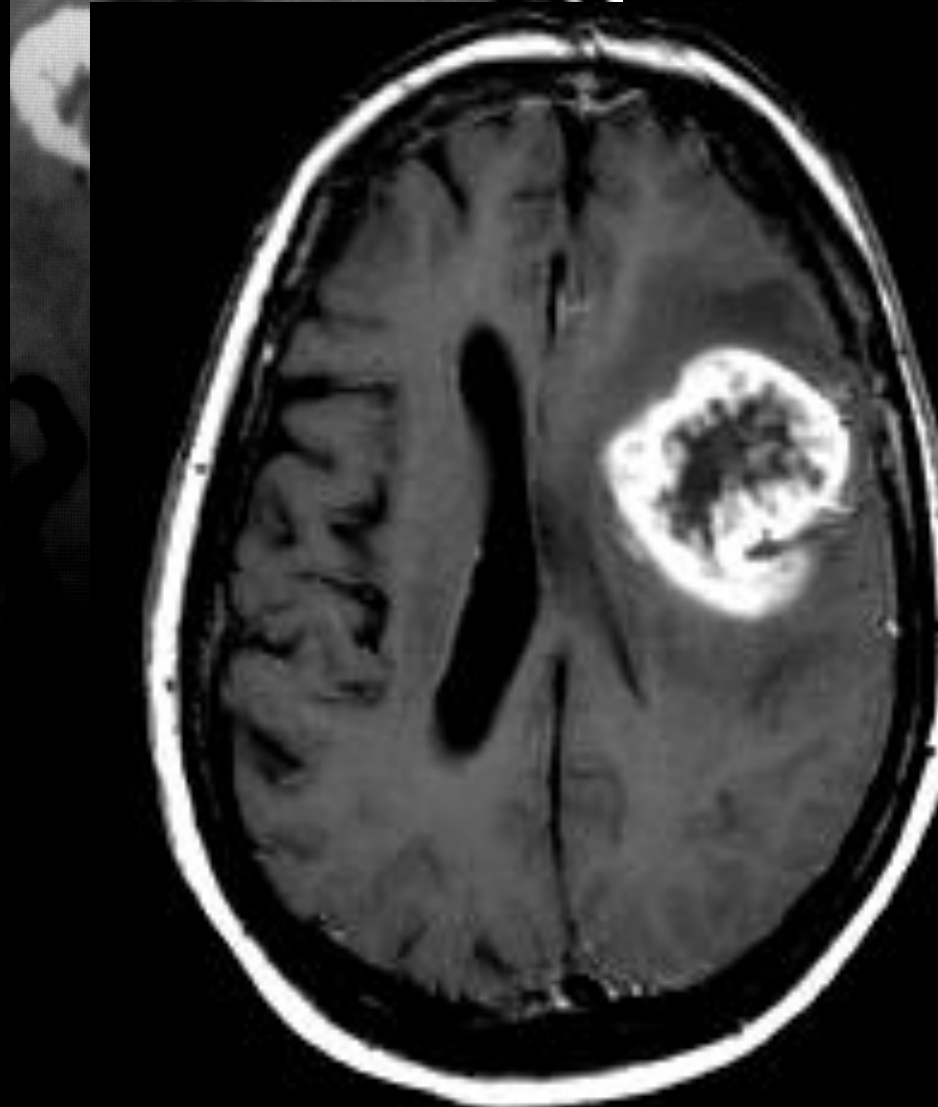


T1W non-contrast

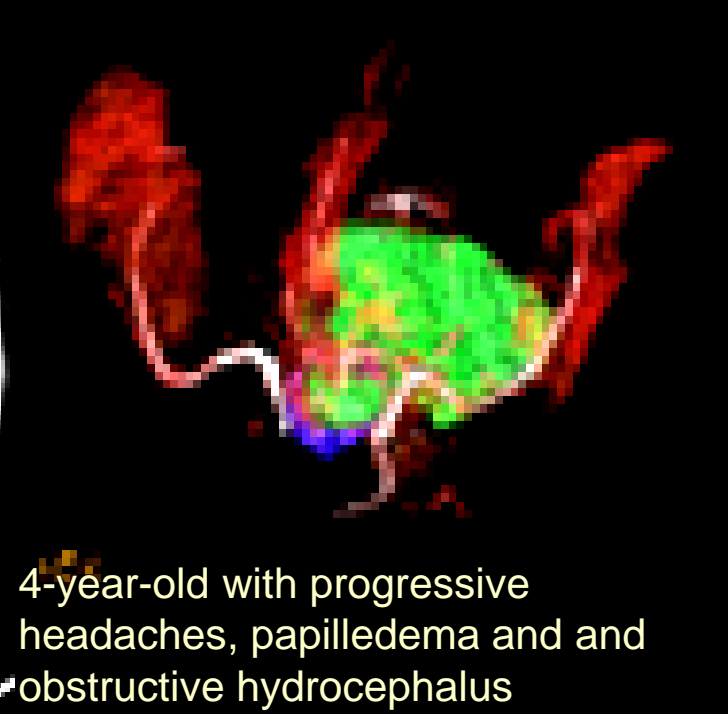
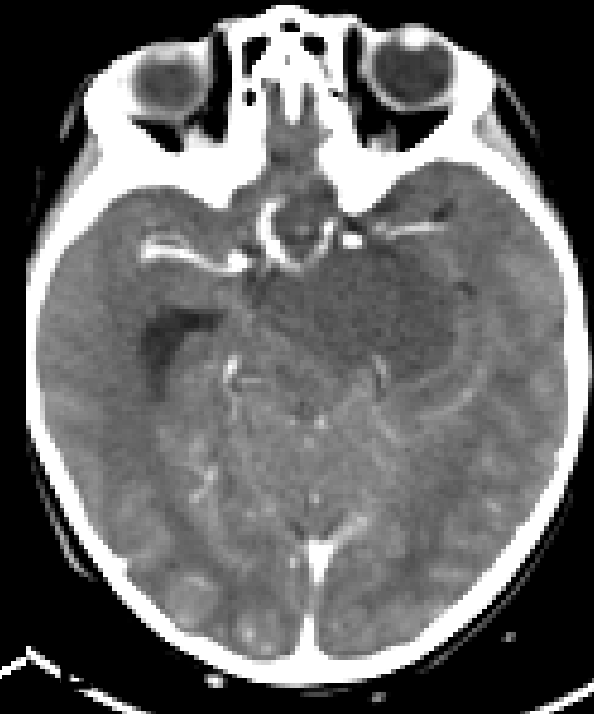
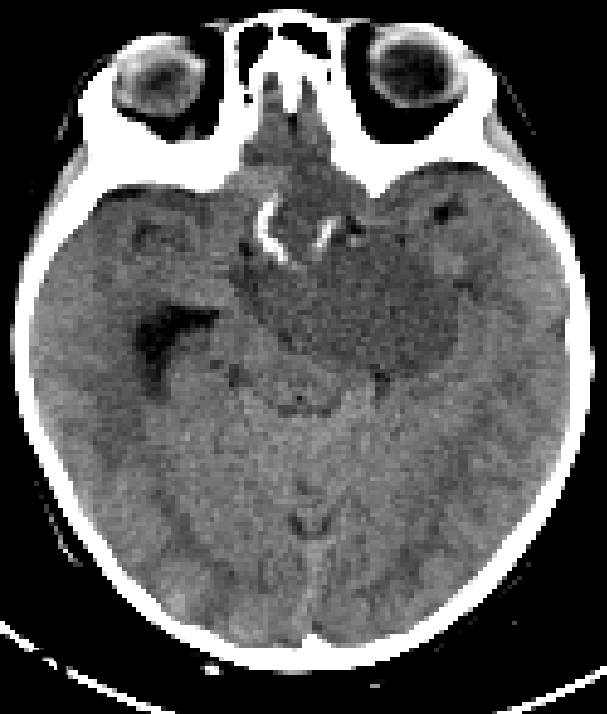
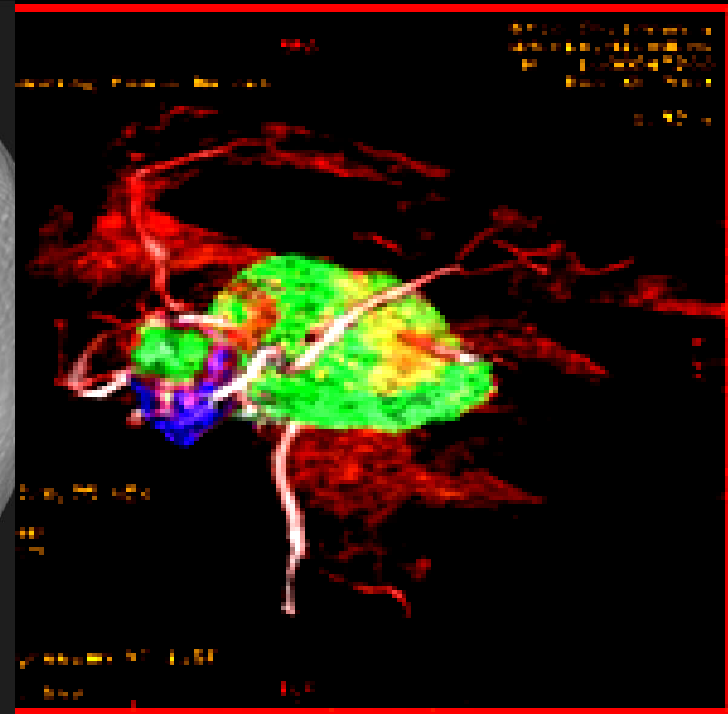
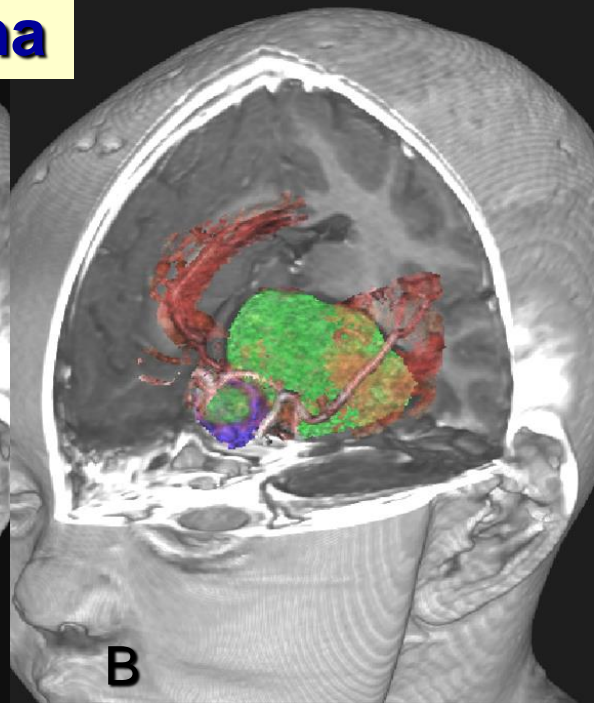
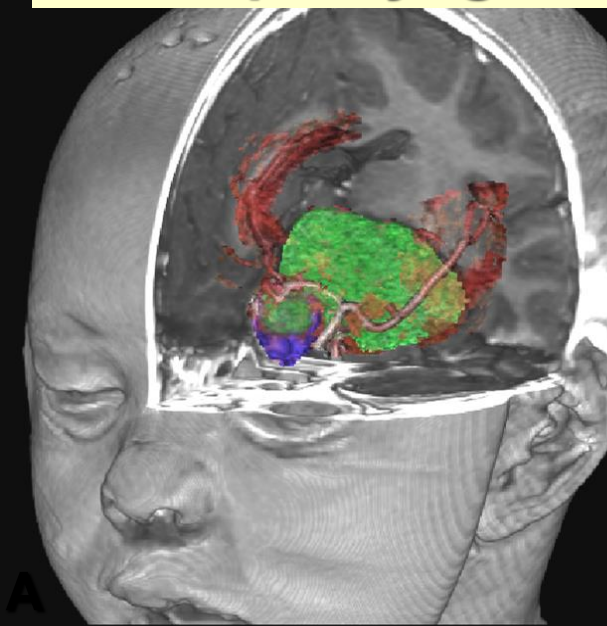


