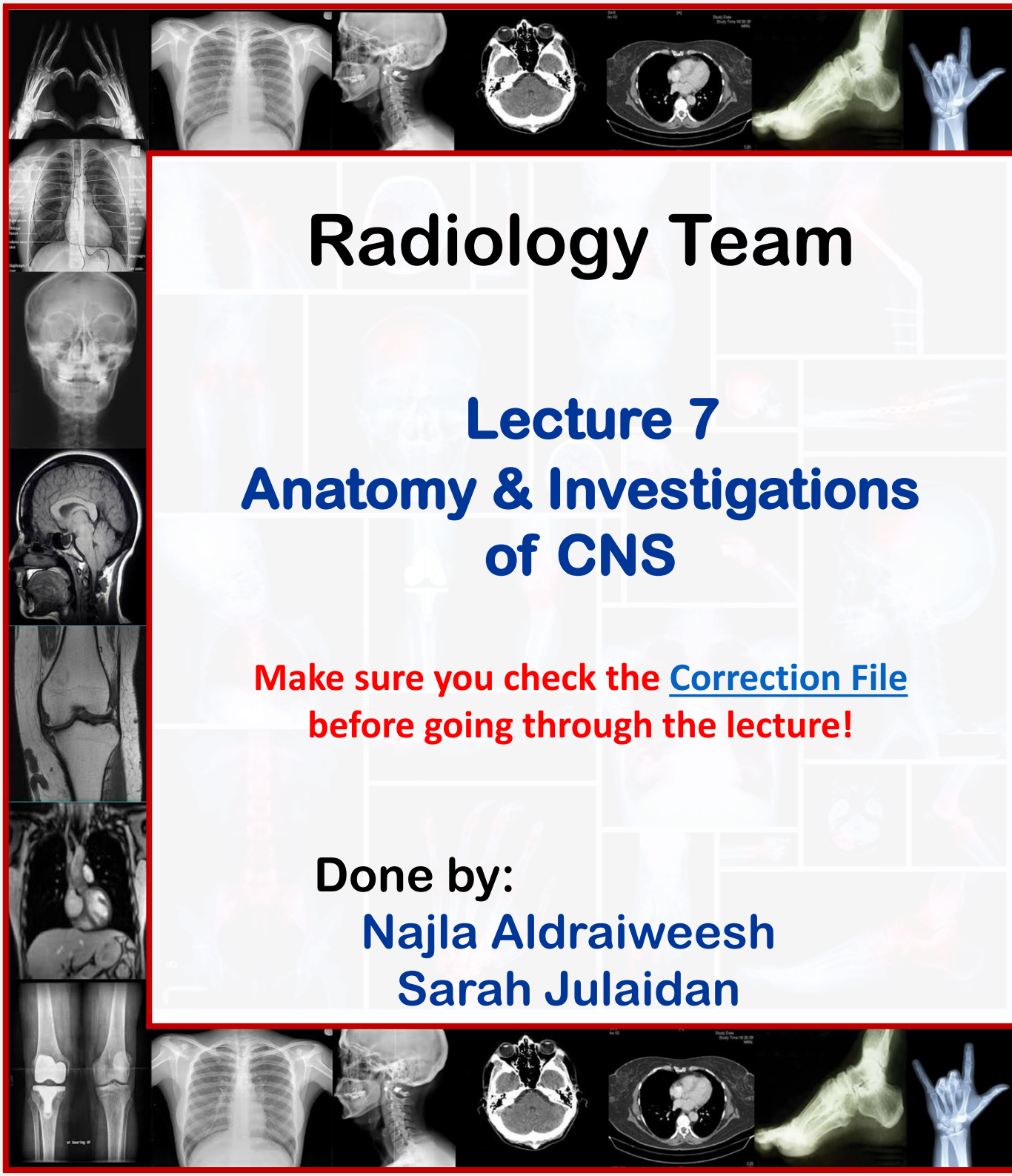


Radiology Team

Lecture 7
Anatomy & Investigations of CNS

Make sure you check the Correction File before going through the lecture!

Done by:

Najla Aldraiweesh

Sarah Julaidan

Color Index:

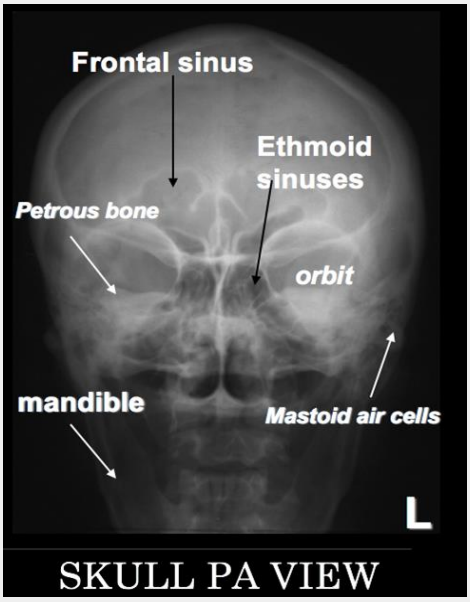
• Important • Females' notes • Males' notes • Explanations

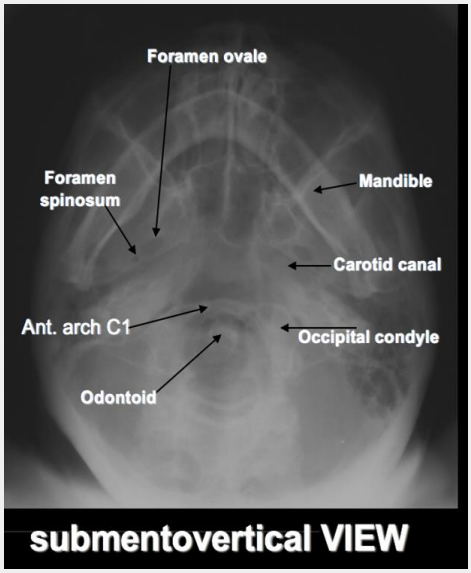
• 433 & 432 Teamwork

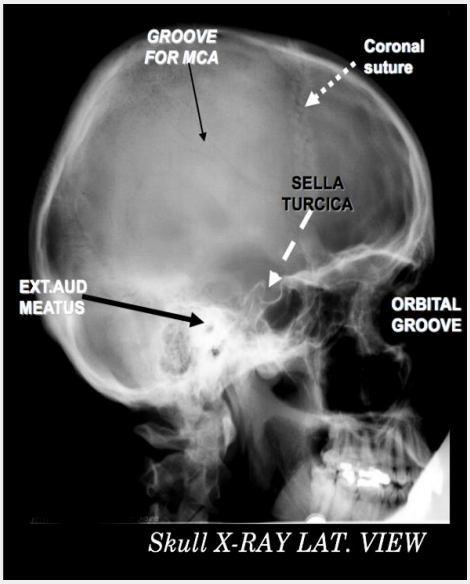
The Radiological Investigation Used For Evaluation of The Brain and Skull:

