NEURORADIOLOGY

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Neuroradiology

- Plain radiographs
- CT
- MRI
- Cerebral Angiogram
- Myelograms

Neuroradiology

- Computerized Axial Tomography (CT)
  - CT without and with contrast
  - CTA – CT angiogram
  - CTP - CT perfusion
- Magnetic Resonance Imaging (MRI)
  - MR without and with contrast
  - MRA – MR angiogram/MRV –MR venogram
  - MRP – MR perfusion
  - MRS- MR spectroscopy
  - MR tractography (DTI)
  - fMRI – functional MRI

Computerized Axial Tomography

- CT images are reconstructed from sets of quantitative x-ray measurements obtained through the head at multiple angles
- X-ray source rotates around the head and divides x-ray attenuation into compartments called **pixels**.
- *The computer assigns a number to each pixel and by using a gray scale, reconstructs an image*.
- Adv: very quick, less expensive
- Disadv: good but not great in delineation of soft tissue anatomy and pathology
  uses x-ray radiation

CT noncontrast uses

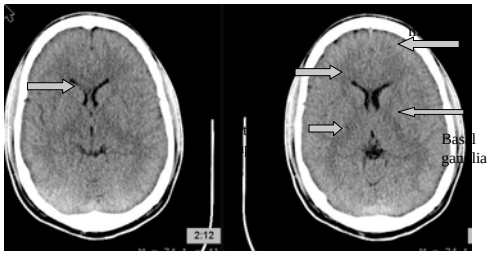
- Intial evaluation of
  - Head injury – acute intracranial hemorrhage especially **subarchnoid hemorrhage –** superior in evaluating **cortical bone structures** of bone and spine
  - Stroke
    - Less sensitive than MRI during first 48 hours
    - Posterior fossa infarcts difficult to see due to beam hardening artifacts (artifacts caused by x-ray attenuation by thick osseus structures eg at skull base.)

Computerized Axial Tomography

- Contrast enhanced CT
  - Iodinated water soluble contrast agents can be given intravenously to enhance differences in tissue density
  - Used to detect lesions that involve breakdown of the blood brain barrier eg: certain tumors, infections or inflammatory conditions
  - Intravenous CT contrast agents are based on iodine – high osmolar contrast media vs low osmolar contrast media (nonionic)

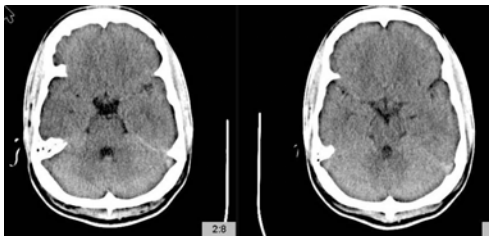
Normal Head CT

Frontal Horns of lateral vents

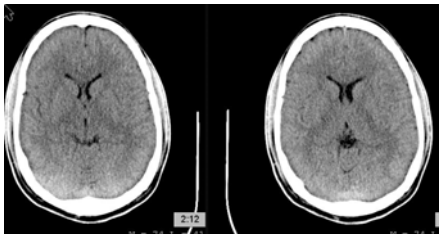


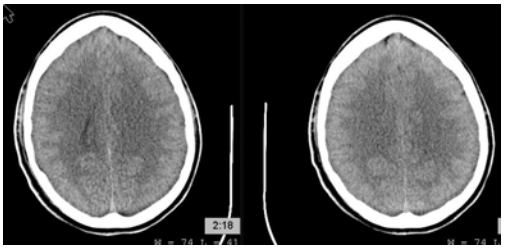
Basal ganglia

Head CT

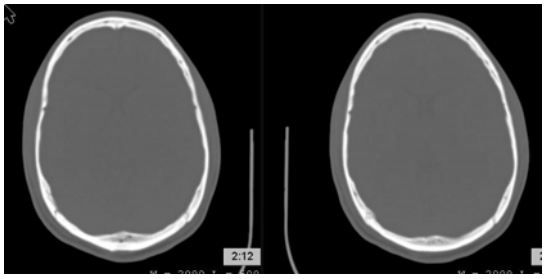


INFERIOR SLICE AT LEVEL OF POSTERIOR FOSSA

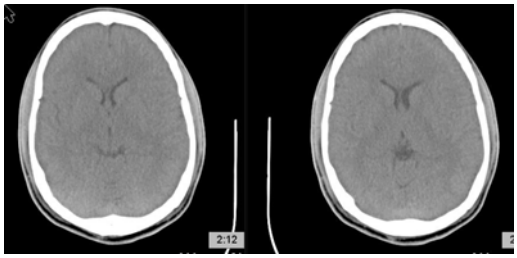




Bone Windows



Subdural windows



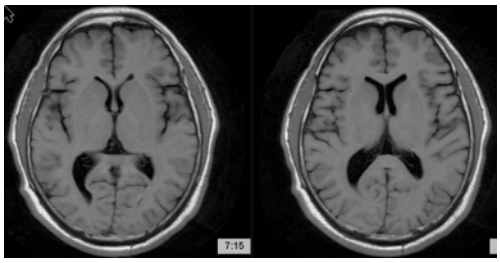
MRI

- Magnetic field causes alignment of atomic nuclei of 2 or more magnetic states.
- Proton based MRI - application of radiowaves of the hydrogen specific resonance frequency to biologic tissues excites some protons into a higher energy state.
- Following the pulse the relaxation of these protons back to their original energy state is accompanied by emission of radiowaves that are characteristic of the particular tissue. Two tissue specific relaxation constants known as T1 and T2 as well as proton density can be measured
- The difference in proton density, T1 and T2 relaxation enable MRI to distinguish fat, muscle, bone marrow and gray or white matter of the brain.