T1W contrast

Glioblastoma Multiforme

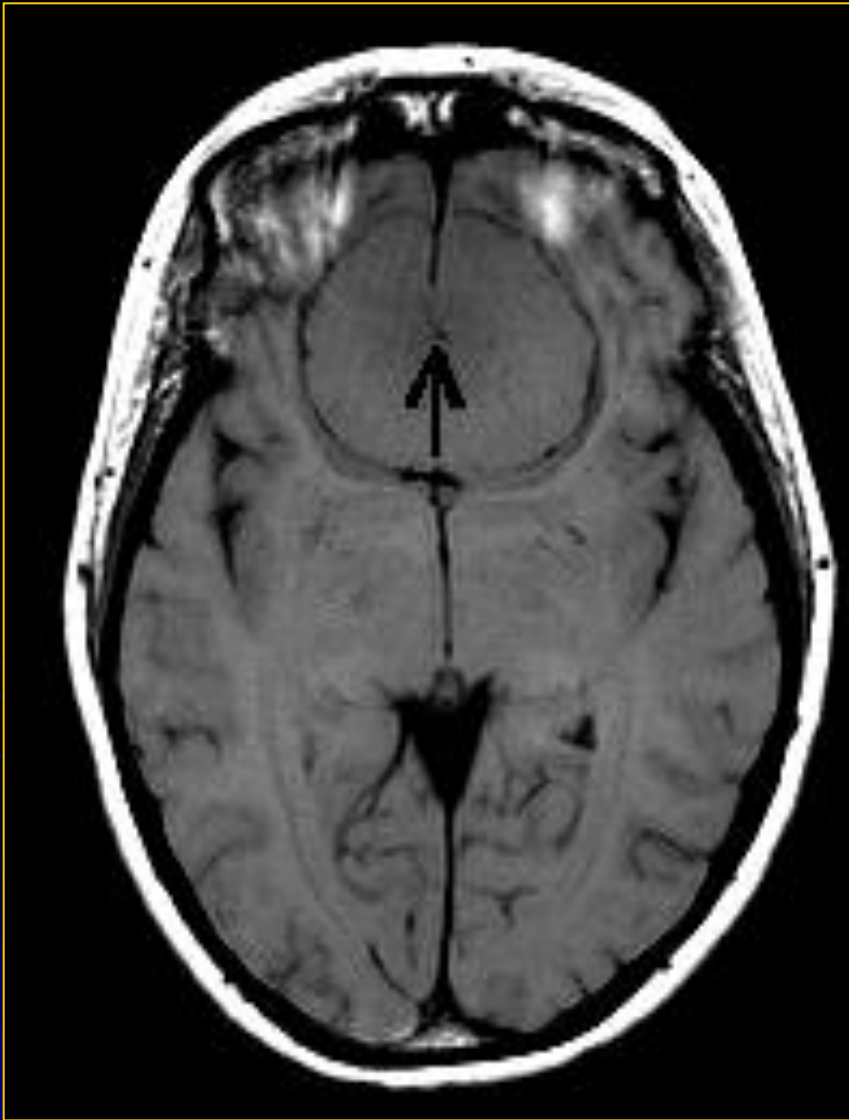


craniopharyngioma

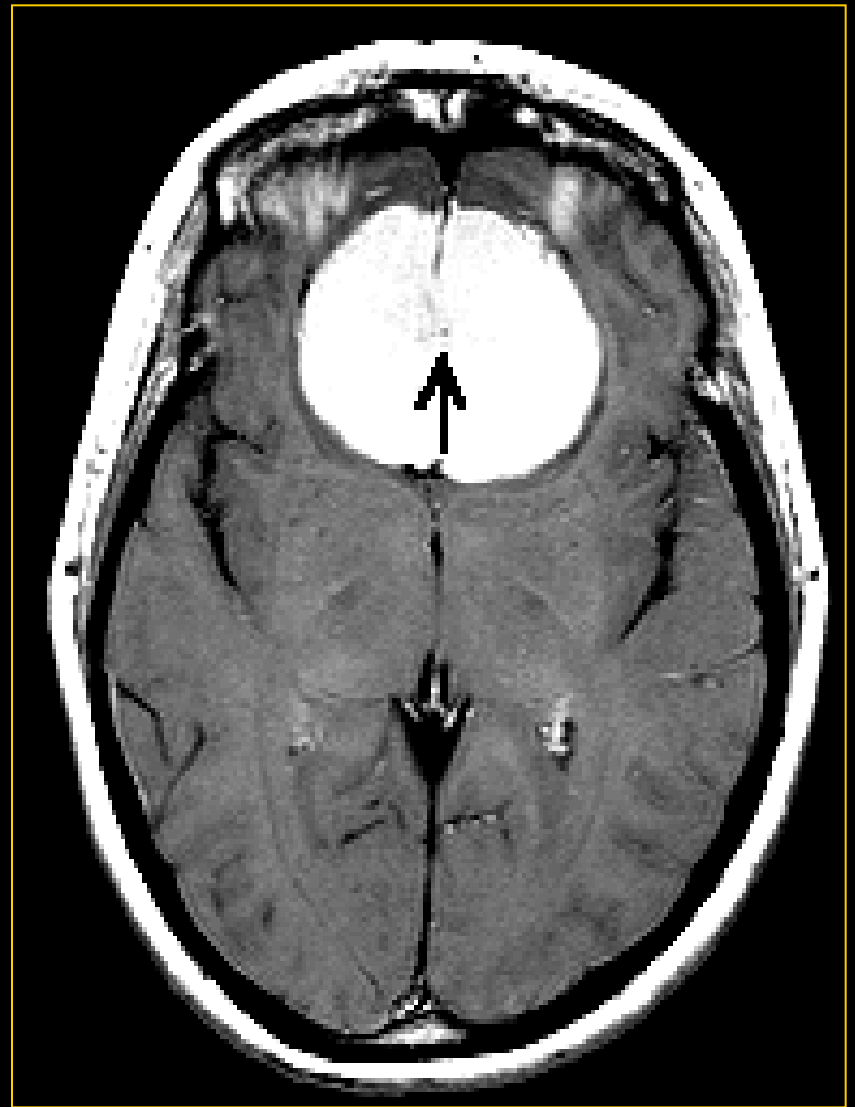


4-year-old with progressive headaches, papilledema and obstructive hydrocephalus

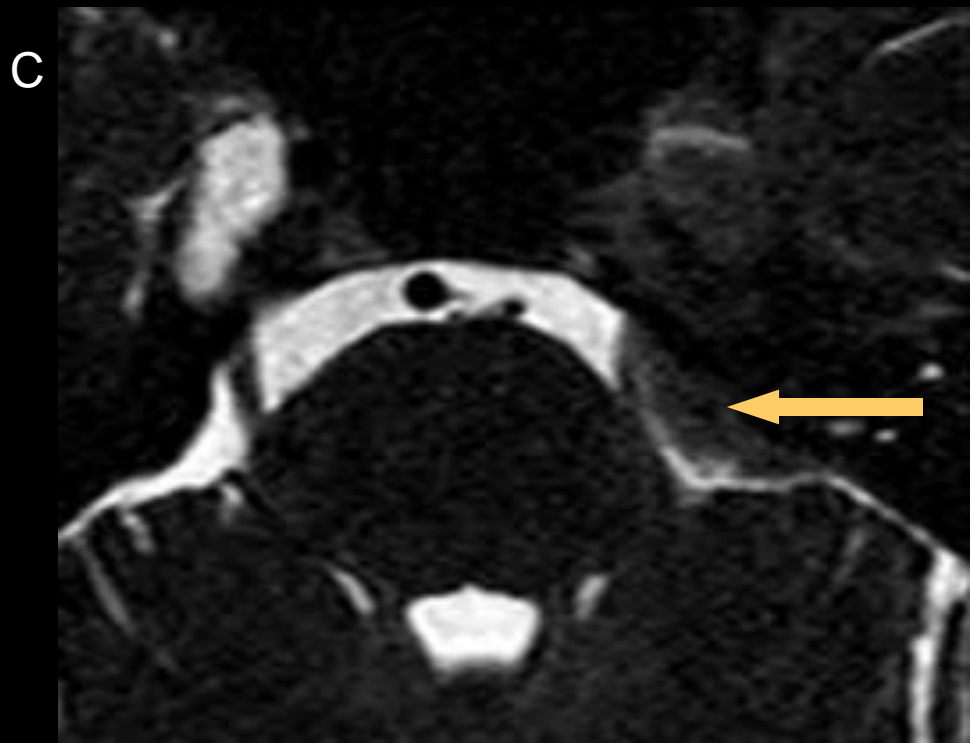
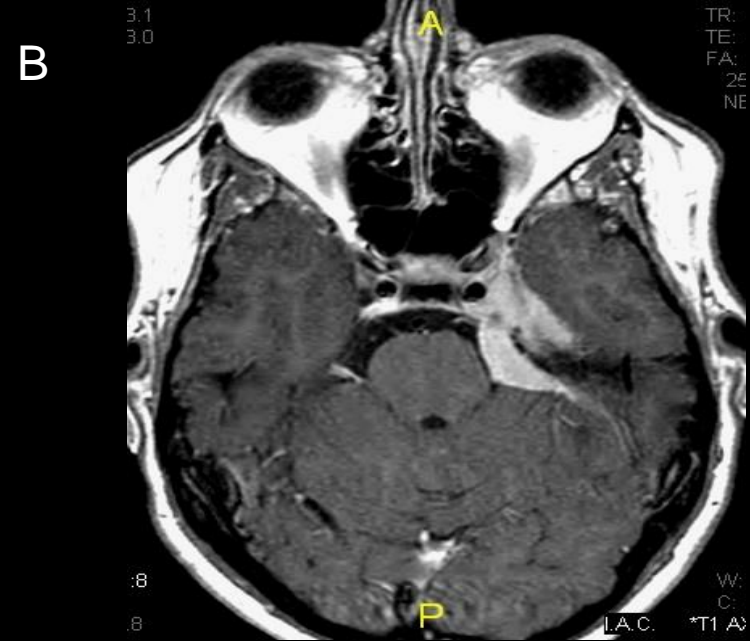
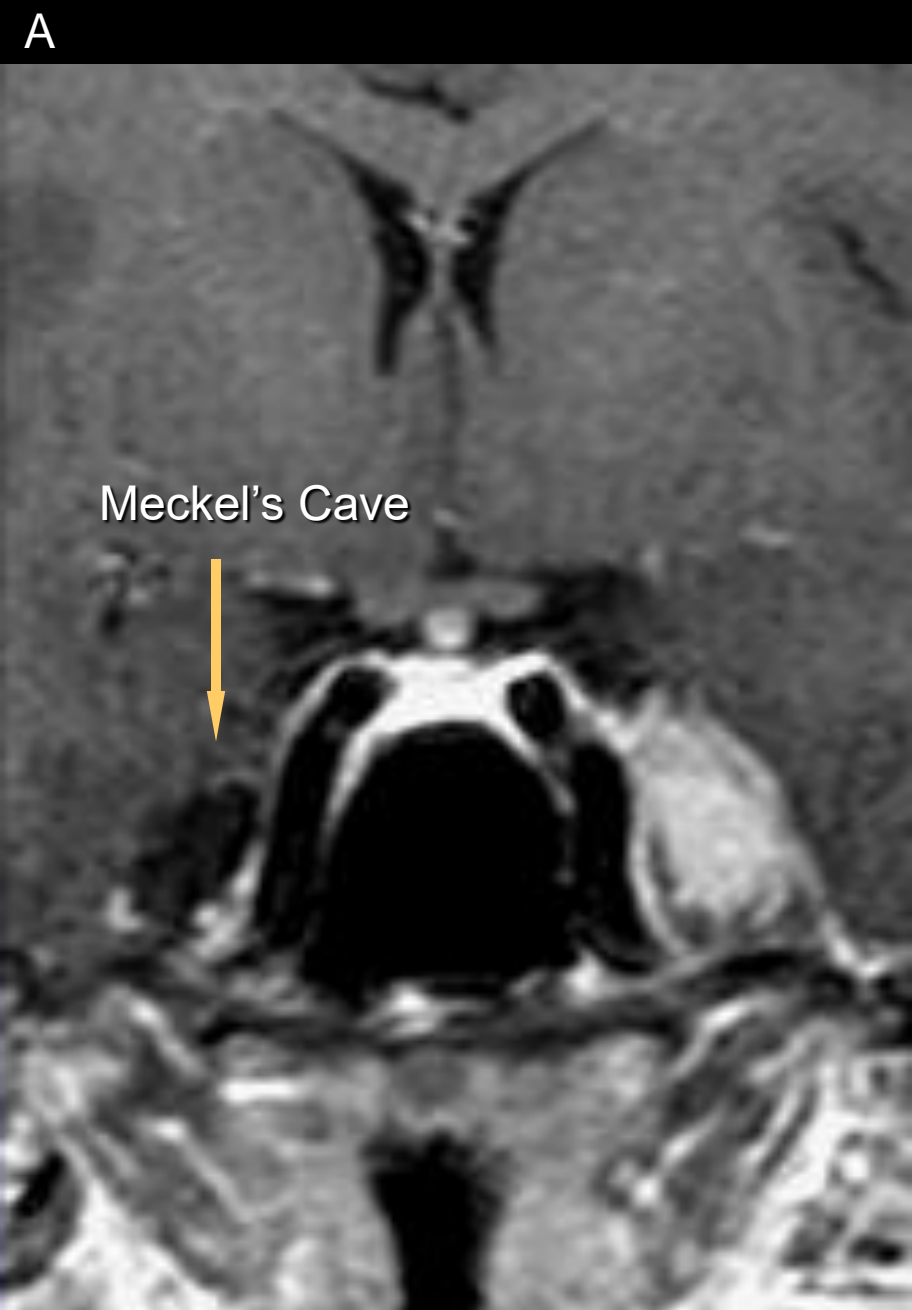
Meningioma