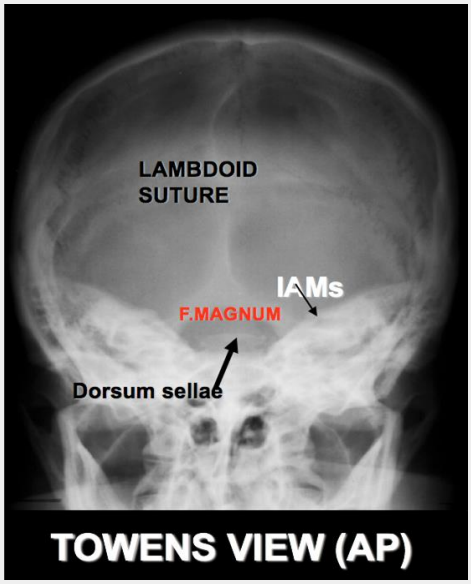
1. Plain X-ray skull

- ★ **The initial investigation for disorders of the bones of the skull (particularly fractures) but otherwise have limited uses.**
- ★ **Indications:**
  - trauma
  - congenital: microcephaly or macrocephaly
  - calcification: normal or abnormal (vascular ,neoplasm)
  - metastasis: lytic /sclerotic
  - multiple myeloma
  - metabolic disorders
- ★ **It's important to know the demonstrated parts in each position (PA,AP,lateral and submentovertical)**









2. CT SCAN

- Spiral CT can perform a head scan in 15 minutes pre&post contrast scans.
- The scan itself can take as little as 10 seconds.
- Patient preparation: nil
- Type of the contrast medium: iodinated contrast (non ionic L.O.C.M)

Indications	Trauma, strokes, tumours. infection, Vascular disorders detection of blood (ex Hematoma)
Disadvantages	Using ionizing radiation
Contraindications	pregnancy (but it's relative contraindication and can be performed with using apron)

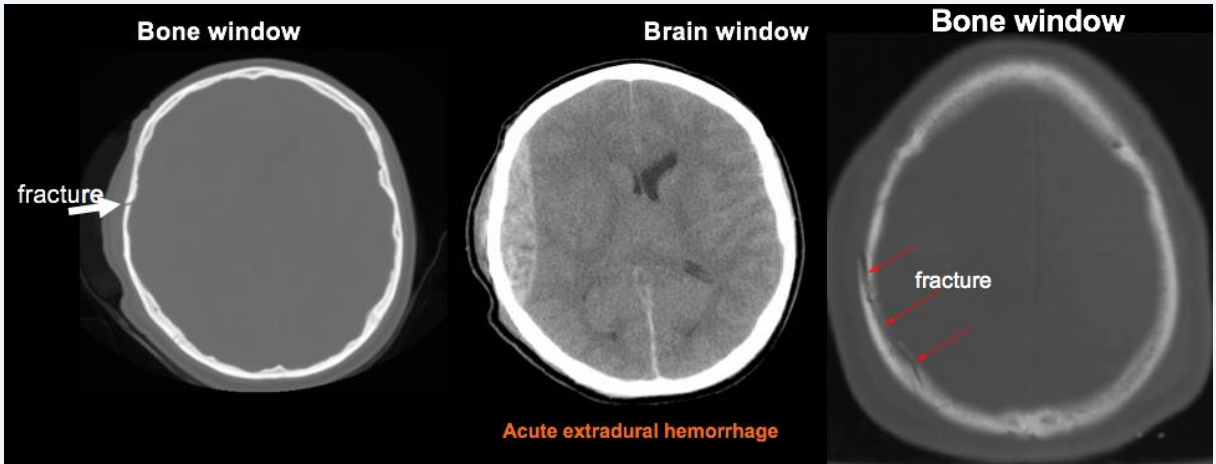
Normal CT of Brain:

- **CSF is seen as water density (black) within ventricular system and subarachnoid space.**
- **Grey matter is differentiated from white matter (white matter is relatively DARKER than grey matter).**
- **The falx (midline) is denser than the brain.**
- **Large arteries and venous sinuses can be recognized when opacified by contrast medium.**
- **Posterior fossa may be obscured by artifacts from overlying temporal and occipital bone.**

Computer reconstructions can in selected circumstances be made from the axial sections which then provide images in coronal or sagittal planes.

Sagittal reconstruction Coronal reconstruction

Windows of CT: The window settings are selected for the brain, but may be altered to shows the bones.

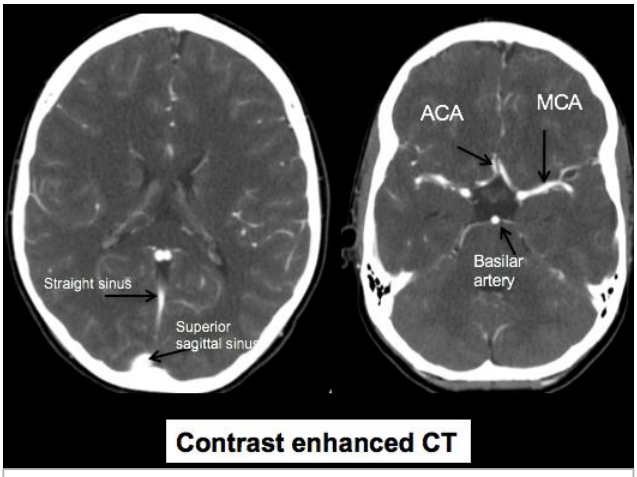


Contrast enhanced CT:

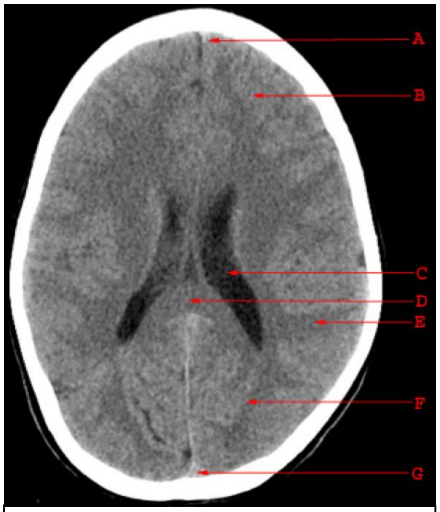
- IV injection of contrast medium is often given because the abnormality not seen in pre contrast scans may be rendered visible following contrast enhancement
- consequence of breakdown of blood brain barrier allowing contrast to enter the lesion particularly in neoplasm, infection, inflammation and certain stage of ischemia
- It is helpful in demonstrating blood vessels.