MRI magnetic resonance imaging

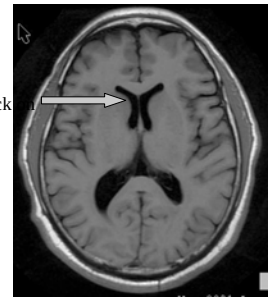
- Adv
  - Superior to CT for the detection of most CNS diseases due to its high soft tissue contrast resolution
  - Multiplanar capability
  - Lack of ionizing radiation
  - Better visualization of the posterior fossa
- Disadv
  - Typical brain MR study takes approx. 30 min
  - Patient must be able to hold still
  - Multiple sequences are obtained
  - CI- Swan Ganz/ Pacemaker

Brain MR axial T1



Brain MRI axial T1

CSF is black on T1



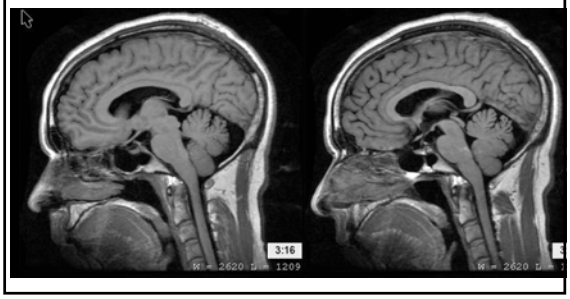
T1 sequence delineates anatomy

Brain MR axial T2

CSF is bright (white) on T2

T2 sequence highlights pathology

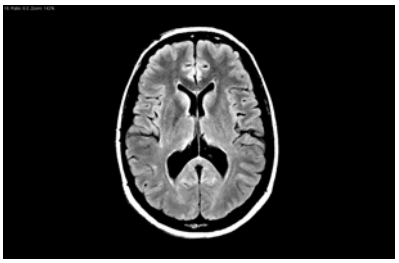
Sagittal T1



Coronal T2

FLAIR

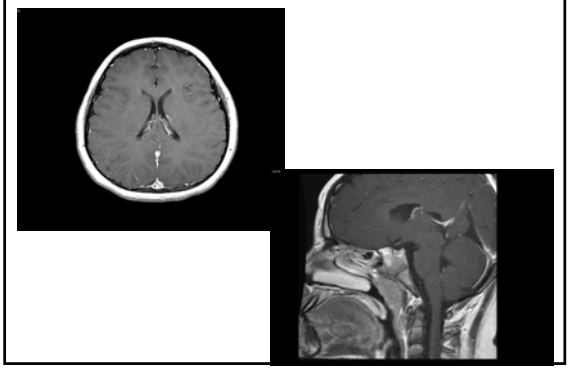
fluid attenuation inversion recovery sequence



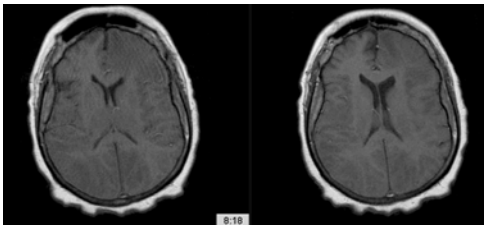
MR with contrast

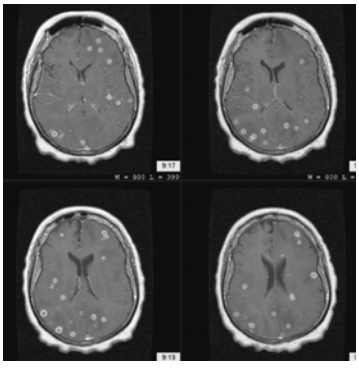
- Administer Gadolinium
- Useful for infection, inflammatory process, neoplasm
- Does not significantly affect renal function – unlike CT contrast
- Less risk of allergic reaction than with iodinated (CT) contrast

MR with contrast



T1 pre-contrast



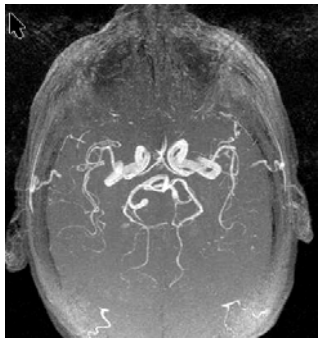


MRA

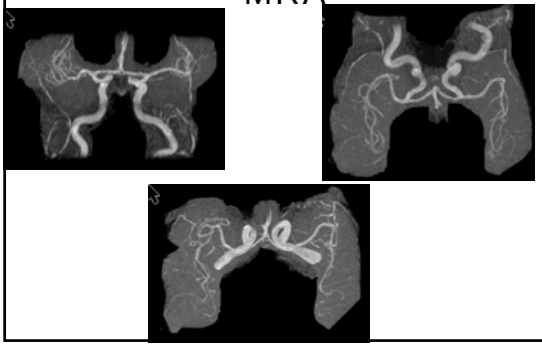
Brain MR angiogram
- does not require contrast injection
- delineates circle of Willis
- evaluates for major vessel stenosis or aneurysm
- resolution is approximately 3mm