T1-non

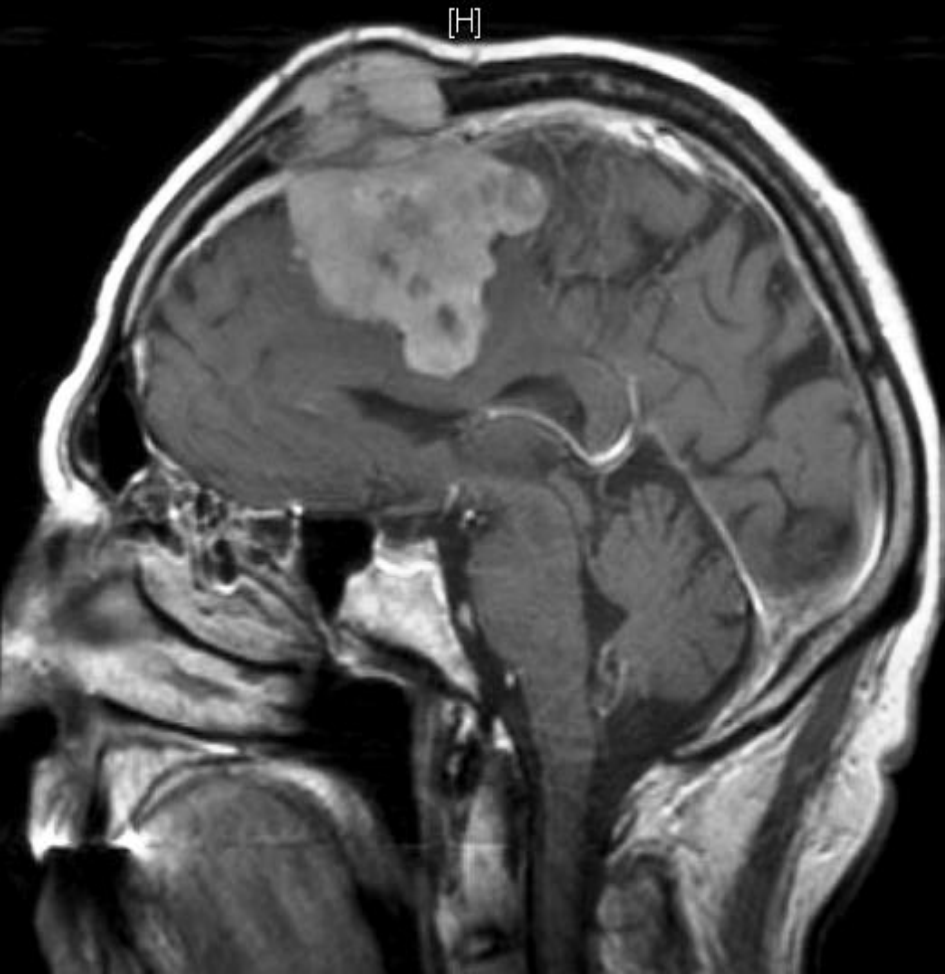


T1-gad



“Trigeminal Neuralgia”

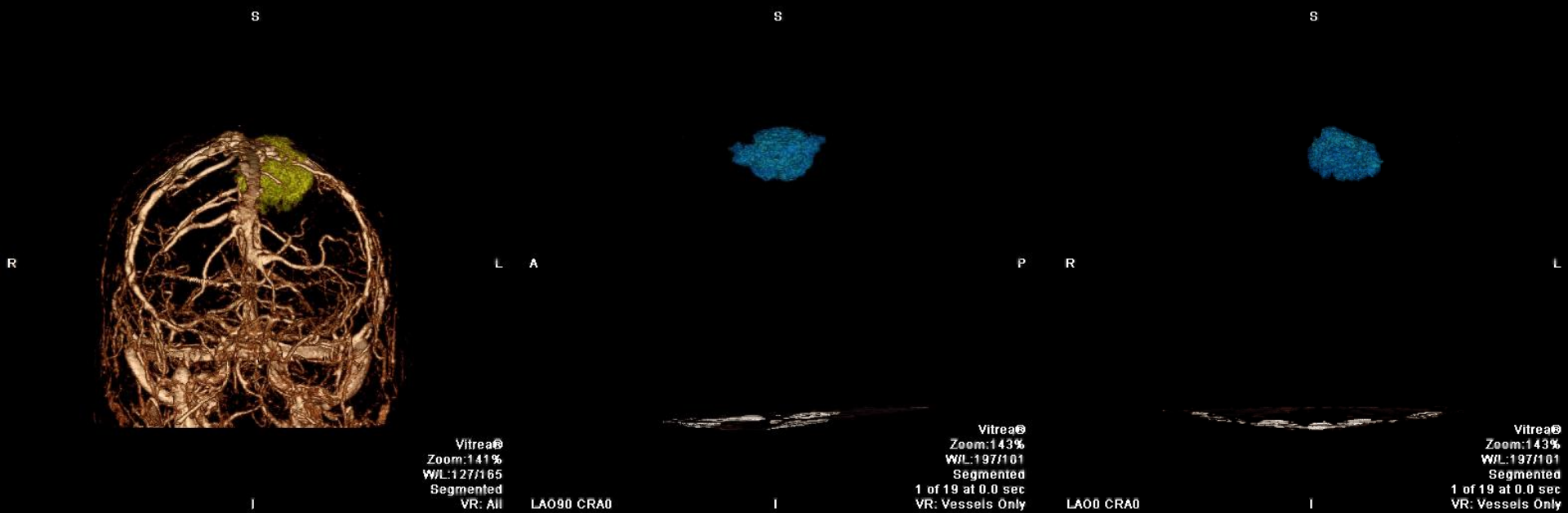
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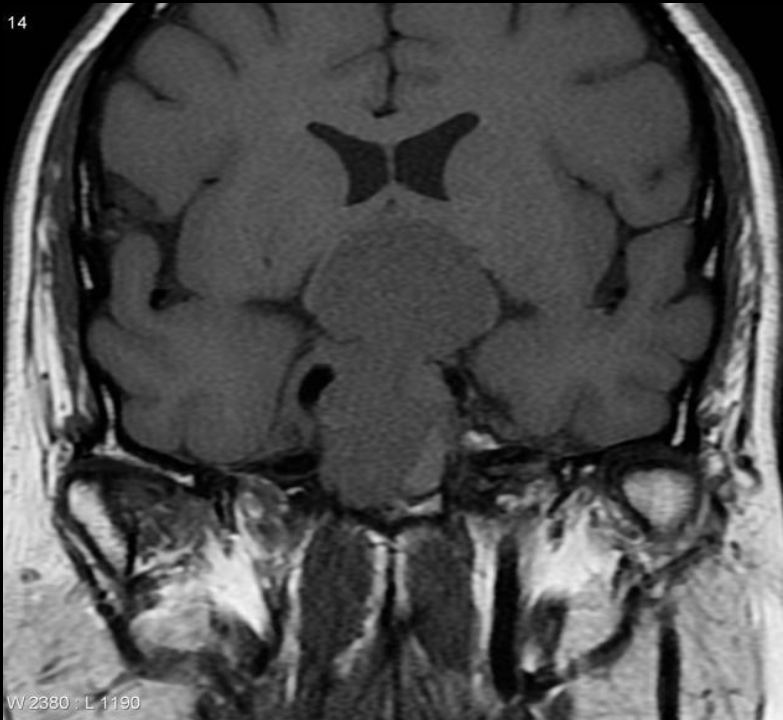
B