There are two types of CT contrast:

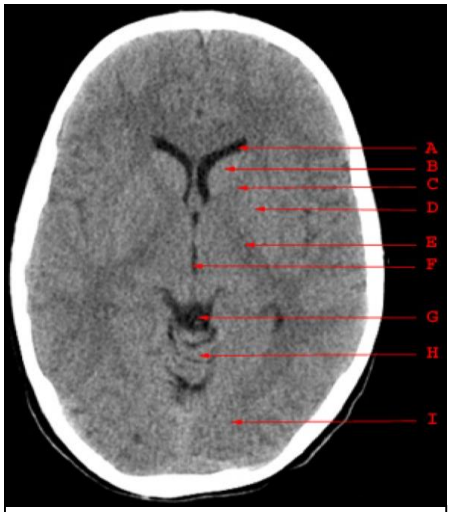
- **Computerized tomography angiogram (CTA):** demonstrates arteries.
- **Computerized tomography venography (CTV):** demonstrates veins. (same contrast but delay in taking image will make the contrast moves to venous system)



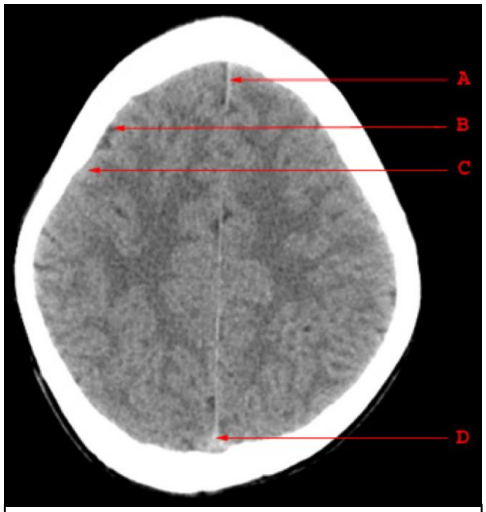
ACA: Anterior cerebral artery, MCA: medial cerebral artery



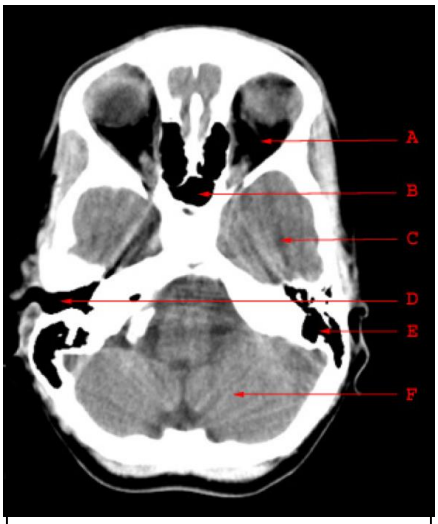
A. Falx Cerebri
B. Frontal Lobe
C. Body of the Lateral Ventricle
D. Splenium of the Corpus Callosum
E. Parietal Lobe
F. Occipital Lobe
G. Superior Sagittal Sinus



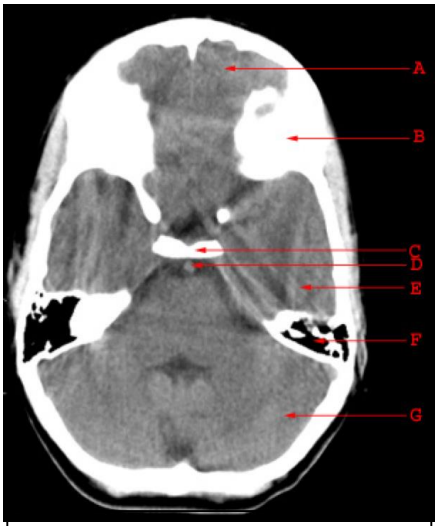
A. Anterior Horn of the Lateral Ventricle
B. Caudate Nucleus
C. Anterior Limb of the Internal Capsule
D. Putamen and Globus Pallidus
E. Posterior Limb of the Internal Capsule
F. Third Ventricle
G. Quadrigeminal Plate Cistern
H. Cerebellar Vermis
I. Occipital Lobe



A. Falx Cerebri
B. Sulcus
C. Gyrus
D. Superior Sagittal Sinus



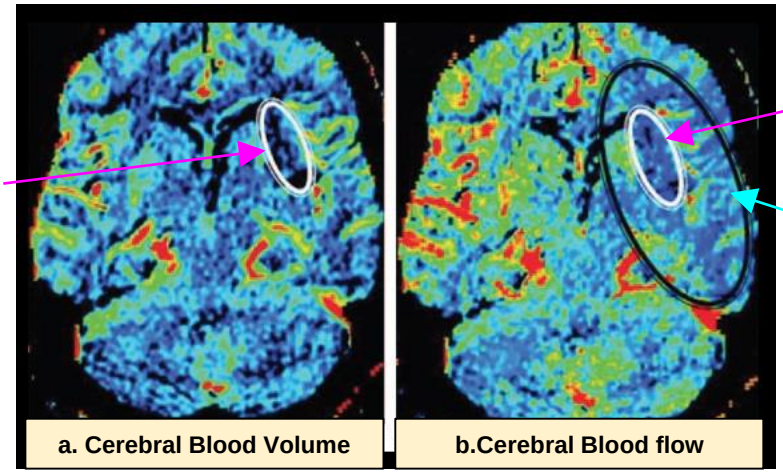
A. Orbit
B. Sphenoid Sinus
C. Temporal Lobe
D.Externa Auditory Canal
E. Mastoid Air Cells
F. Cerebellar Hemisphere



A. Frontal Lobe
B. Frontal Bone (Superior Surface of Orbital Part)
C. Dorsum Sellae
D. Basilar Artery
E. Temporal Lobe
F. Mastoid Air Cells
G. Cerebellar Hemisphere