MRA

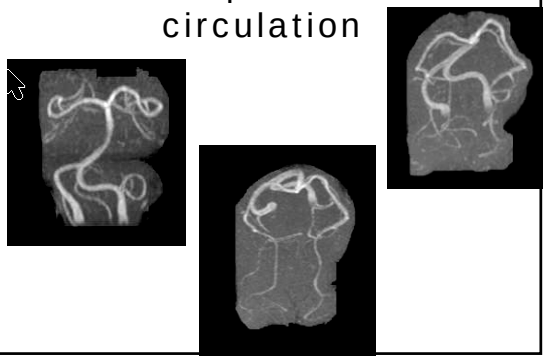
Composite 3D view



MRA

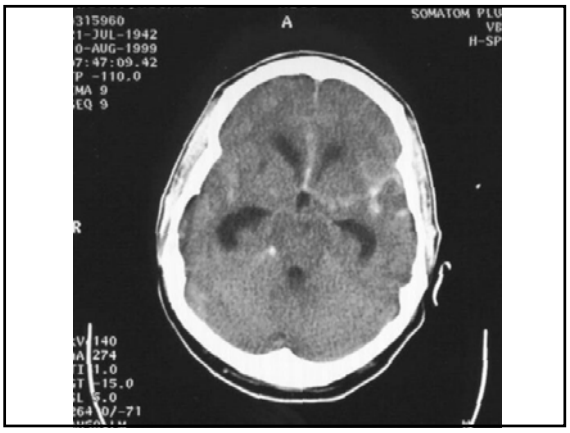


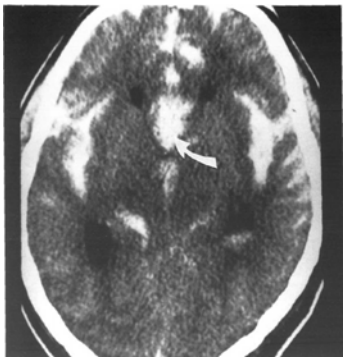
MRA posterior circulation



28 year old with worst headache of life

- **If Intracranial Hemorrhage Is Suspected The Initial Test Of Choice Is CT without contrast**
- **MR May Be Obtained If There Is Question About The Age/Ages Of The Hemorrhage (classically child abuse)**





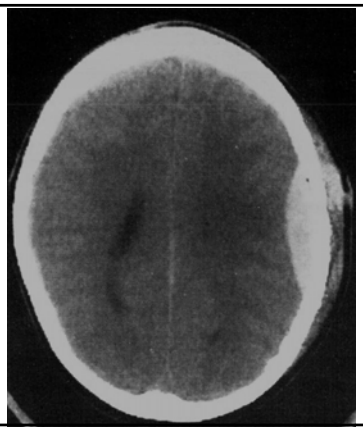
Subarachnoid Hemorrhage

- Traumatic SAH
  - Most common cause
- Non-trauma SAH
  - Rupture of intracranial aneurysm
    - (50-70%)
  - Leak from a primary intraparenchymal hemorrhage
  - AVM
  - Blood dyscrasia

Subarachnoid Hemorrhage

- Clinical presentation
  - Worst headache of the person's life
- CT is test of choice
  - If CT is positive (and no other cause is evident, i.e. trauma), cerebral angiogram is usually done.
  - If CT is negative, an LP may be performed next to look for xanthocromia
  - MR is relatively less sensitive/obvious to SAH. (Although some claim FLAIR imaging works relatively well)

30 y/o s/p head trauma with no immediate neurologic findings, rapid clinical deterioration 20 minutes later

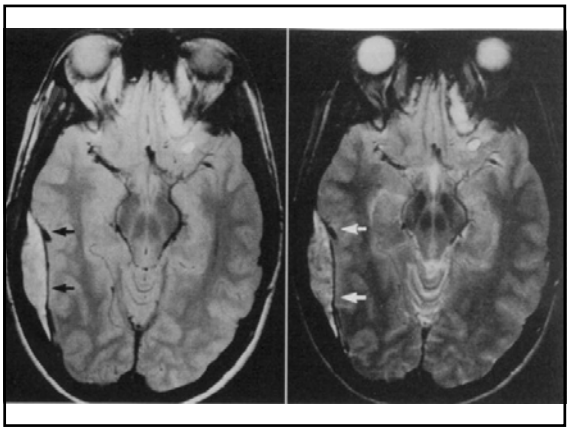


Epidural Hemorrhage

- Usually secondary to trauma
- Arterial epidural
  - Most common
  - From laceration of the **middle meningeal artery**
  - Associated with a temporal bone **fracture**
- Venous epidural
  - Less common
  - From tear of middle meningeal vein
  - Laceration of a venous sinus (posterior fossa, more common in children)

CT/MR Findings

- Biconvex, lentiform extra-axial mass
- Between skull & dura
- Confined by the cranial sutures
- At the sutures, the dural membrane is firmly adherent to the bone (forms the endosteum)

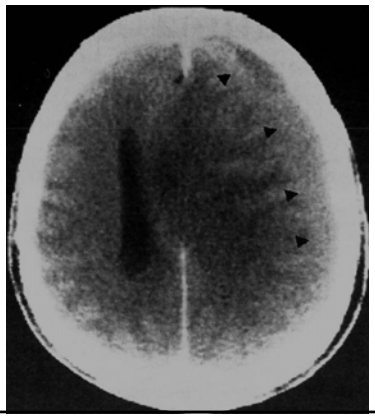


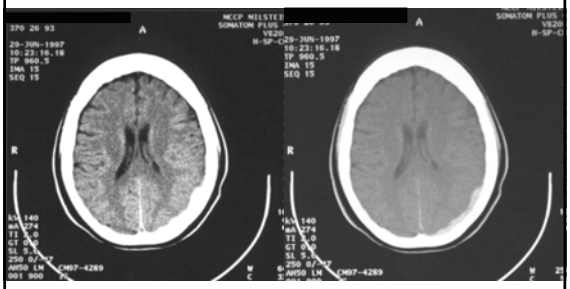
Subdural Hemorrhage

- Usually secondary to trauma
  - In young patient this is usually secondary to an automotive accident
  - Results from **shearing of bridging veins**
  - In the elderly it is most common secondary to a fall. (Bridging veins are stretched and more delicate secondary to underlying brain atrophy)