Meningioma

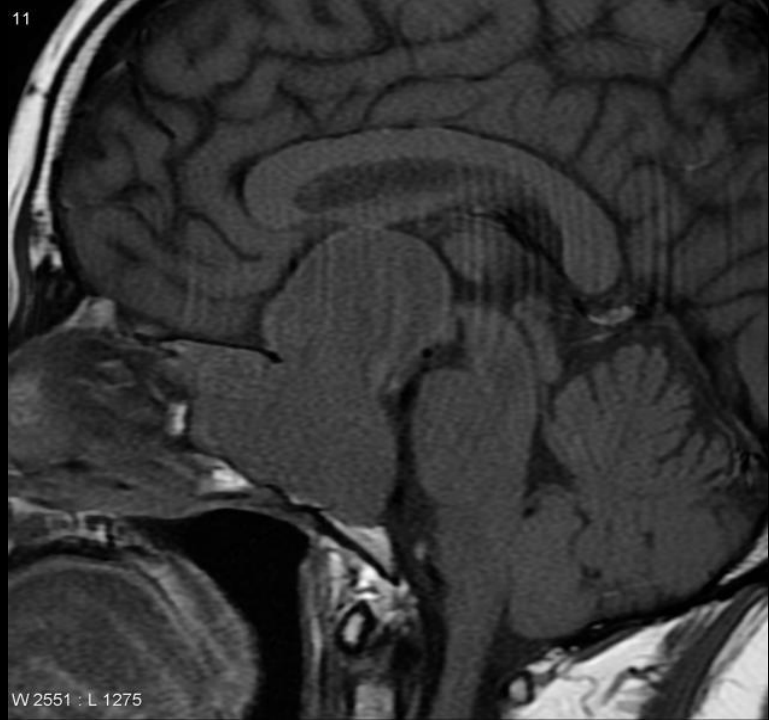


14

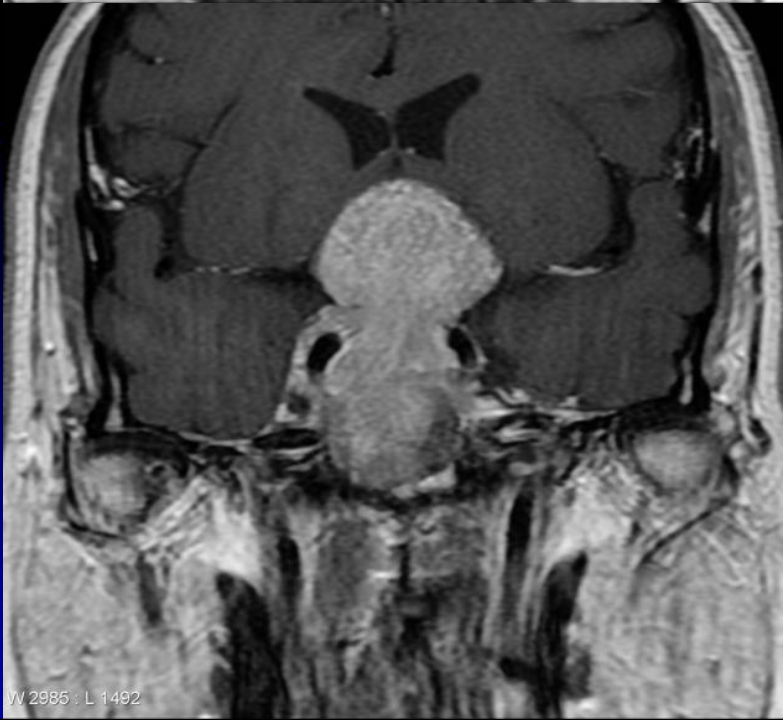


W2380 · L 1190

11

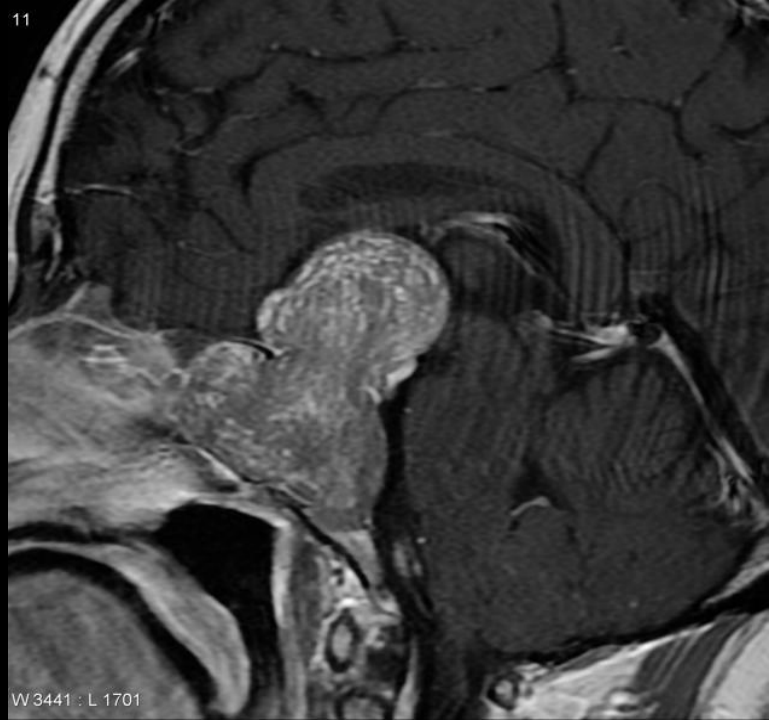


W 2551 · L 1275



W 2985 · L 1492

11



W 3441 · L 1701

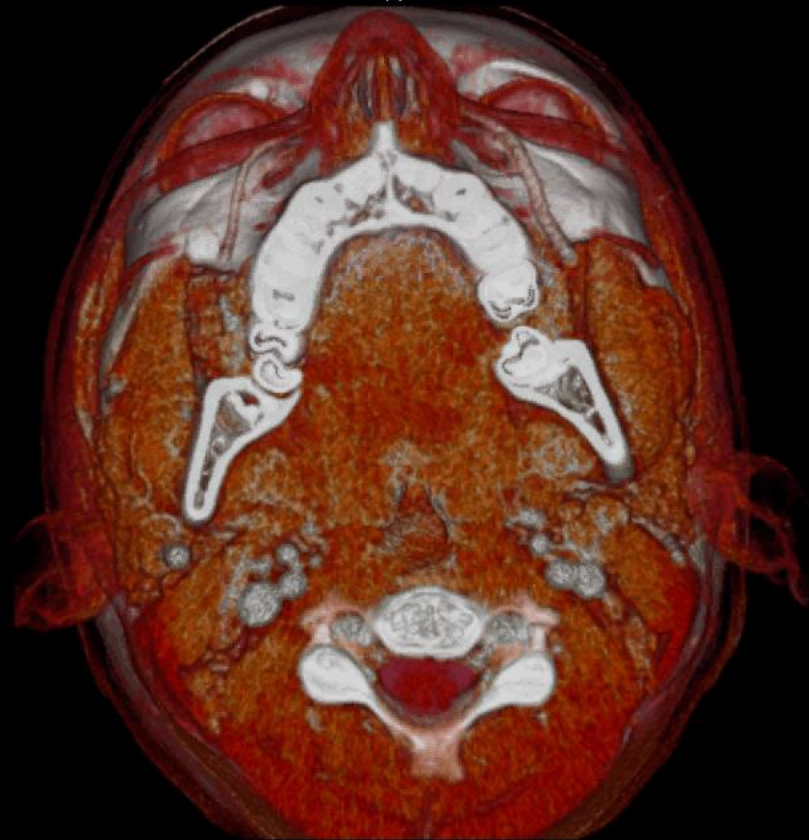
Skull Base Mass - Ped

S



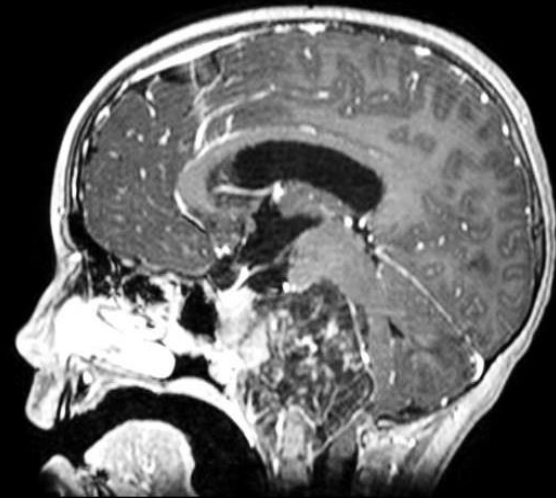
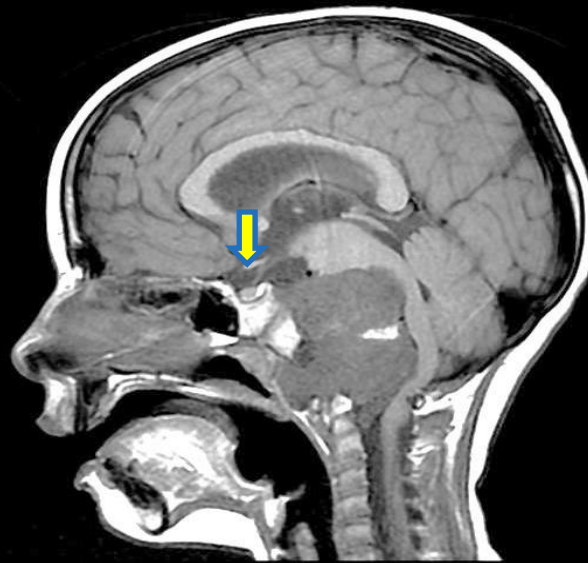
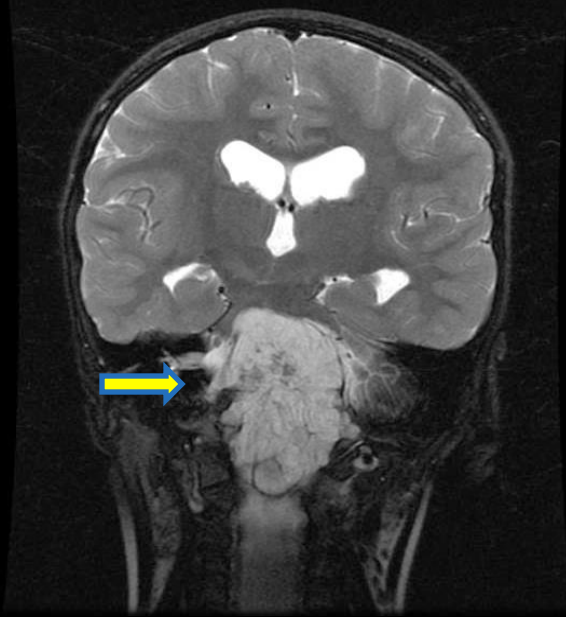
R

A

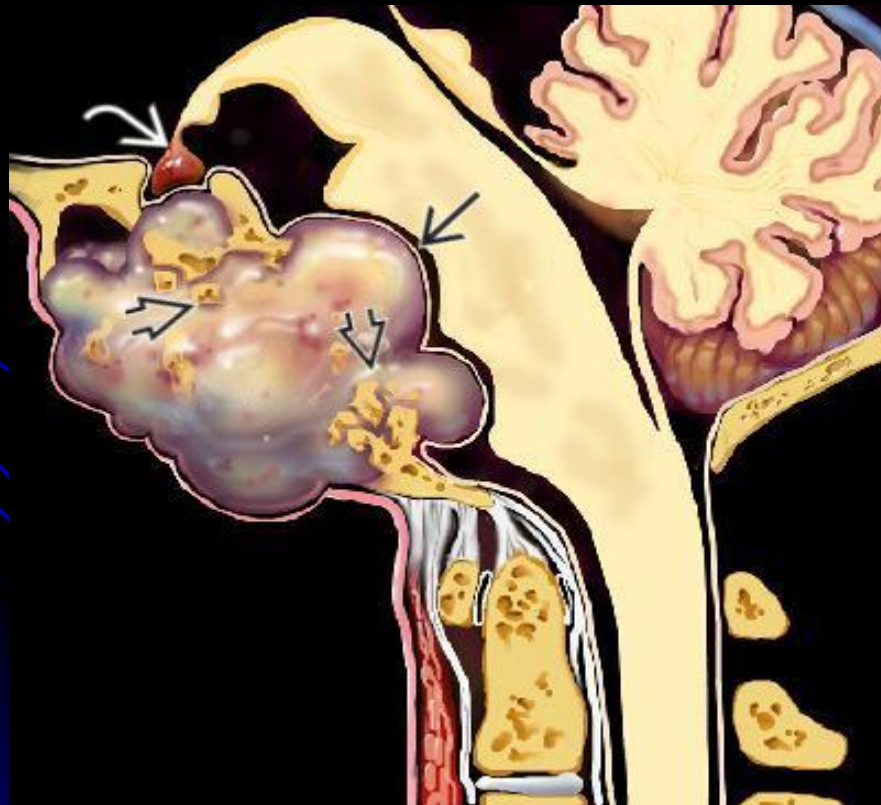


L R

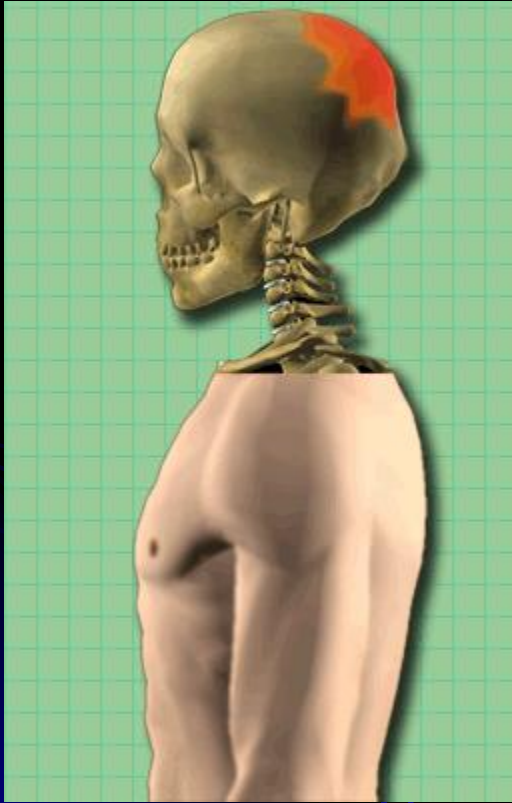
L



Chordoma



Vertex Headache Exacerbated by Neck Flexion



Furthermore.....

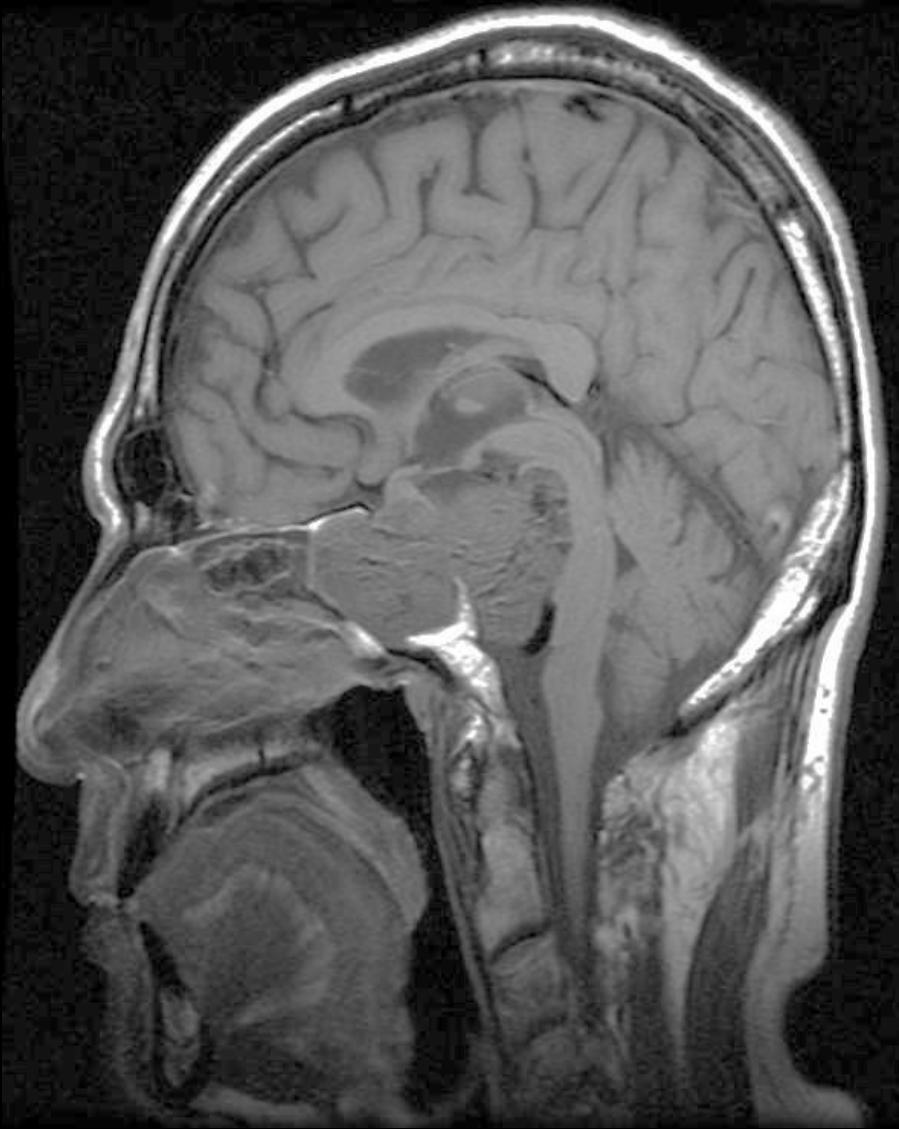
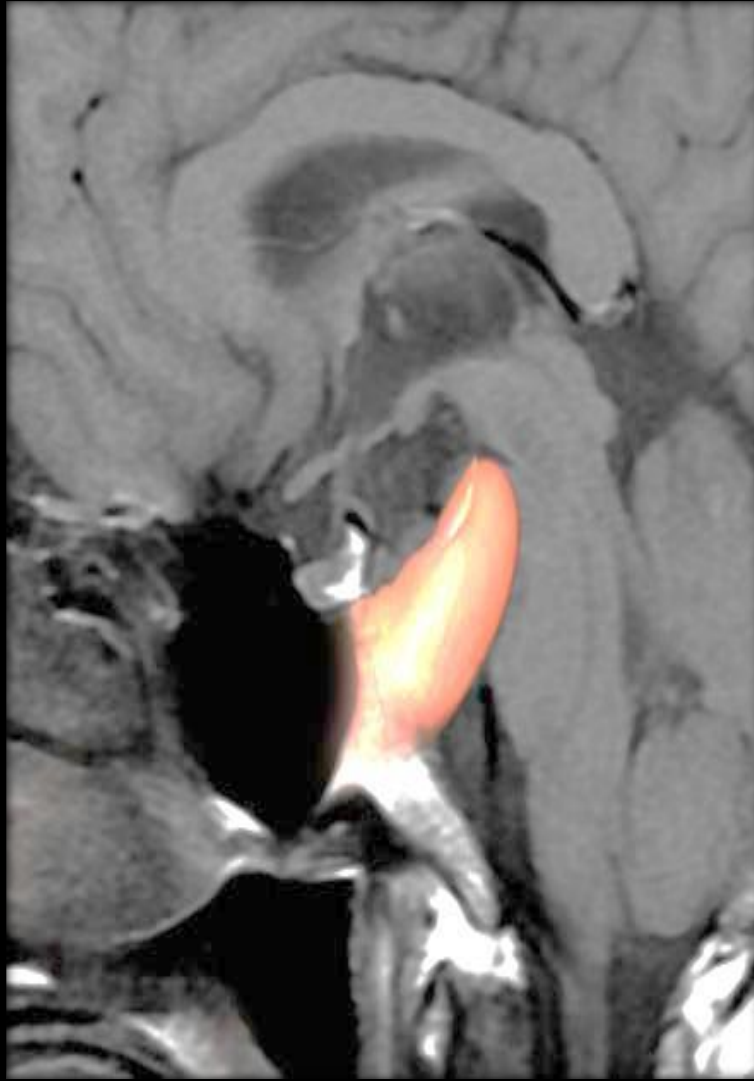
Abducens palsy (diplopia)