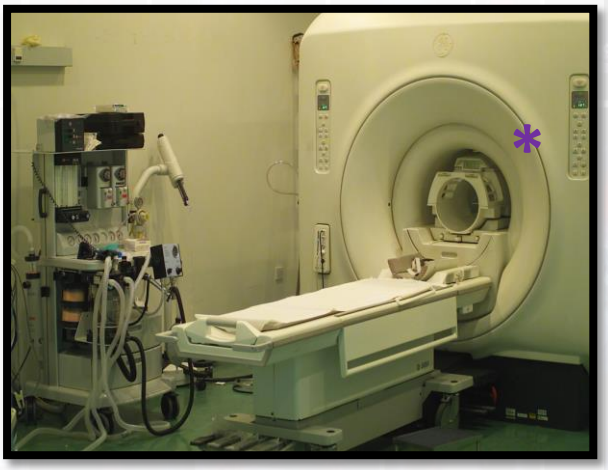
CT PERFUSION

- ★ **In acute stroke**, very early cranial CT may be normal. Perfusion CT shows great promise in refining the selection of patients suitable for thrombolysis,
- ★ It can accurately determine infarct core from potentially salvageable ischaemic penumbra.
- ★ Some cerebral tumours are associated with angiogenesis and a breakdown of the blood-brain barrier.
    - Angiogenesis can be detected as an increase in flow and volume parameters
    - Blood-brain barrier breakdown can be quantified as contrast accumulates in the interstitial space.
- ★ Such aggressive features can distinguish malignant from benign tumours when standard imaging may not.
- ★ CT perfusion is a very important technique to help clinician in emergency to know if this patient can benefit from thrombolytic agent or not .



MRI

-Could be the first technique nowadays of assessing the brain diseases
-This is a gantry*
-Comparing with CT, here we can't see what is behind the MRI
-Like a tunnel (cave) inside



-No ionizing radiation (Just microwaves & radio frequency pulses depends on what is going on through the magnetic field)
-Patient preparation: Nil unless fasting for general anesthesia.
-More safer for pregnancy but still it is C/I in the 1st trimester pregnancy
-We check if there is any metal inside the patient due to previous injury (such as: bullet)
-We ask the patient about any surgery with metal like prostheses in the bone, clips in intracranial. This maybe harm the patient or harm the technique itself → it cause some obscuring of the details of the brain
-Contrast medium: Gadolinium

-Indications:
1-strokes
2-tumours
3-infection
4-Vascular disorders
5-white matter disease
6-some cases of trauma

-Same indication of the CT but we start with stroke but here there is no trauma (come at the end)
-trauma patient needs faster technique
-Every patient with tumor should do MRI
-WMD such as Multiple sclerosis (adult) congenital white matter disease (pediatric)
-Not acute trauma, after few days if the patient is still there is some manifestation which not explained by the CT findings some times they are ordering MRI to check any other information which not easily can been seen on CT like axonal injury which make the patient very sick

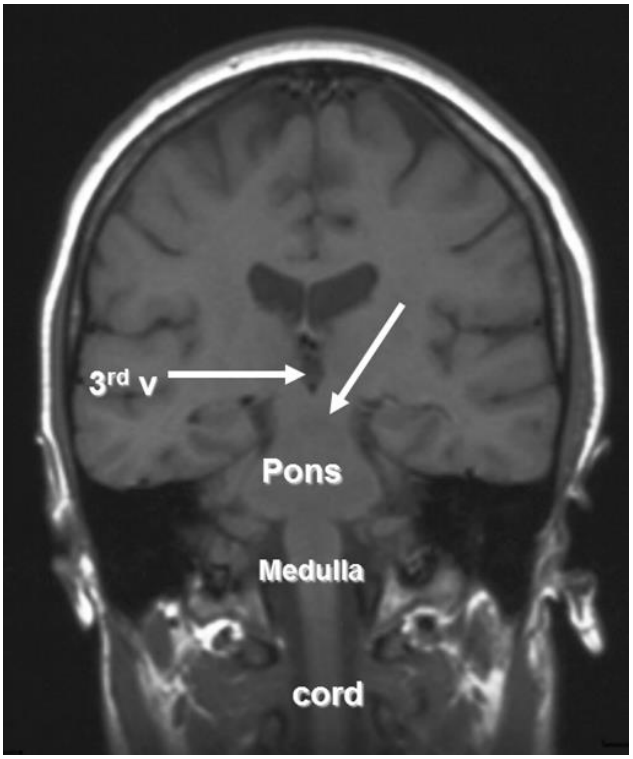
Contraindications(nowadays is changing) years ago MRI was absolute C/I in certain cases)

1-cardiac pacemaker Nowadays we ca perform MRI to them with certain precaution while using low magnetic field machine. (it measured by tessla T) in our unit we have machine with 3T (powerful machine) & other 2 machines 1.5T for cardiac pacemaker
+team of cardiology & physiology for the cardiac assessment should be with patient to adjust to get the pacemaker off during the exam
2-cochlear implants
3-ocular prostheses
4-intraocular ferrous foreign body(absolute C/I) maybe moved & rupture the eye globe)
5-neurostimulators
6-pregnancy (1st trimester)We don't know about the hazards yet (not proved until now) so it still better to avoid
7-claustrophobia

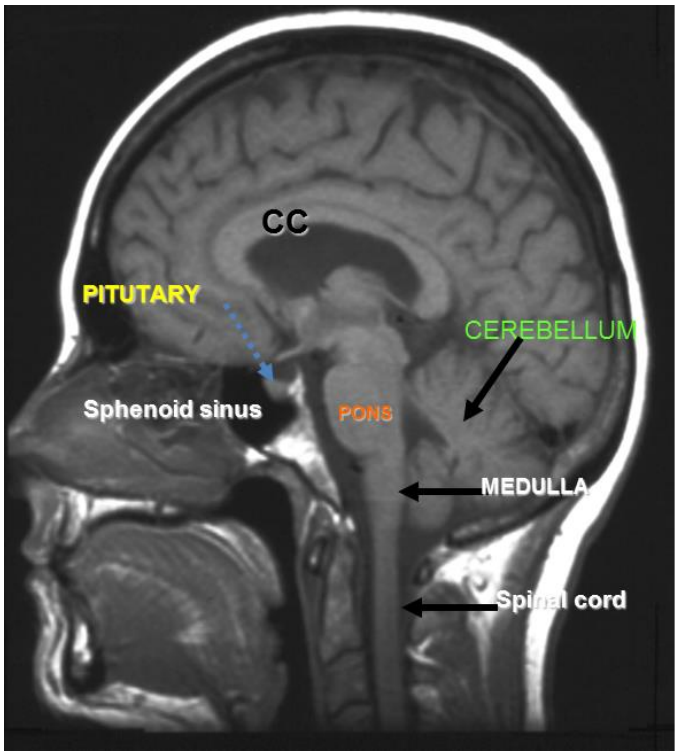
-MRI is a multiplanar technique (can produce direct images in Sagittal, axial and coronal planes) which is useful for assessment of extent of brain tumors and for better visualization of structures of posterior fossa and cranio-cervical junction.
CT→ it is in axial cut after that it is reconstructed