Imaging Findings

- Extra-axial biconcave, crescent shape
- Crosses the cranial sutures
- May miss an isodense subdural on CT
  - Subacute
- Important to look at:
  - Subdural windows
  - Gray/white junction to see if it displaced inward





Cerebral Aneurysm

- Besides subarachnoid hemorrhage, an aneurysm may present secondary to mass effect.
- PCA or Superior Cerebellar Artery aneurysm may press on the third nerve causing a palsy

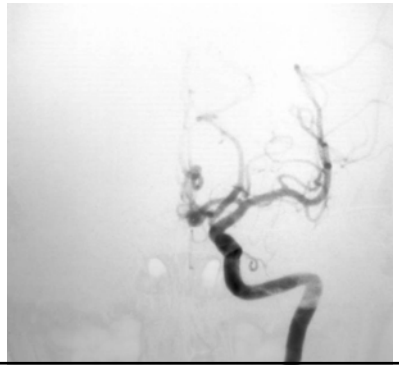
Angiography

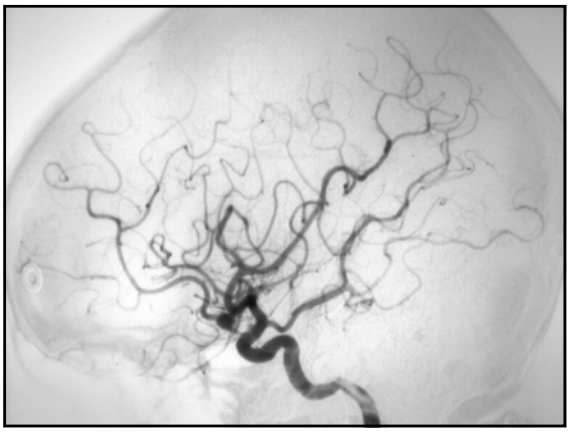
- Gold standard for diagnosis of an aneurysm
- Is however an invasive procedure
  - NPO
  - Well hydrated
  - Off coumadin, if on heparin d/c 4 hrs prior
  - Need recent PT/PTT, Platelet count, BUN, creatinine
  - Off Glucophage

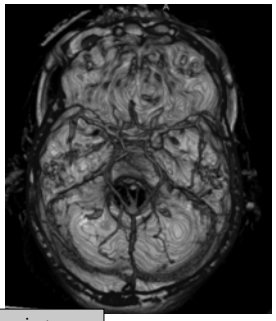
CTA

- CT angiogram
- High volume fast injection with subsequent 3D reconstruction
- noninvasive

Acom aneurysm







CT Angiogram using Intravenous iodinated contrast

Stroke

- Stroke is the third leading cause of death in the USA. Each year 750,000 new patients are diagnosed resulting in > 200,000 deaths/year .
- Stroke is the number one cause of disability in the USA and the largest cause of inpatient Medicare reimbursement of long term adult care.
- The only FDA approved therapy is IV thrombolytics.

CVA

- Early cerebral infarct may not be visible on CT
- Remains initial study in suspected stroke case
  - Quick
  - Excludes hemorrhage
  - Evaluates for possible mass effect

- Conventional CT has a 42% sensitivity and 91% specificity in the diagnosis of hyperacute stroke.

Conventional CT Imaging of Hyperacute Stroke

- CT Findings in Hyperacute stroke:
  - Loss of grey and white matter differentiation.
  - Dense arterial thrombus sign.
    - Within 90 minutes of the initial event. Sensitivity 30% Specificity 100%.[4]
  - Obscuration of the basal ganglia.
    - Within 120 minutes of initial event.
  - Insular ribbon sign

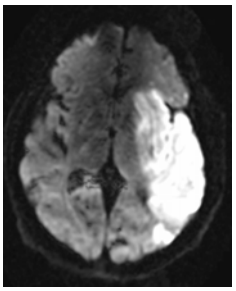
Initial CT

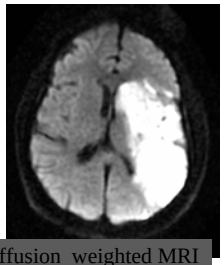
18 hours later

MRI is often necessary to exclude an acute infarct

- SENSITIVE AND RELATIVELY SPECIFIC SEQUENCE FOR ACUTE INFARCTS: DWI diffusion weighted imaging

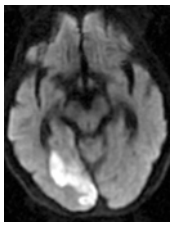
- Conventional MRI has a 70% sensitivity and 94% specificity in the diagnosis of hyperacute stroke.3
- Conventional MRI findings in acute stroke include:
  - Hyperintense signal on T2 weighted images
  - Loss of arterial flow voids.
- Diffusion weighted imaging (DWI) has a 94% sensitivity and 97% specificity.
- High signal intensity on DWI with normal T2 weighted images can be seen in the first few hours of stroke onset.