Bilateral cranial neuropathies (VI-XII)

Brainstem signs

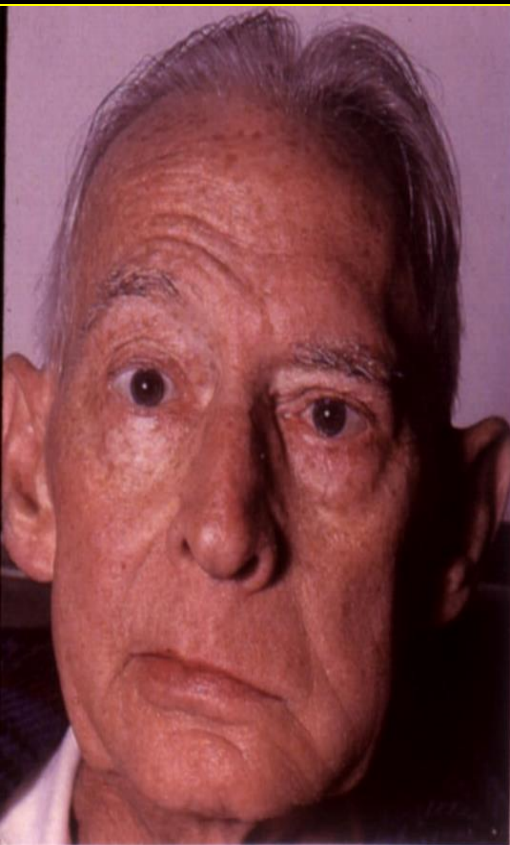
!!!! Prudent to stabilize the neck before undergoing neuroimaging !!!!

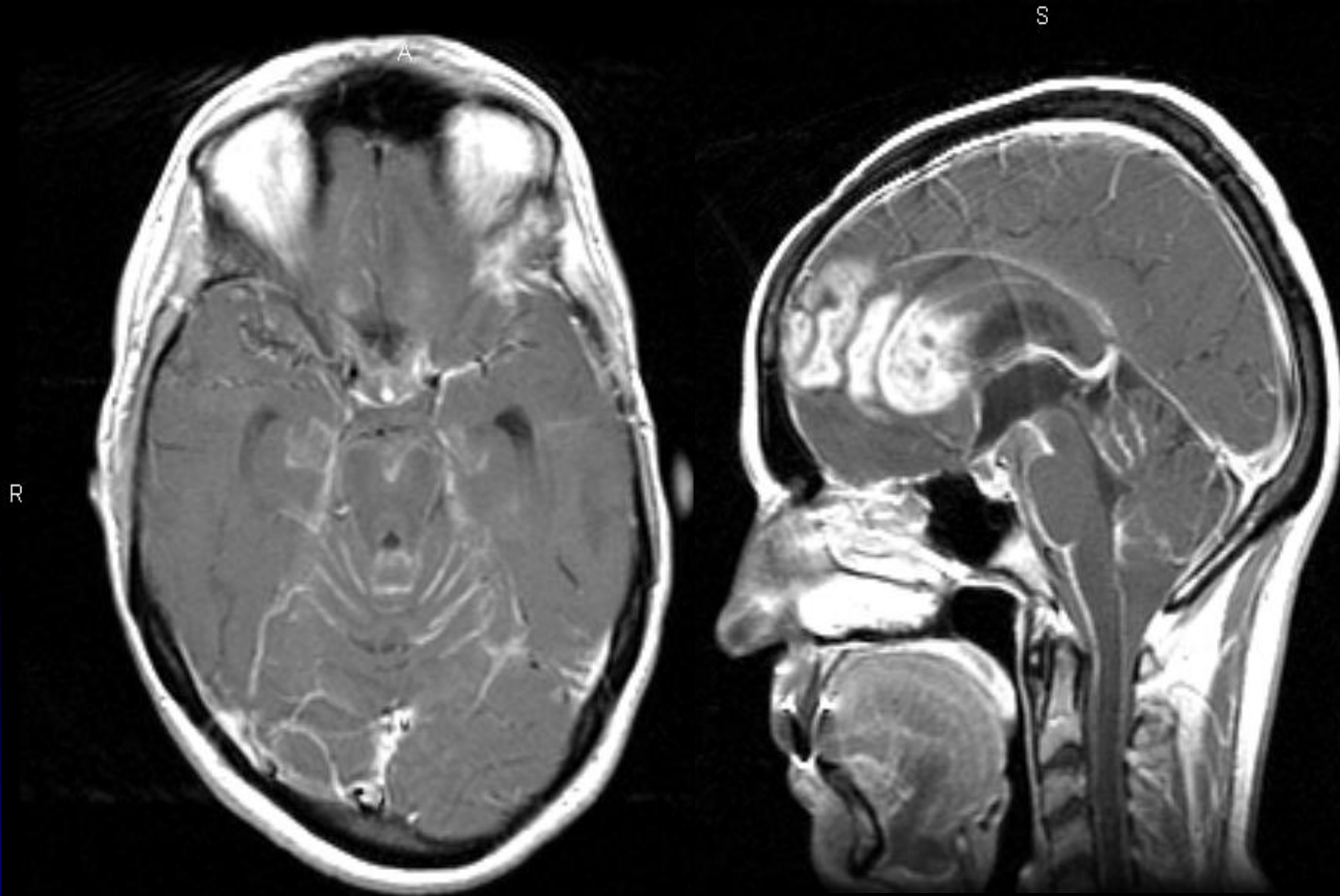
“Thumb sign”



Chordoma

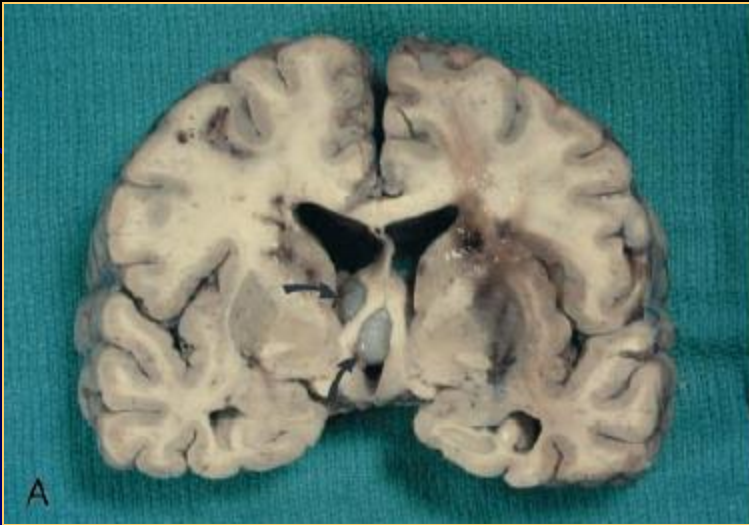
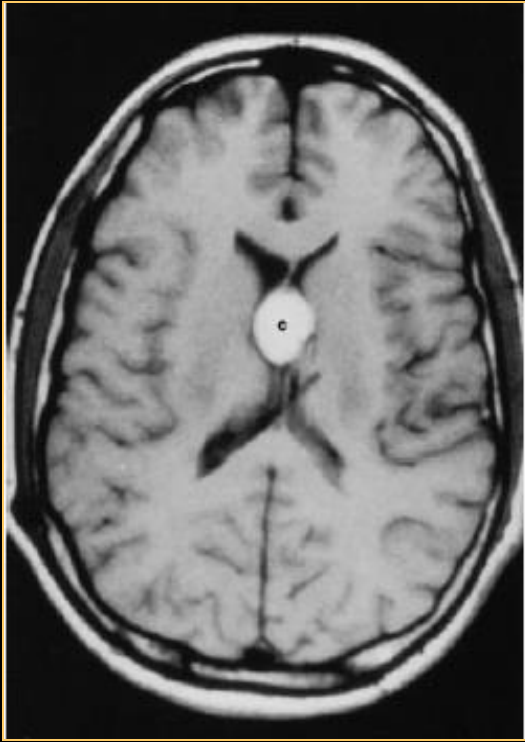
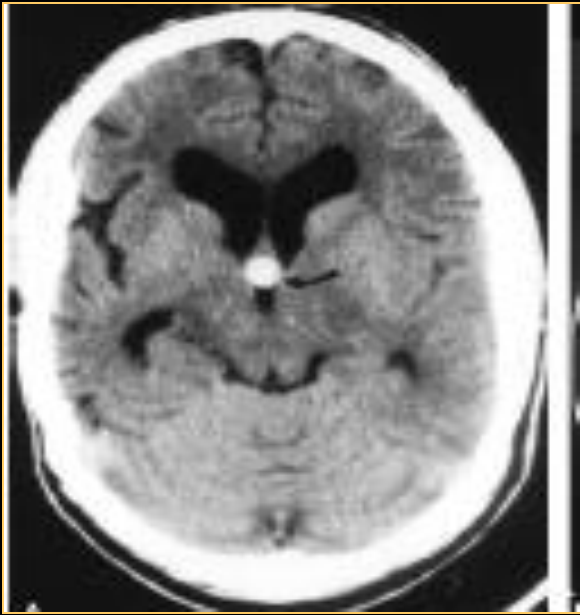
Leptomeningeal Disease