-MRI is a multisequential technique (can create images in T1WI, T2WI, FLAIR, gradient and other sequences). CT → only we can change bone –brain window

-It is possible to recognize flowing blood and therefore large arteries and veins stand out clearly without the need for contrast medium injection.
-Reading MRI is more complicated than CT

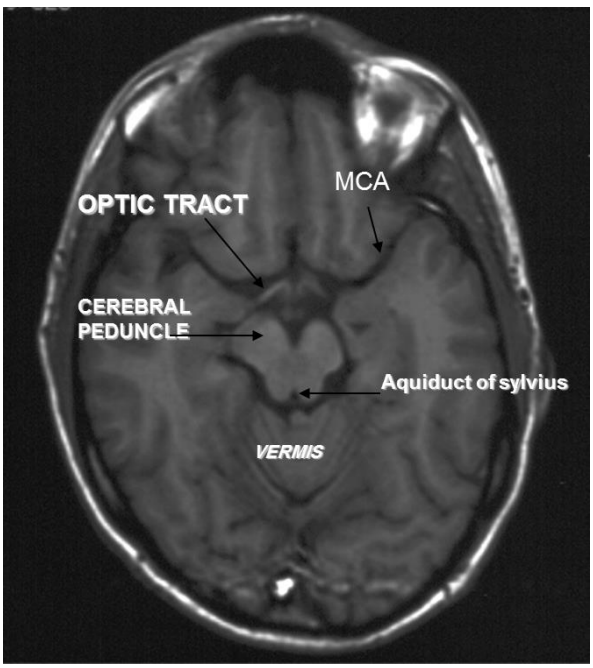


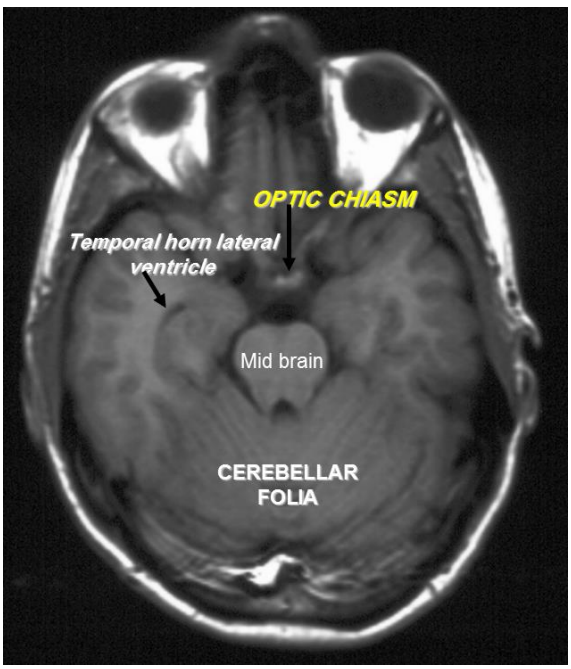
MRI BRAIN (CORONAL T1WI)



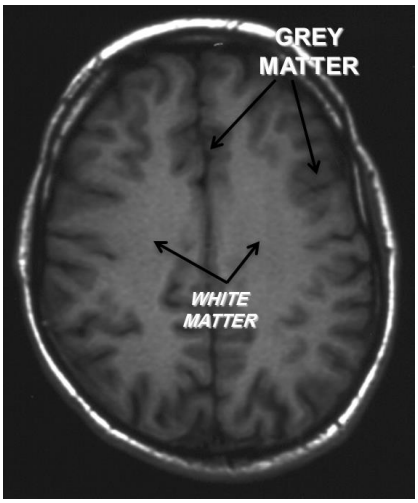
MRI BRAIN (SAGITTAL T1WI)

-Brain Parenchyma (gray and white matter) is better visualized in MRI than in CT
-CT → thick petrous bone in the lower cut → can produce artifacts (it is not easy to assess the brain stem in CT) but here no, the bone is not seen nicely in the MRI (no artifacts)
-So, we can assess brain stem & cerebellum nicely in MRI + we can see the anatomy of each part of the brain
-Even the vessel we can see them without contrast

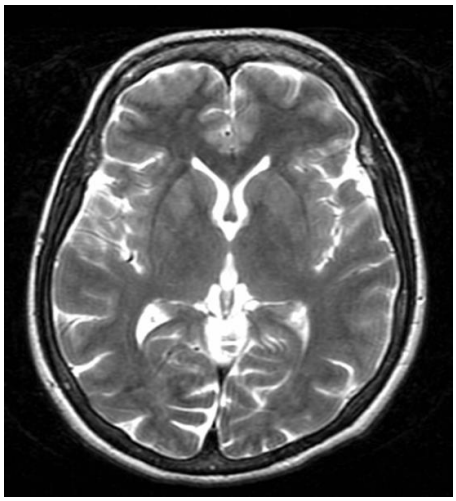




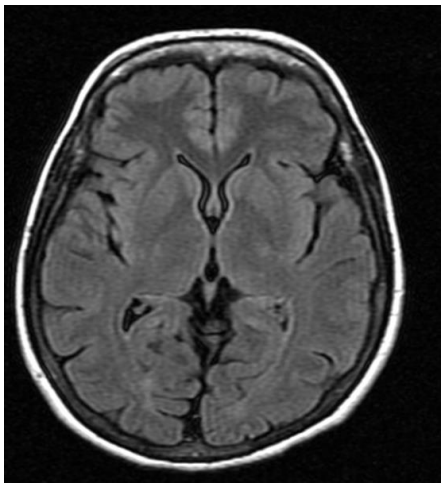
MRI BRAIN (AXIAL T1WI)



MRI BRAIN (AXIAL T1WI)



T2WI



FLAIR

The Characteristic signal intensity of brain structures in different MRI sequences:

	Grey matter	White matter	CSF
T1WI	grey	light	dark
T2WI	light	dark	white
FLAIR	light	dark	dark

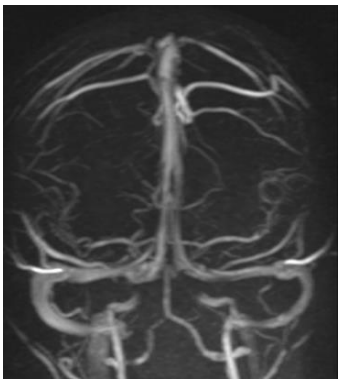
MR Angiography..