Acute left MCA stroke on Diffusion weighted MRI DWI

Left hemianopsia



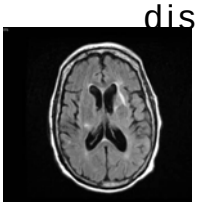
White Matter Diseases

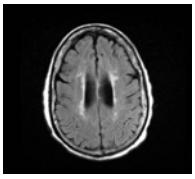
- Microvascular Ischemic Disease
- Primary Demyelinating diseases
  - Multiple Sclerosis
- Secondary demyelinating diseases
  - Infectious agents/vaccinations
  - Nutritional/vitamin deficiency
  - Physical/chemical agents or therapy
  - Vascular
  - Genetic abnormality

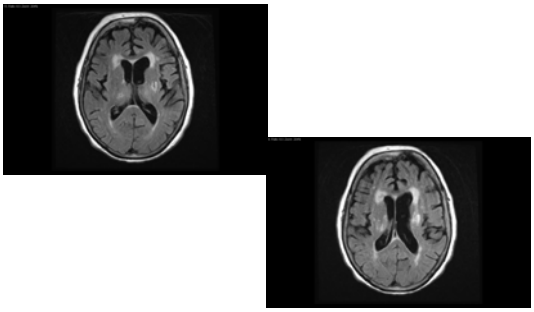
Big Two

- Microvascular ischemic disease
- Multiple sclerosis (MS)

Microvascular ischemic disease



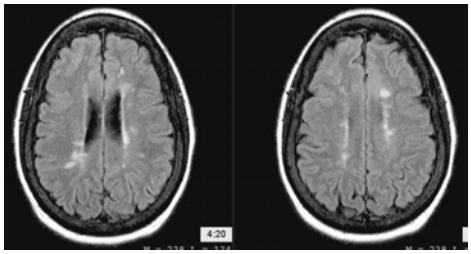




Microvascular ischemic disease

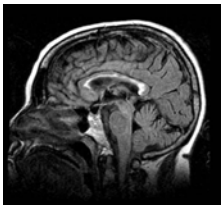
- Common in elderly; may not correlate with neurological deficits
- Part of normal aging ?
- Hypertension, diabetes
- Patchy, multifocal, periventicular and deep white matter optic radiations
- Basal ganglia
- When extensive, some correlation between white matter ischemic disease and dementia (Binswanger encephalopathy)

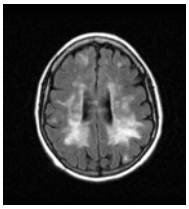
MS



Hyperintense FLAIR foci oriented perpendicular to the body of the lateral ventricles – Dawson's fingers

MS



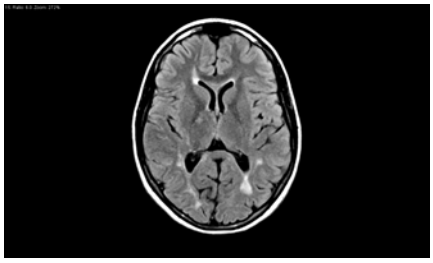


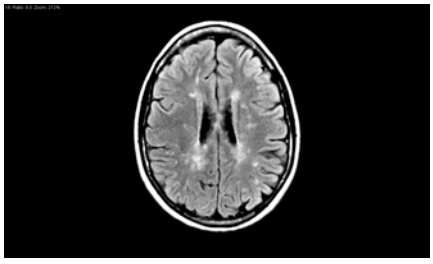
Corpus callossum lesions

MS

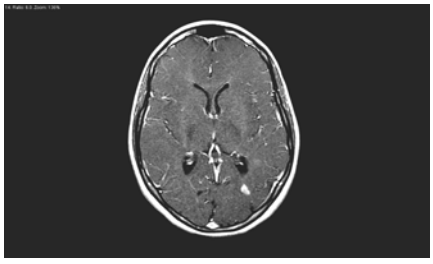
- Variety of clinical courses and disease patterns
- Periventricular white matter, internal capsule, CC, pons, and brachium pontis
- Subcortical U fibers
- Gray matter (5%)
- Callosal-septal interface
- Dawson's fingers
- Enhancement variable (2-8 weeks)
- Spinal cord (cervical; less than 2 vertebral body)
- Optic neuritis

28 year old female





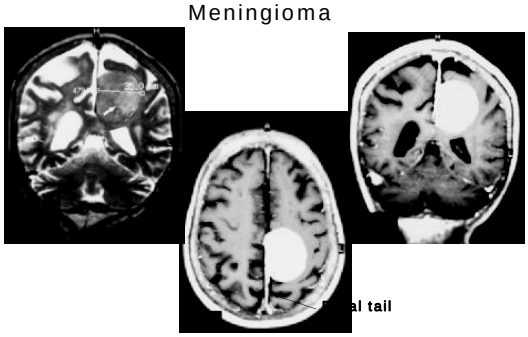
Post-contrast enhancement suggestive of active demyelinating MS plaque



Tumors

- Primary versus metastatic
- Intra-axial versus extra-axial
- Low grade versus High Grade