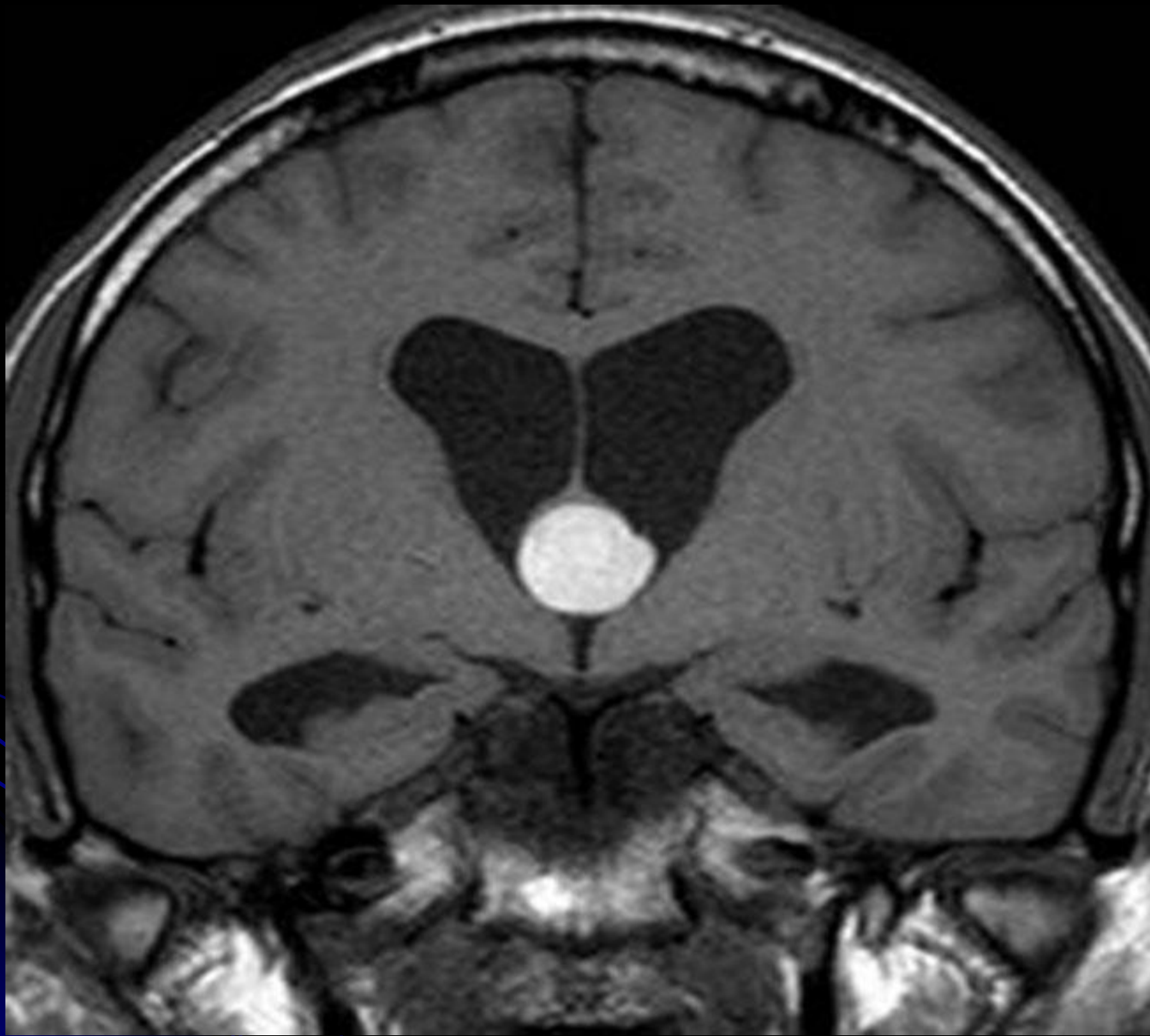


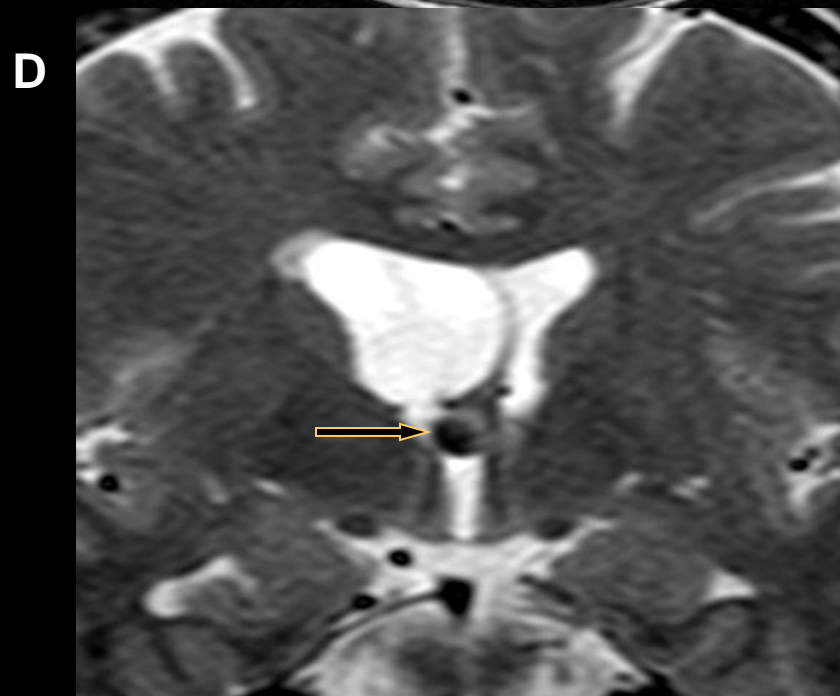
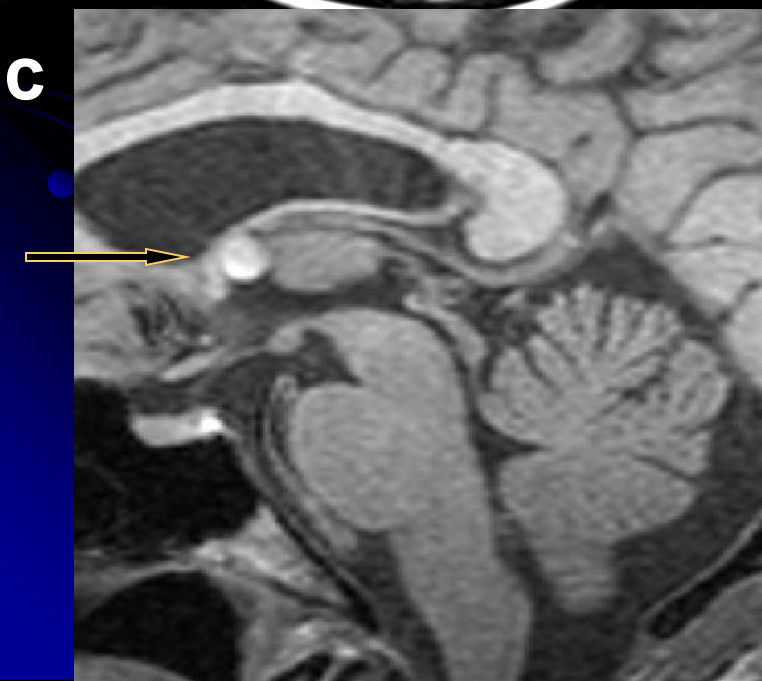
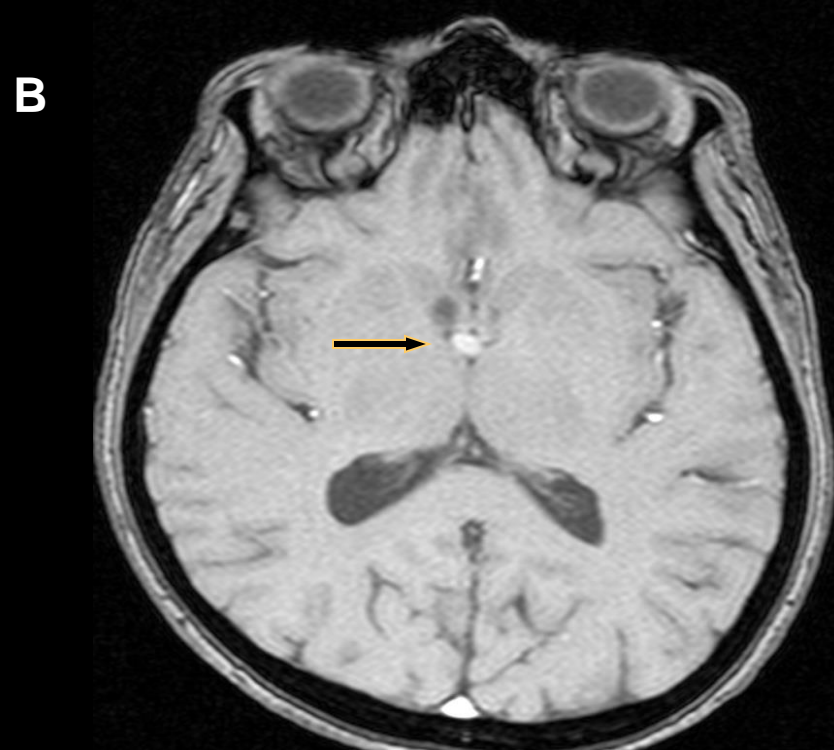
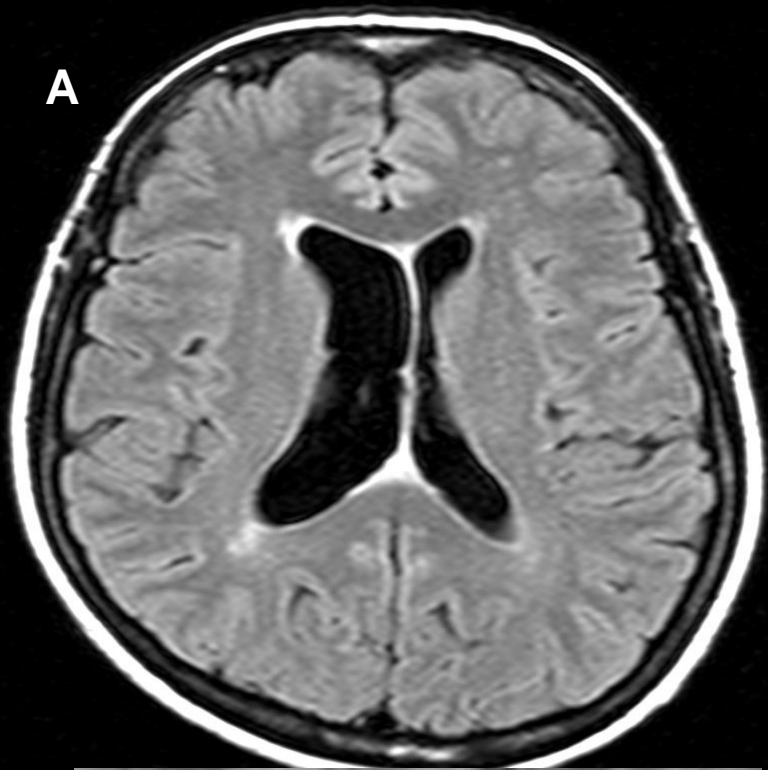


axial and sagittal T1 Weighted contrast

Colloid cyst



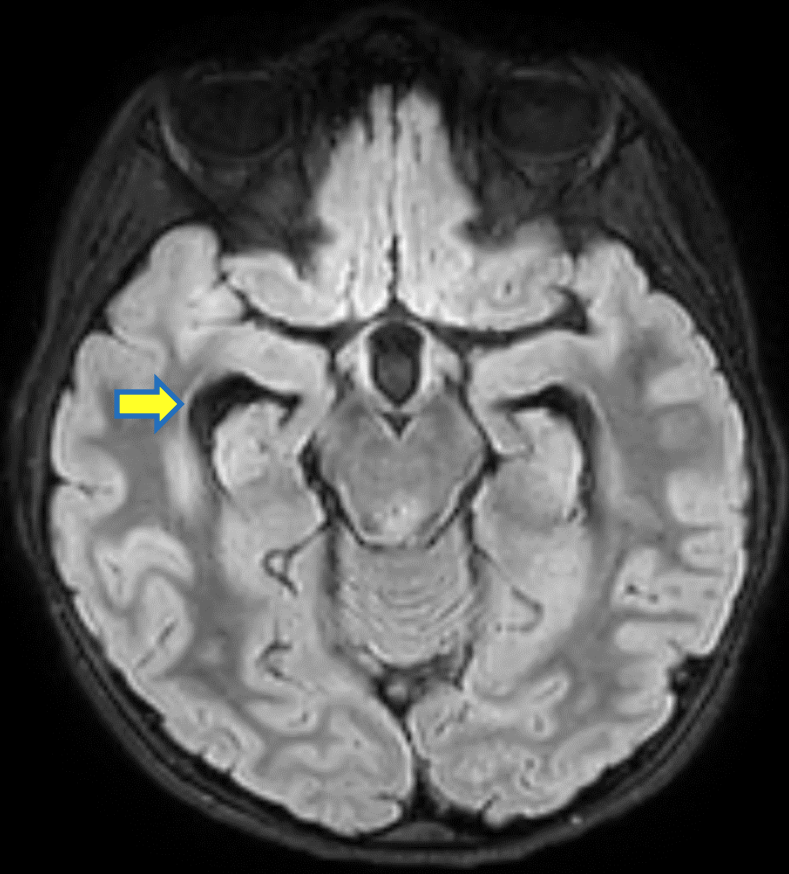


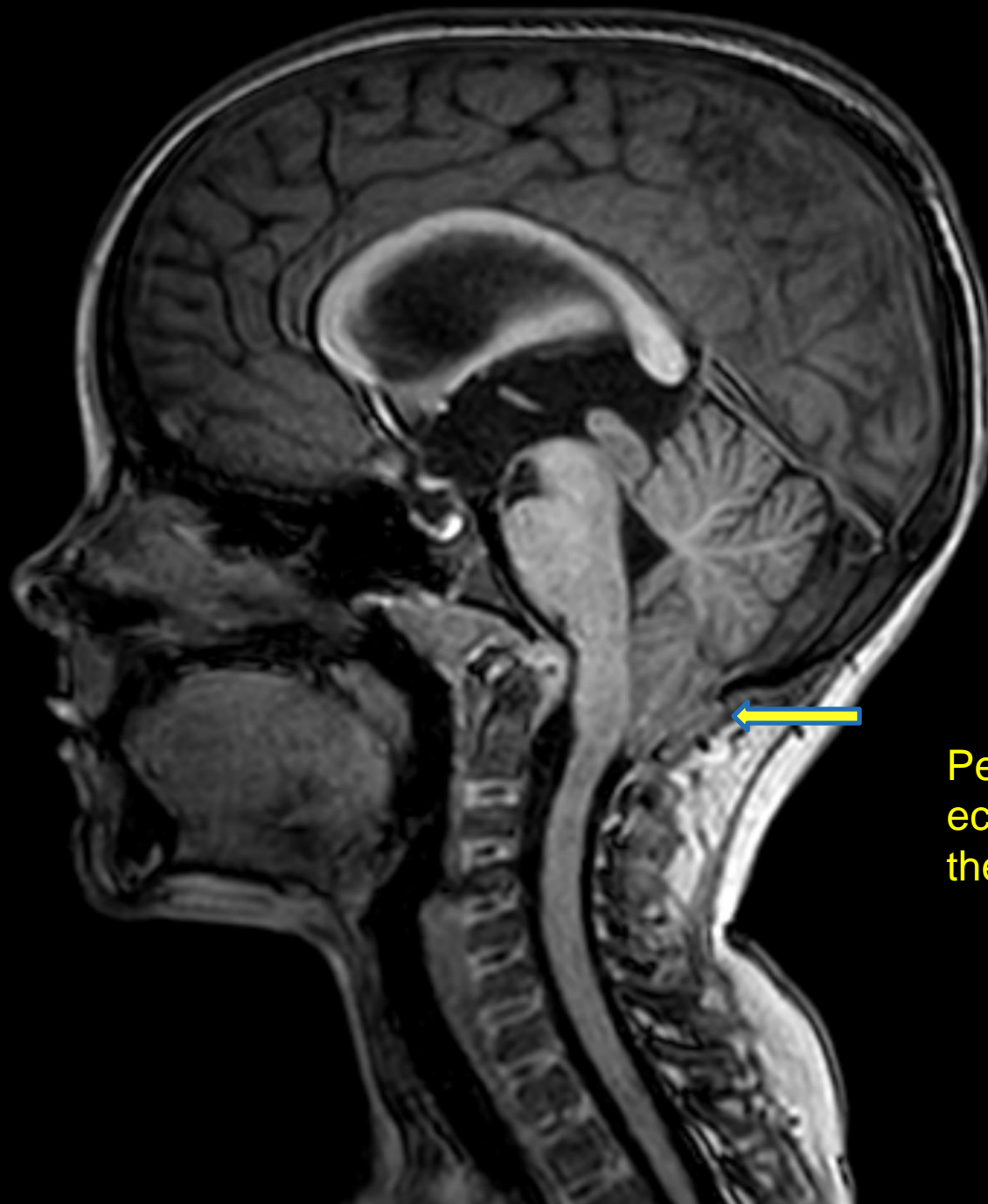


7 y/o female

- Progressive daily headaches since 9/19
- Pressing occipital HA's radiating to neck
- Moderate to severe with N/V
- Awakens her at night
- Ibuprofen helps
- Grandparents have migraine
- Exam normal