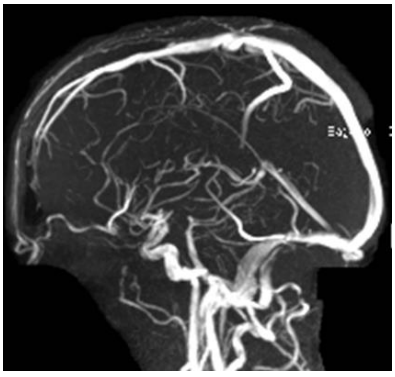
MRA Same as CT, assess the vessels
-Can be done without injection of contrast medium using time of flight technique.
-Can be used to assess intra and extra cranial arteries for any vascular abnormalities such as stenosis, occlusion or vascular malformation.
-We can do it without giving a contrast, it called time of flight technique → depends on the flow of the blood (& this is unique)

MR Venography..

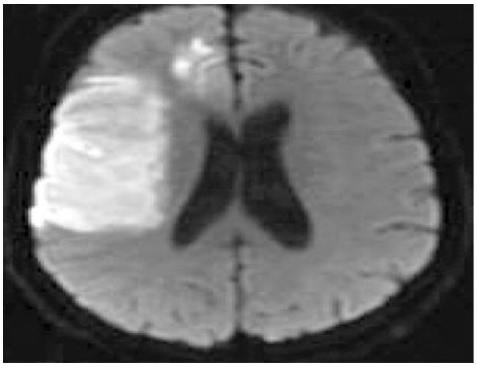
MRV

-Can be done either with or without injection of contrast medium.
-Assess venous dural sinuses superficial and deep venous system.
-Can confirm presence of venous thrombosis
-Assessment of the venous side of the vessels
-We can do it with time of flight as MRA but it is better to give contrast & this is what we called contrast enhanced MRV
-More sensitive technique with contrast

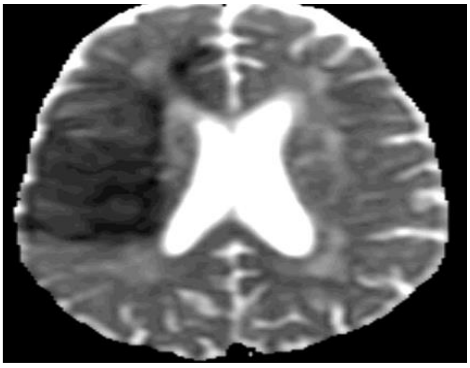




MRI Diffusion..



DWI



ADC map

Very helpful in assessment of:

1-Early brain infarction.
2-Brain abscess.
3-Certain types of brain tumor.

-One of the very important technique, very helpful sequence to detect early infraction.
-We know that infraction in CT can be seen either immediate after the onset or it maybe late up to 12 hours (sometimes 24 hours) so the patient have the symptoms & the signs of stroke but not seen in CT. MRI can detect the infraction just after starting of the onset (few minutes) by using this technique.
-So most sensitive sequence to detect early infraction is diffusion sequence → after that FLAIR → T2 → the least is T1.

-We are assessing the water molecules moving through the brain. When we said it is restricted, this means the fluid can't be moved easily within the brain parenchyma & this is what we calls diffusion restriction. If there is no diffusion restriction that means that the water can move easily passing through the brain parenchyma.

-What are the condition that produce restriction of water? One of these is the early acute arterial infraction (what we calls cytotoxic edema) the fluid is intracellular in early stroke → so the fluid inside the cells → so it is not easy to be moved within the brain (restricted).

-**How can we know that area have a restricted diffusion?** We have to assess the diffusion in two sequences
1-DWI (diffused weighted image)
2-ADC map (attenuated diffusion coefficient) the second image is post processing image (computer image) but the image of the patient is DWI

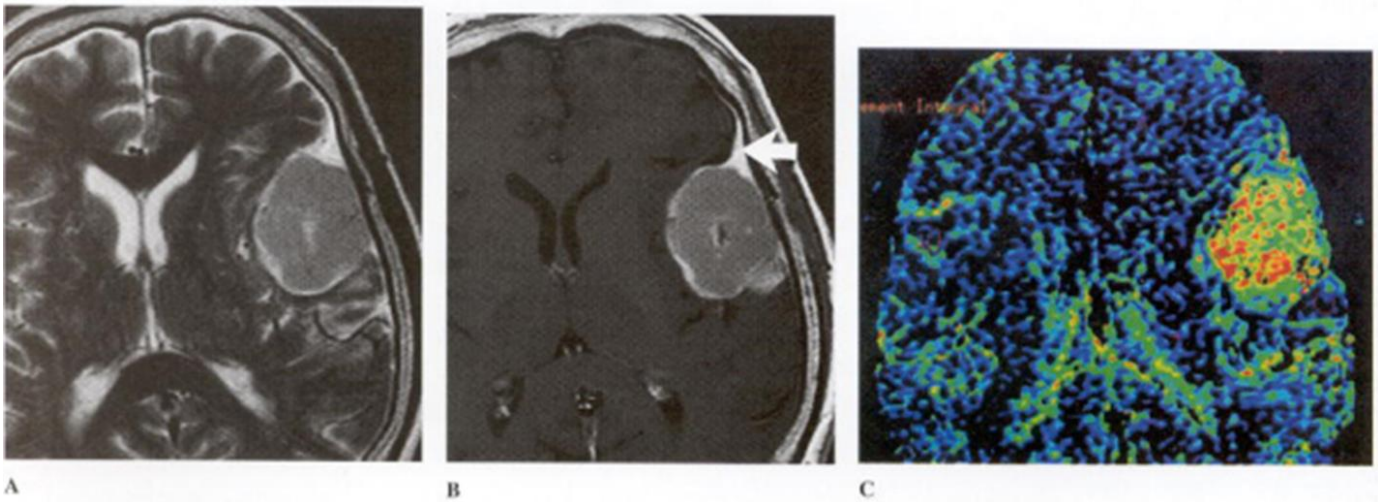
-**Why are we using the 2nd image which is the post processing image?**
To say this is a true diffusion restricted you have to see the area of diffusion restricted very bright on DWI & very dark or black on ADC map.
If you see the area of diffusion is bright on DWI & bright on ADC map this is not true diffusion restricted (so not consider a lesion of diffusion restricted)