Extra-axial Tumor
Meningioma

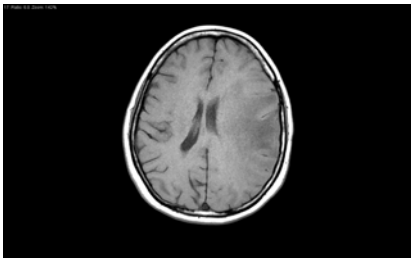


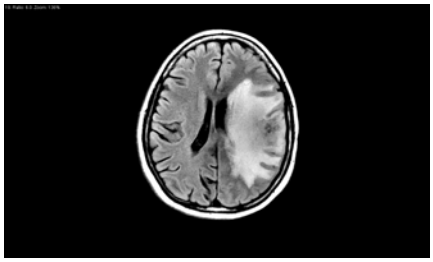
Emedicine , German Castillo, August 6,

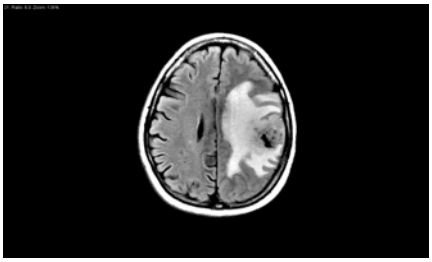
Neoplasm

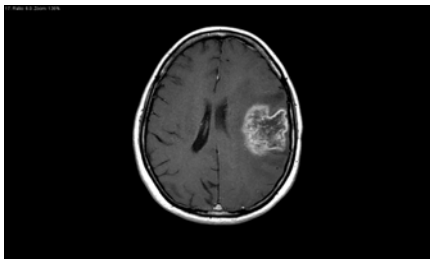
- Most common metastatic
- Primary

32 year old female with GBM

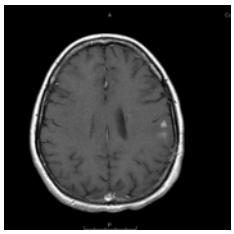


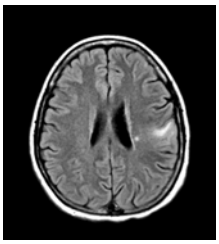




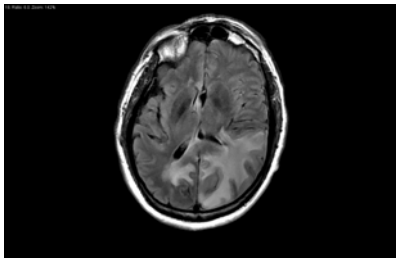


4 months earlier

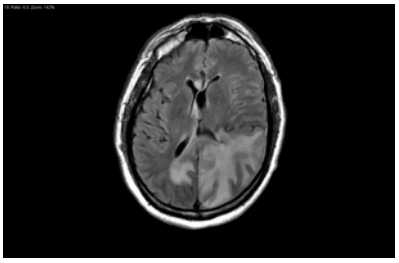




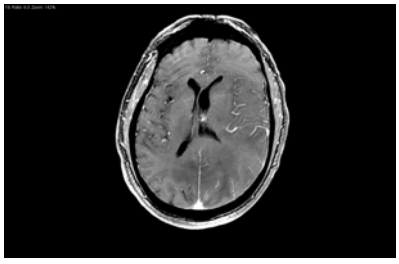
Infiltrative High Grade Tumor



Severe mass effect

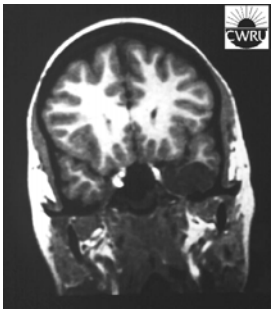


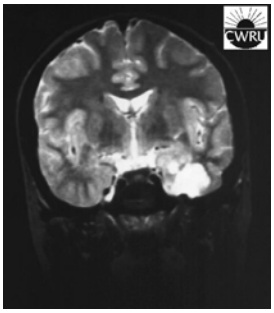
Post-contrast
Lack of enhancement does not imply low grade tumor



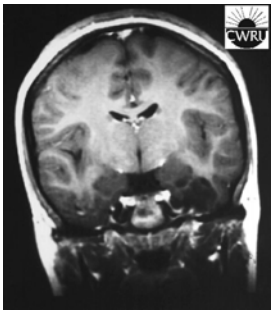
High grade infiltrative tumor

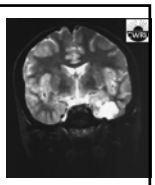
- Enhancement is a reflection of lack of blood brain barrier – for example metastatic lesions
- Primary brain tumors have a blood brain barrier – as a tumor becomes very aggressive and necrotic it will cause a breakdown in the blood brain barrier with subsequent enhancement





Post-contrast

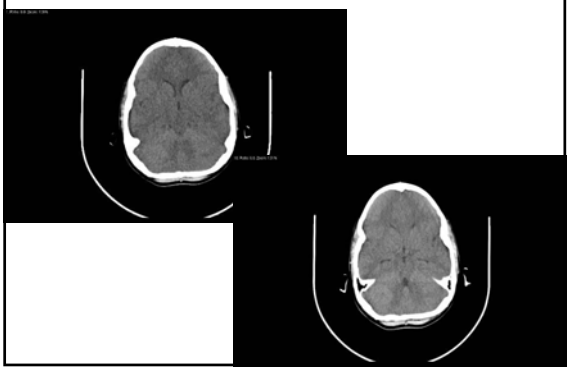




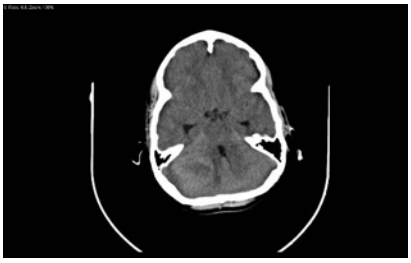
- DNET – low grade tumor
- Dysembryoplastic Neuroepithelial Tumor (DNT) benign tumor associated with medically intractable, partialcomplex seizures. Mean age of onset of symptoms is nine years (range 1-19years). All reported DNT's have been supratentorial, most often involving the temporal lobe (approximately 2/3) followed in frequency by the frontal lobe (1/3).
- The tumors are primarily **cortical** in location, although they may extend to involve the subcortical white matter.