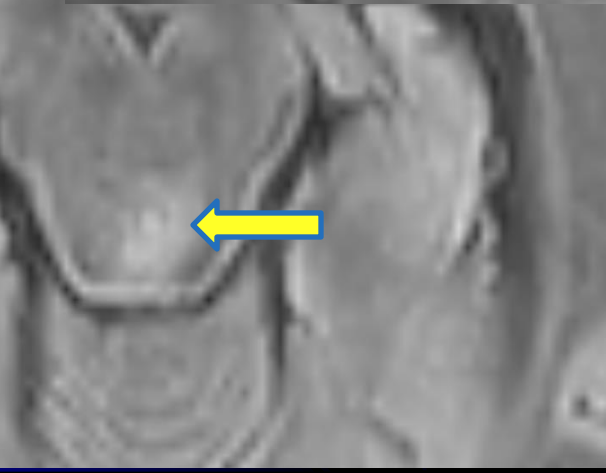
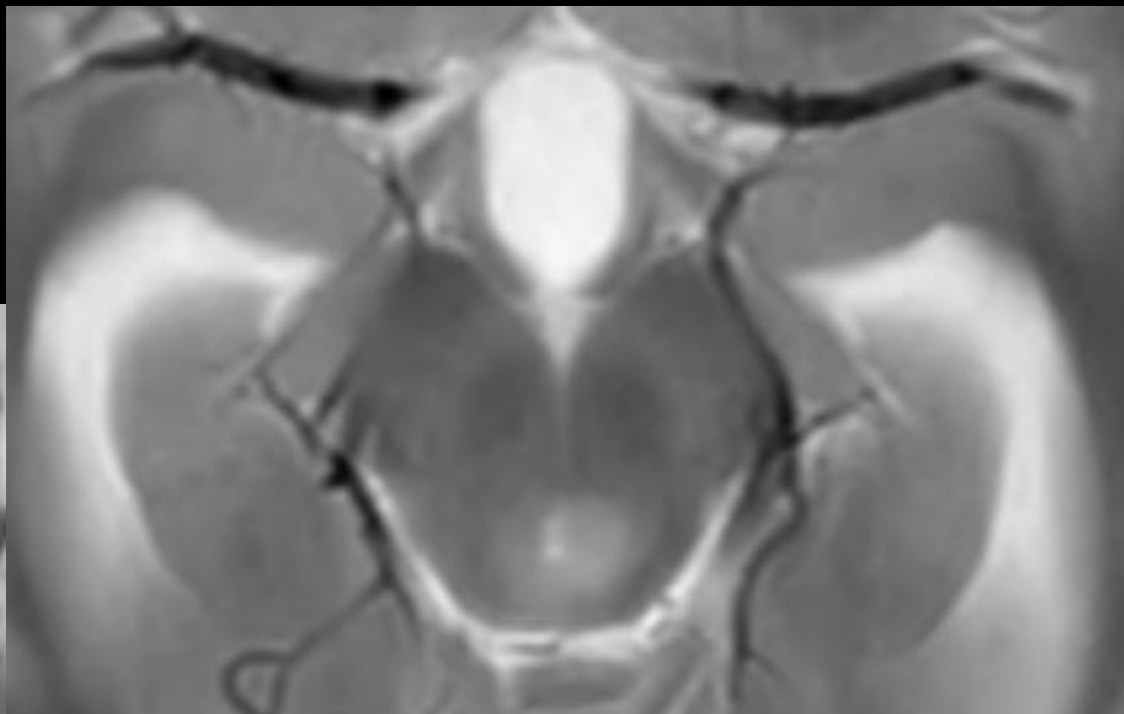
FLAIR





Peg-like tonsillar ectopia 15 mm below the McRae line

FLAIR axial



T1 sagittal

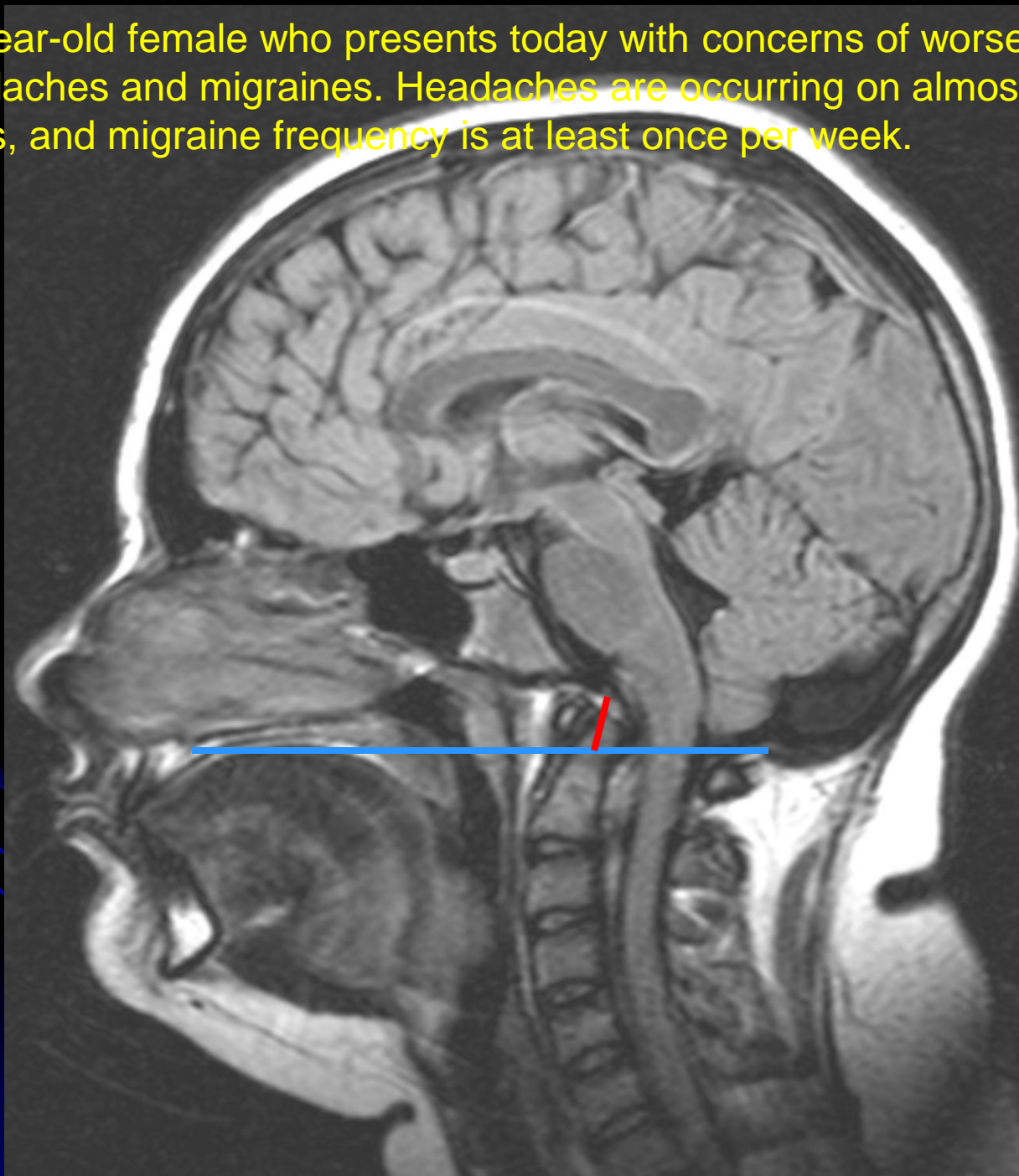


1. Partial empty sellar
2. Tonsilla ectopia 15 mm
3. Aqueductal stenosis
4. Enlargement of the 3rd and lateral ventricle

Diagnosis

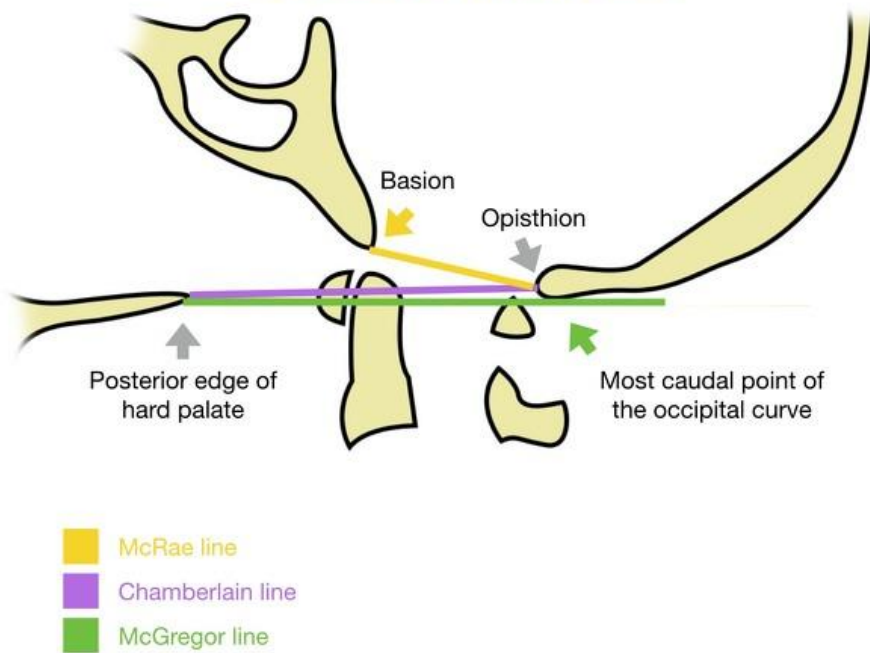
- Obstructive hydrocephalus with transependymal flow with a secondary Chiari malformation (15 mm) and empty sellar.
- Etiology? Tectal glioma or periaqueductal gliosis
- Treatment : ETV vs shunt

21-year-old female who presents today with concerns of worsening headaches and migraines. Headaches are occurring on almost a daily basis, and migraine frequency is at least once per week.



Basilar invagination

McRae line , McGregor line & Chamberlain line



McRae line: connecting basion and opisthion the tip of the odontoid process normally projects below this line, therefore, basilar invagination is diagnosed when the tip crosses this line

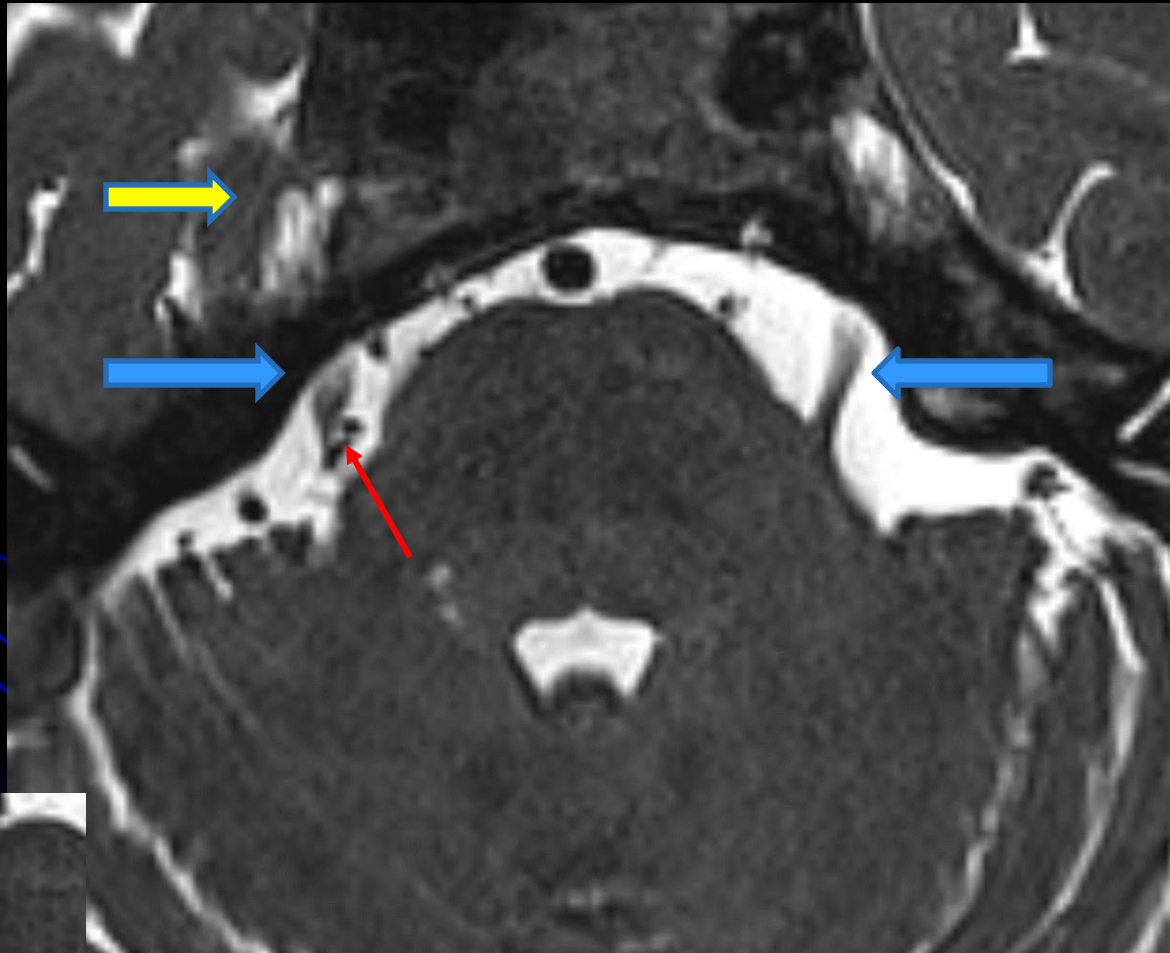
Chamberlain line: connecting the posterior border of hard palate and opisthion the tip of the odontoid process projects normally not more than 3 mm above this line