-diffusion restricted it means water in this area can't move
In which conditions?
1-early arterial infraction. By time → diffusion will be less, the brightness will be less & the darkness is getting more bright. After one month you will not find any change in the brain in diffusion sequence.
2-certain types of tumors (such as high grade tumor)
3-pus (abscess)

-These 3 are shown the same image in this technique, after that comes the interpretation of many sequences & how it looks on T2, T1 & FLAIR and knowing the clinical finding to reach to the diagnosis

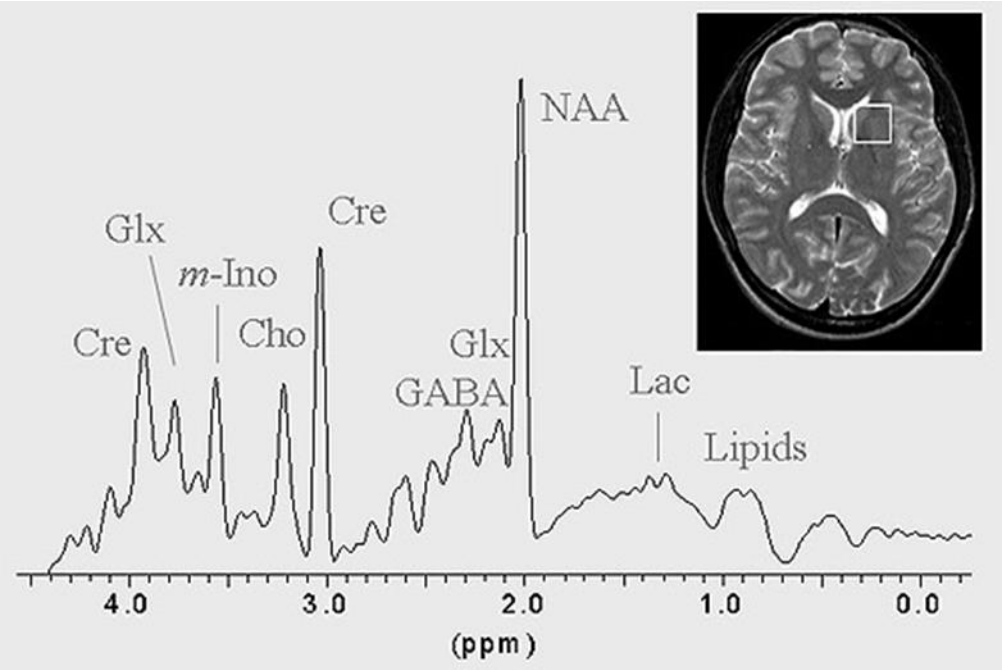
-Bright-bright (T2 shine through) there is no diffusion restricted, we can see the inherited character of T2 (T2 nature of the lesion itself)

Meningioma



T2 Contrasted T1 Perfusion-Weighted

MR Spectroscopy..

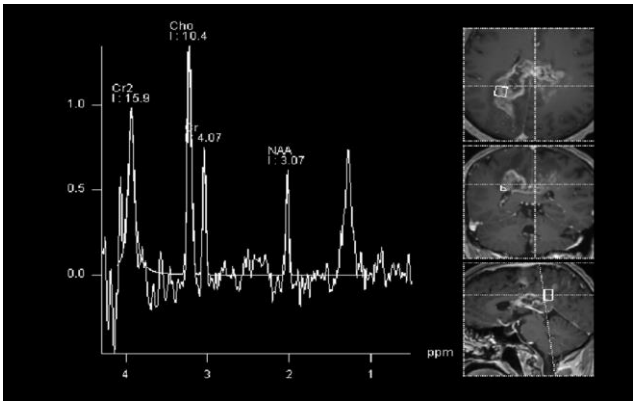


Unlike MRI, the technique of MRS does not generally produce images, instead creating spectra (see figure). Each peak in the spectrum arises from different brain metabolite (NAA, N-acetylaspartate; Cre, Creatine; Cho, Choline; myol, myo-Inositol; Lac, lactate; Glx, Glutamate and Glutamine; GABA, gamma amino butyric acid). The height of each peak is an indication of metabolite concentrations. The NAA peak arises from the neurons in the brain. Loss of this metabolite indicates damage or loss of neurons.

-A curve (Not an image)
-In each area of the brain there is a normal curve like this
-Height in the normal brain is almost stable
-If there is abnormality like brain tumor what will happen to the curve?
These ratio between the peaks of these metabolites will change like if we have Increase cho +cre , decrease aspartate → most likely it is a neoplastic process.
-If we got increase lac it could be a necrotic part of a tumor but if it is in white matter if could be part of congenital white matter disease in pediatric age.
-If there is myo insitol in certain areas in the brain this indicate multiple sclerosis.
-If we want to differentiate between tumor & infections we can use this technique.
-It is not specific but at least it is helpful.

MR Spectroscopy

Very helpful in:
-Differentiating neoplastic from non neoplastic processes.
-Differentiating benign from malignant tumors.
-Determination of certain types of tumors.
-Assessment of white matter diseases
-Assessment of neurodegeneartive diseases



MR Spectroscopy in GBM

CEREBRAL ANGIOGRAM..

-It is the gold standard technique for assessment of intra and extra cranial vessels.

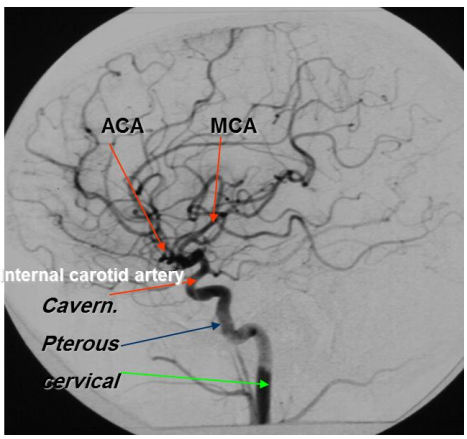
-It can demonstrate different vascular diseases (stenosis, occlusion, vascular malformation and blood supply of brain tumors.