- On CT scans, DNT's are well-defined, low-attenuation lesions which may be mistaken for cysts. The tumors tend to be low signal on T1-weighted MR images and high signal on T2-weighted images, i.e., similar to CSF, but on proton-density images, they are slightly higher in signal than CSF.
- Less than 25% calcify or enhance.
- There is associated calvarial remodeling in approximately 1/3 of cases.
- Ddx ganglioglioma

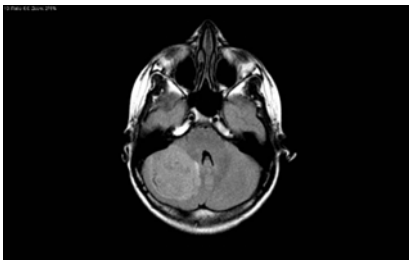
13 year old S/P trauma with vomiting



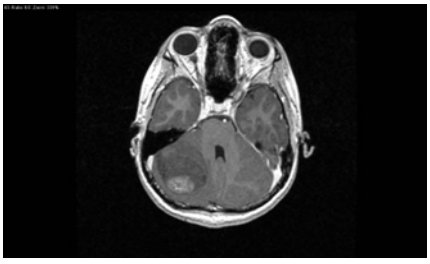
2 months later



FLAIR



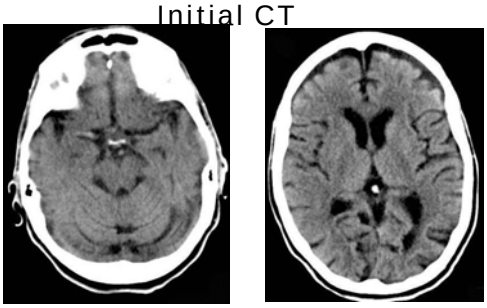
T1 post-contrast



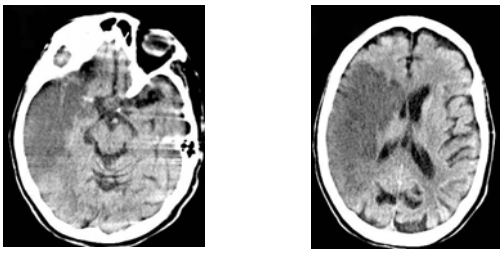
DDX?

- Medulloblastoma
- astrocytoma

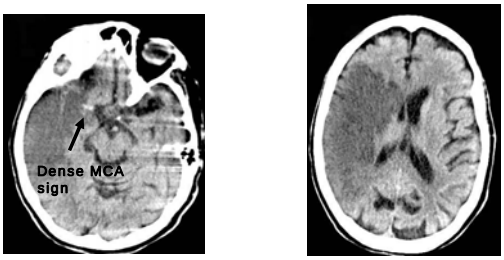
Altered mental status 78 year old male
Initial CT