McGregor line: connecting the posterior edge of the hard palate to the most caudal point of the occipital curve the tip of the odontoid process projects normally not more than 5 mm above this line

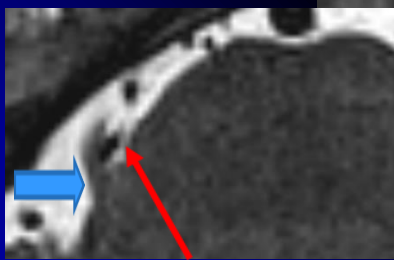
58 y/o male with lancinating
facial pain on the right



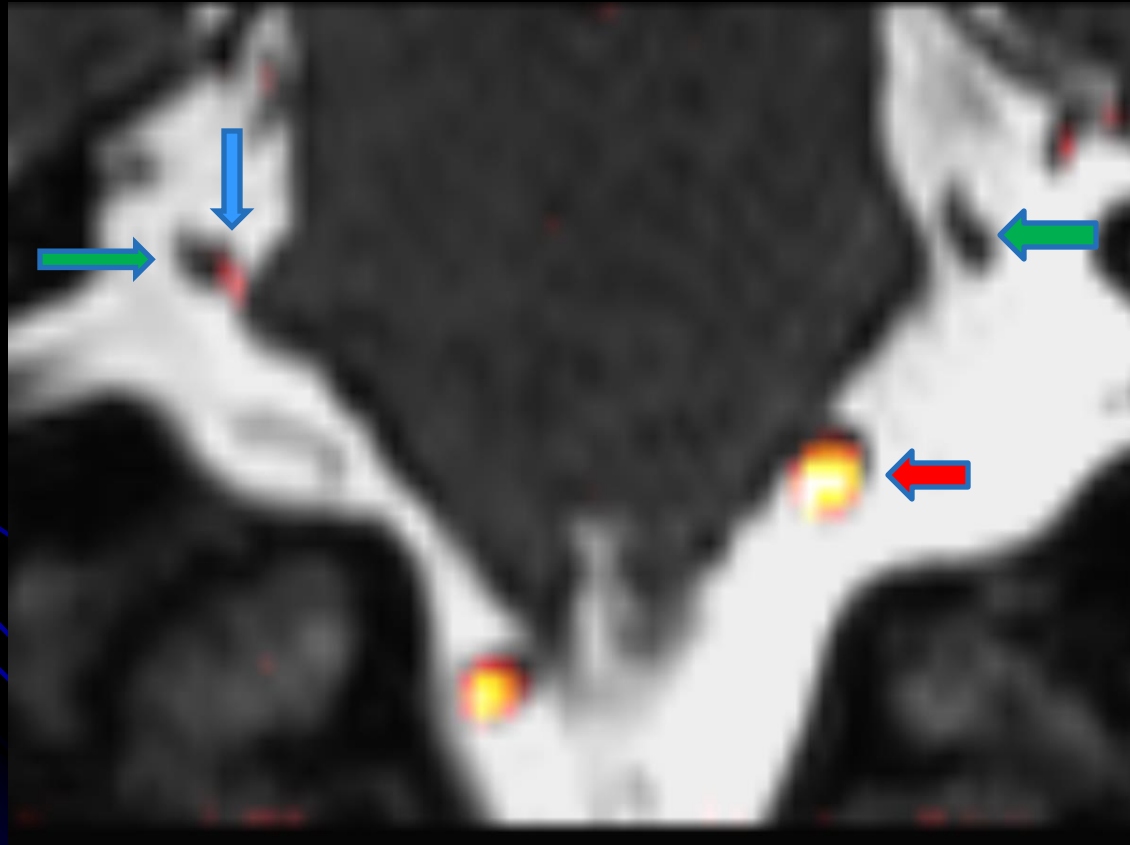
T2 Drive axial sequence .5 mm



- ← V th n.
- Meckel's cave
- ↗ SCA



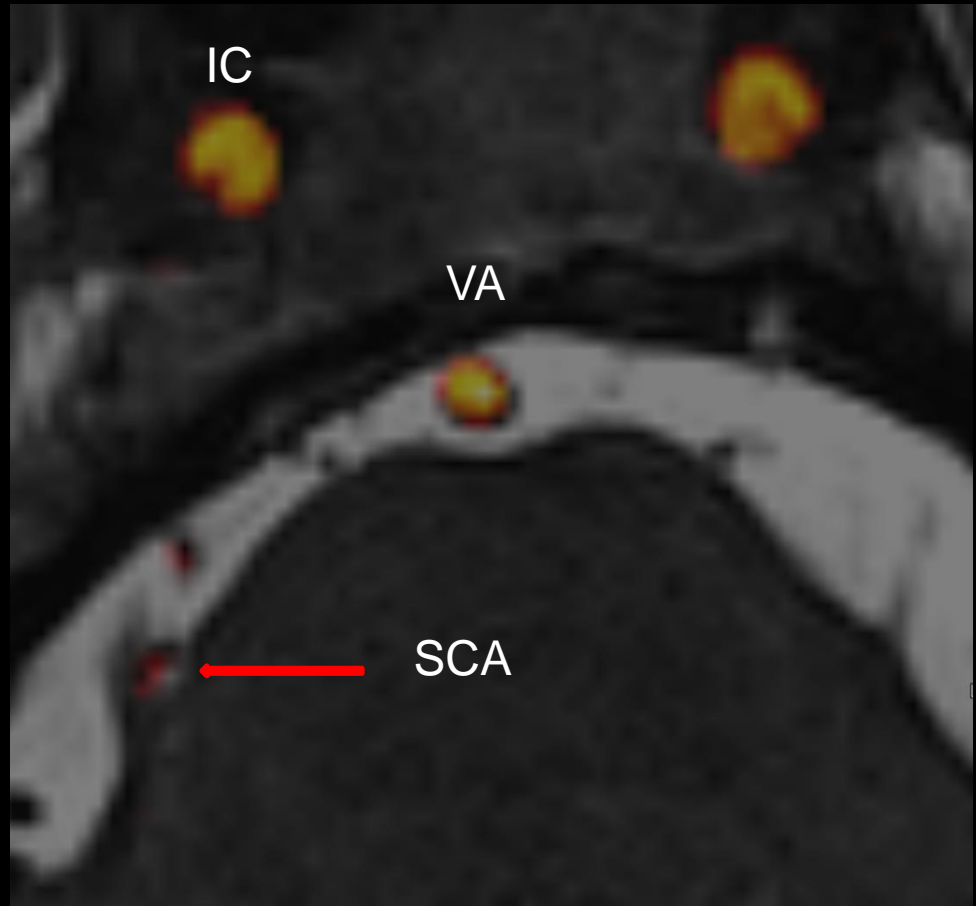
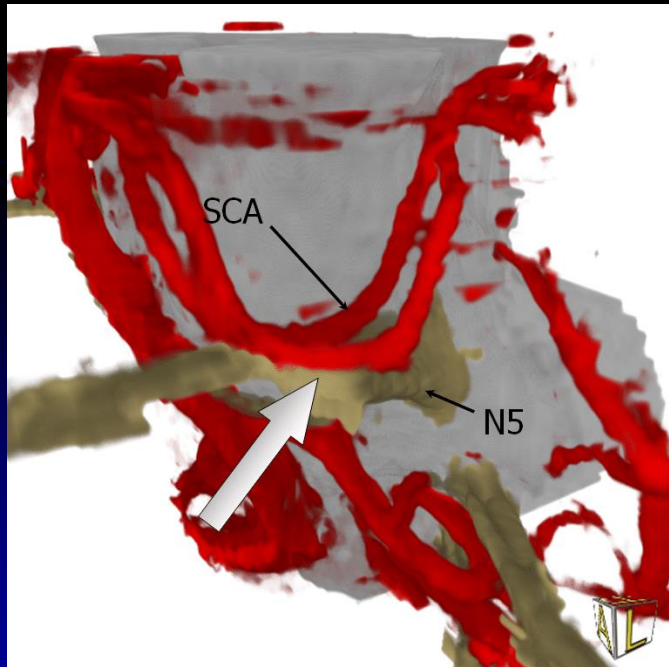
T2 Drive coronal sequence .5 mm



← Trigeminal n.

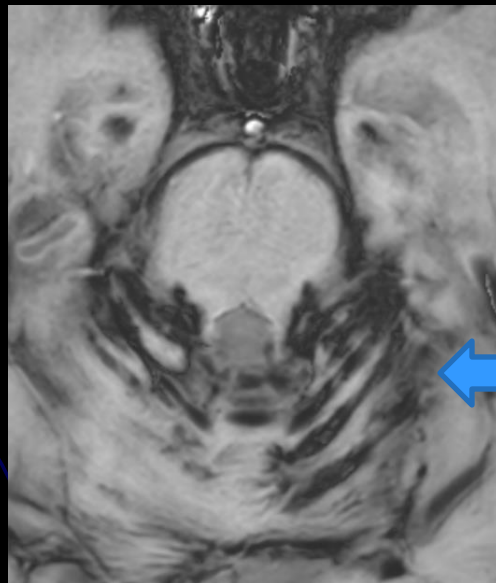
← Vertebral a.

↓ Superior cerebellar a.

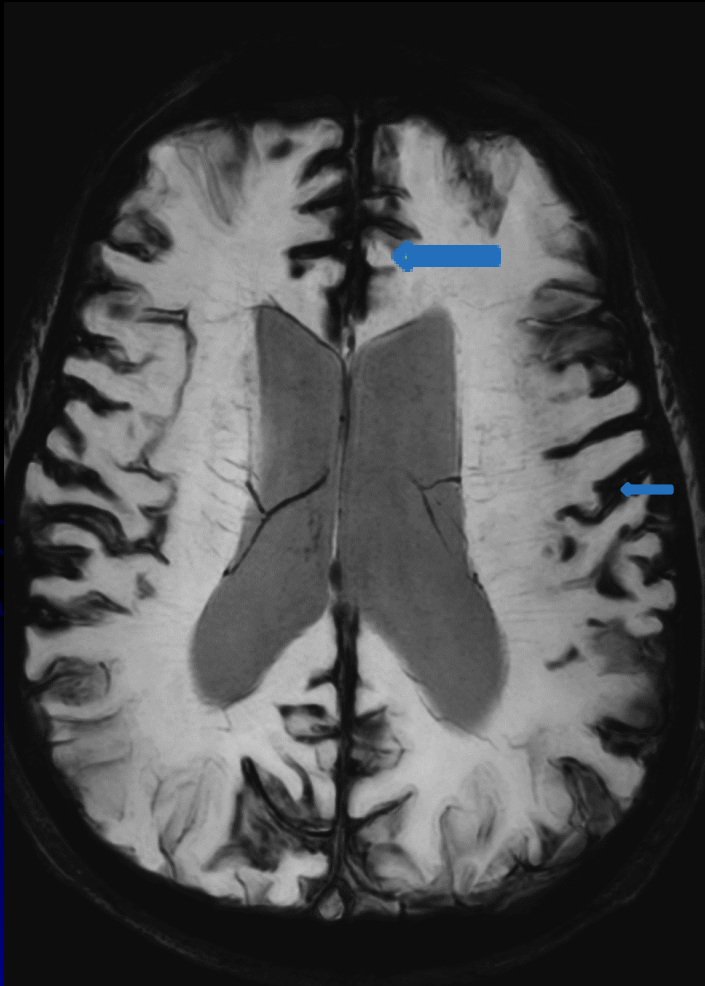


25 y/o with thunderclap then chronic headaches and LBP

- MRA was negative
- Went bfrom ED to ED across the south for years
- LBP progressive aqnd radicular in nature



SWI siderosis



SWI



T1W

Siderosis



Myxopapillary Ependymoma



T2W



T1W non



T1W contrast

Dent Headache protocol

- T1 axial 4mm
 - 3d FLAIR axial 2mm
 - DWI/ADC
 - T1 sagittal 1mm
 - T2W axial 4mm
 - T2W Coronal 2.5 mm
- 