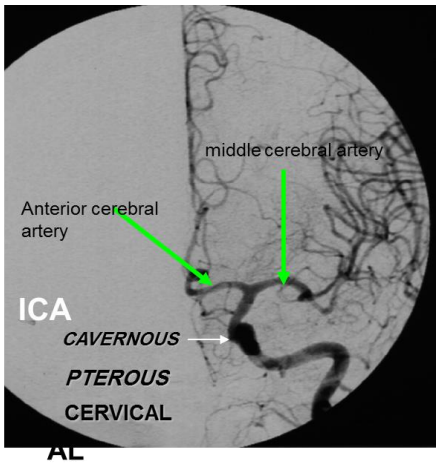
-It is an invasive technique.

-Recently its main role for intervention purposes such as treatment of vascular malformaion (aneurysm/arterovenous malformation) or pre operative embolization of vascular supply of tumor.

-It can assess the distal branches of the vessels (terminal vessels) which is less to be examine or assess by CT & MRI
-Not only for diagnosis but also for management
-CT & MRI → diagnosis, after that if we need intervention we can use cerebral angiogram

Internal carotid angiogram lateral view

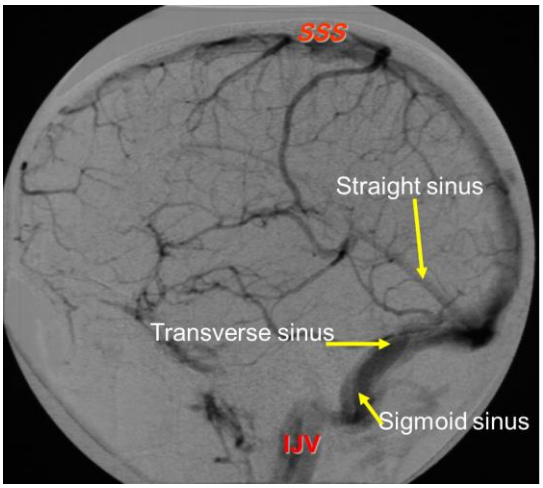




Internal carotid angiogram AP

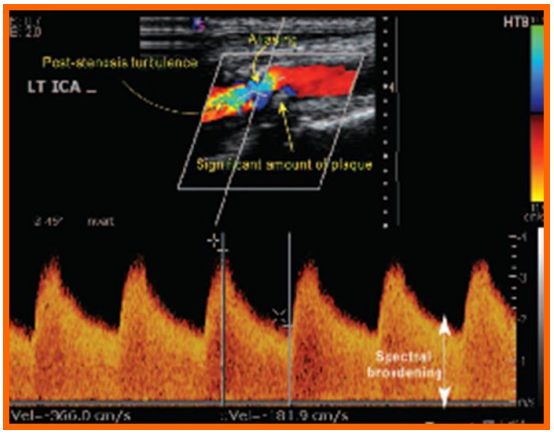
VENOUS PHASE CEREBRAL ANGIOGRAM..

Difference between CA & MRA
-CA → puncture the artery → put wire (catheter) come to the area that need to be assessed (in the brain)
-MRA → not invasive → in the peripheral vessels (hands)



CAROTID DOPPLER..

-One of the easiest way to assess the vessels of the neck
-For any stenosis + can measure the degree of stenosis (important for vascular surgeon to know if the patient need surgery or not)
-assess the blood flow

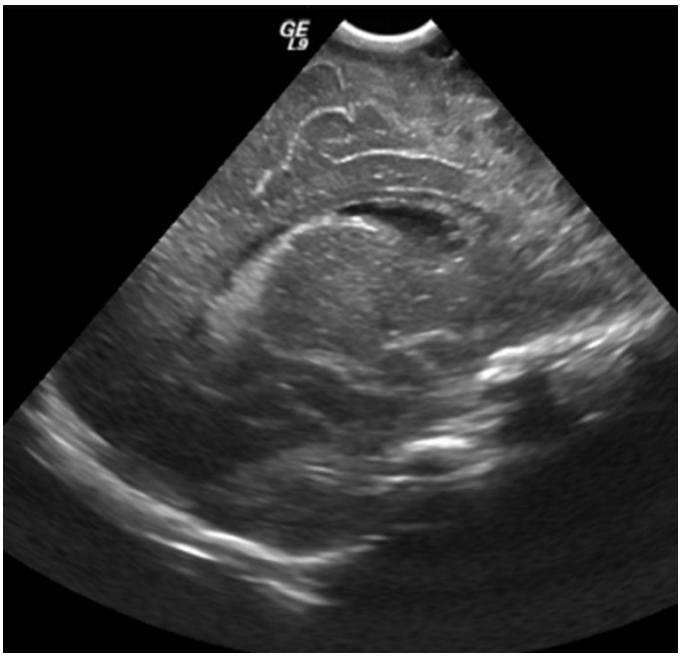


ULTRASOUND NEONATAL BRAIN..

- It is a simple and easy way to scan the head of neonates and young babies.
- Not using ionizing radiation
- Scanning is best done through an open fontanelle.
- Little discomfort to the baby.
- Readily carried out even on ill babies in intensive care units.
- It has proved particular useful in detecting ventricular dilatation (hydrocephalus), intracerebral hemorrhage and congenital abnormality of the brain

-It assess the gross pattern of the brain pathology
-Not specified for white matter disease
-It is the best to be done in the opening area of the frontal head (because it can't go through bone)

CORONAL



SAGITTAL

Just rotating the US probe we can get:

1-axial
2-coronal
3-sagittal

Don’t Forget !

- Plain X-ray has limited use, only for fractures and metastases.
- CT and MRI are the best and considered standard investigation for brain imaging.
- Trauma patient needs faster technique (CT)
- Every patient with tumor should do MRI
- intraocular ferrous foreign body is an absolute C/I in MRI
- We can assess brain stem & cerebellum nicely in MRI + we can see the anatomy of each part of the brain
- Even the vessel we can see them without contrast in MRI
- MRI diffusion is very helpful in assessment of:

1-Early brain infarction.

2-Brain abscess.

3-Certain types of brain tumor.

- CEREBRAL ANGIOGRAM is the gold standard technique for assessment of intra and extra cranial vessels.