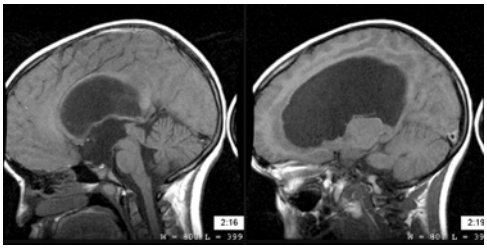
48 hours later



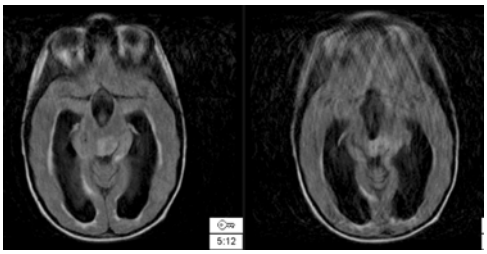
48 hours later

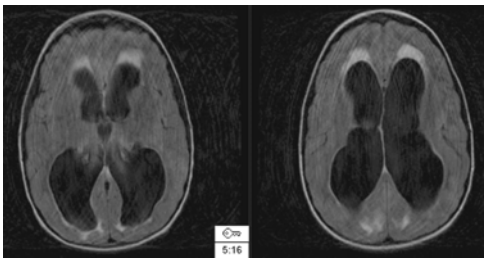


7 year old with right sided weakness, mild ataxia, for 3 weeks, h/o travel to DR

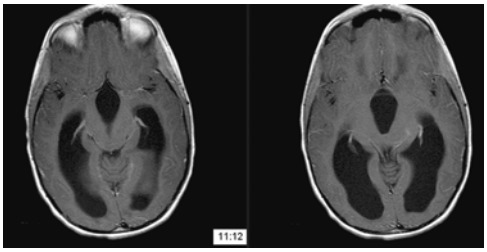


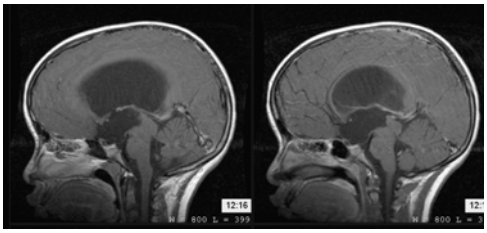
FLAIR





Post-contrast T1

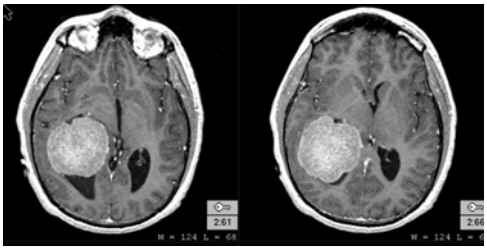


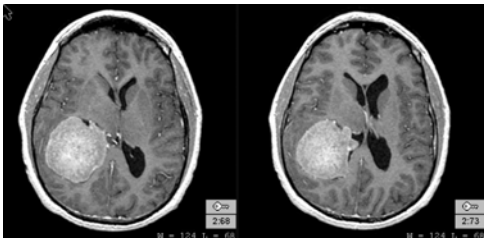


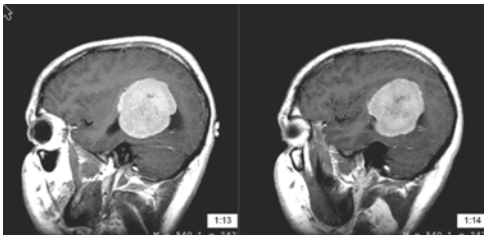
DX

- Midbrain – Tectal glioma – low grade

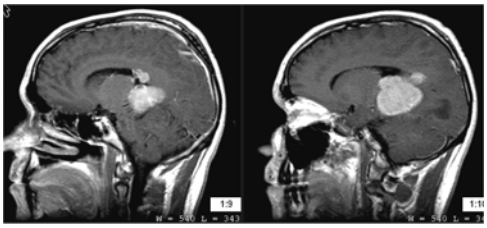
24 y/o male with headache







DX?



DDX

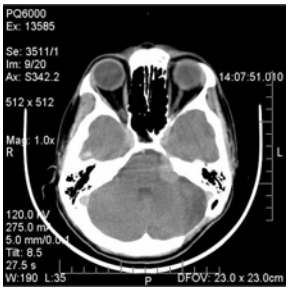
- **Meningioma**
  - lateral ventricles - glomus
  - middle aged and elderly
  - smooth margin/ oval configuration
  - usually silent until block ventricular system with dilatation and blockage of distal portion
  - MR- strong uptake of contrast usually homogeeous

- **Choroid plexus papilloma**
- children
  - 5% of intracranial tumors
  - 80% in the lateral ventricles
- adults
  - 0.5% of all intracranial tumors
  - 43% in one of the lateral ventricles
  - 40% in 4th vent (in adults
  - 10% third ventricle

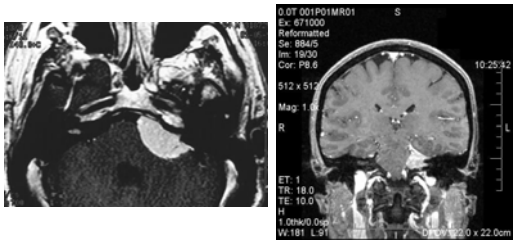
- **Choroid plexus papilloma**
- large tumors expand the ventricle
- hydrocephalus frequent
  - overproduction of CSF
  - blockage
- MR
  - very lobulated- nodular, irreg surface
  - heterogeneous on T2 - hemorrhagic/cystic
  - T1- linear, punctate hypointensities - vascularity and tumor calcification
  - enhance strongly - depends on heterogeneity

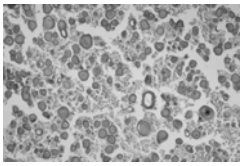
- **Ependymoma**
- more common in children
- MR - marked heterogeneity - cystic regions/necrosis/hemorrhage
  - low signal on T2- hypercellulerity
  - calcify
  - heterog enhancement
- 2/3 infratentorial - associated with 4th ventricle or outlet foramina
- 1/3 body of the lateral ventricle
  - less commonly separated from the ventricular system and tend to center in the parenchyma

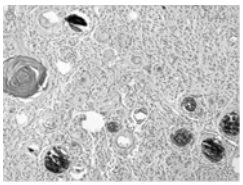
Unilateral hearing loss



Post contrast







Abundant psammoma bodies
Irregular calcified and occasionally ossified masses

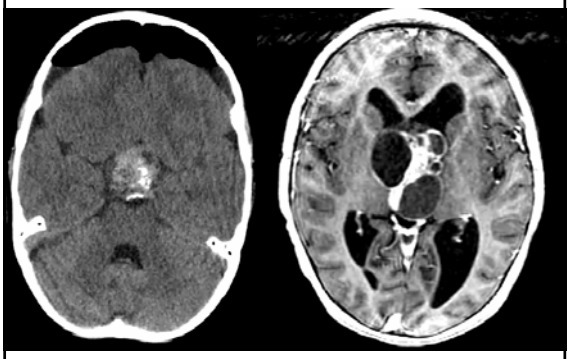
DX?

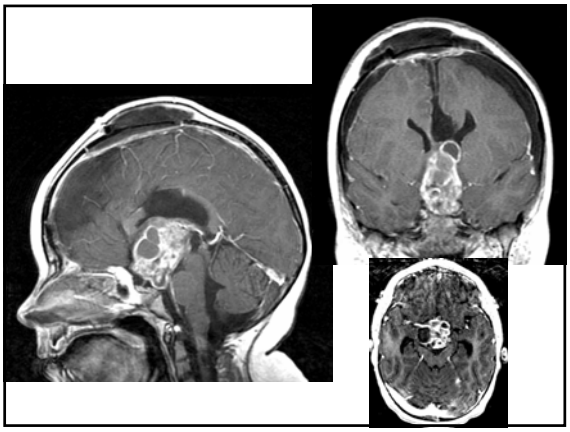
Meningioma

- CT
  - Isodense (25%) to hyperdense (75%)
  - Enhance, Hyperostosis, Dural tail
  - calcification
- MRI
  - T1
    - Isointese to hyperintense
    - Homogeneous enhancement
    - Dural tail
  - T2
    - Variable

Thank you for your attention!

8 year old male with visual changes





DX?

- craniopharyngioma

Thank you for your attention!