Lecture 7:

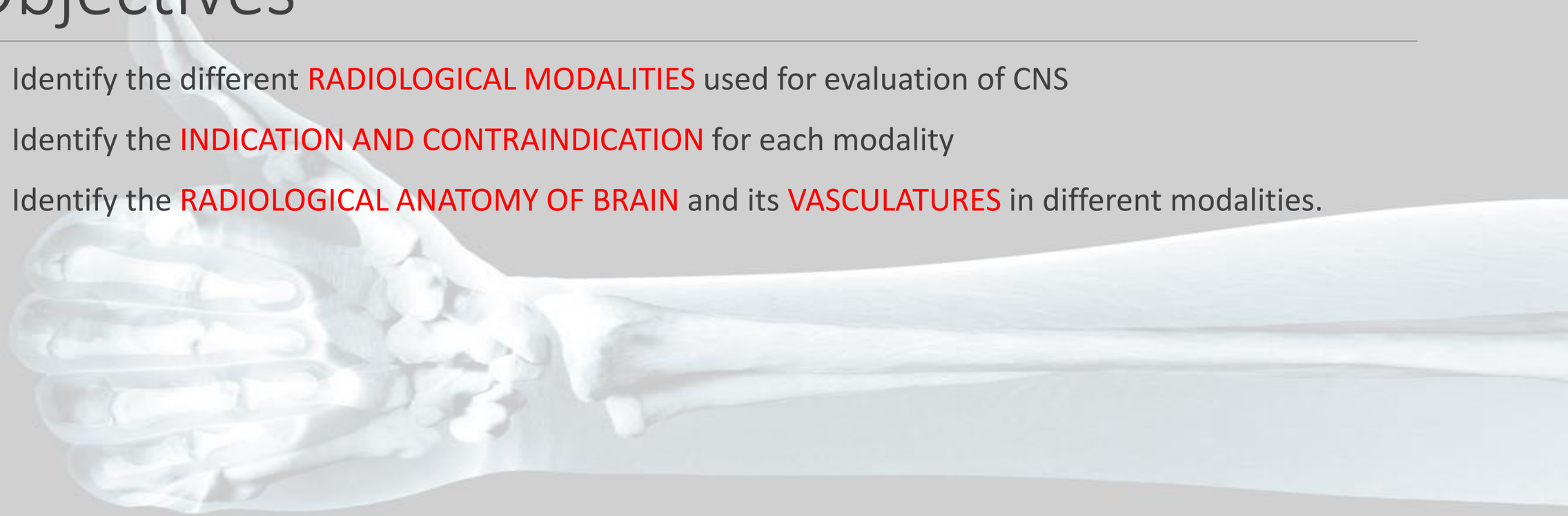
Anatomy & investigation of CNS

Radiology Team
Med433

● Slides ● Explanation ● Notes ● Additions ● Important

Objectives

1. Identify the different RADIOLOGICAL MODALITIES used for evaluation of CNS
2. Identify the INDICATION AND CONTRAINDICATION for each modality
3. Identify the RADIOLOGICAL ANATOMY OF BRAIN and its VASCULATURES in different modalities.



Overview of the modalities which will be discussed in details in the lecture

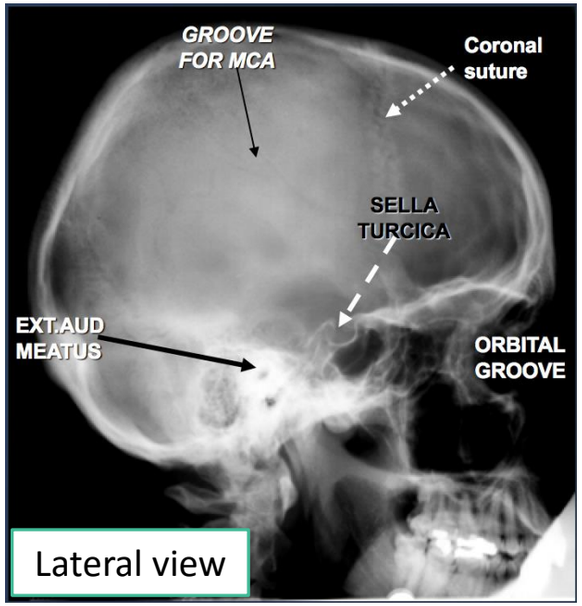
1. Plain x-ray	Skull fractures, metastasis (limited view and use) (Cant asses brain parenchyma)
2. CT scan	Best and standard investigation for brain imaging
3. MRI	
3.1 MRA, 3.2 MRV , 3.3 CTA 3.4 CTV	To assess the vessels (Arteries and veins)
4. Catheter angiogram	Used to treat (intervention) rather than to diagnosis
5. Duplex ultra sound of carotid arteries	(Asses neck vessels and some of the arteries in the superficial part of the brain)
6. Ultrasound for neonates	

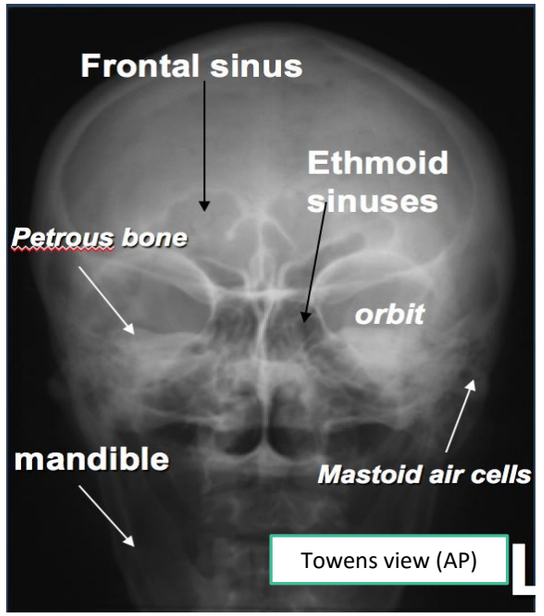
1. Plain X-Ray limited uses

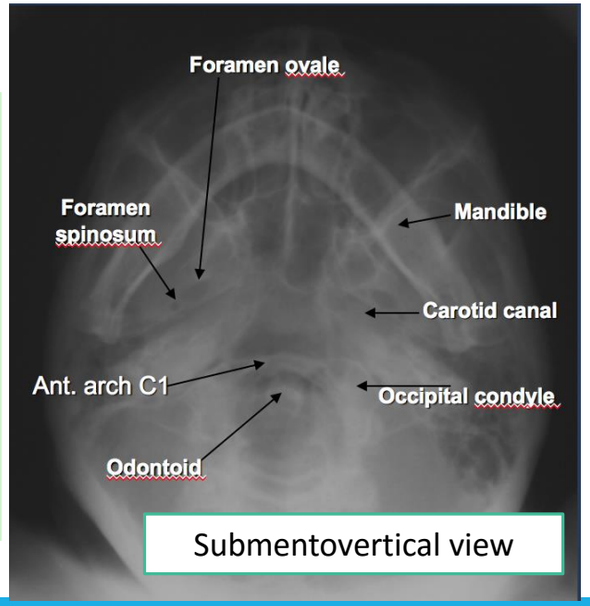
Indications :

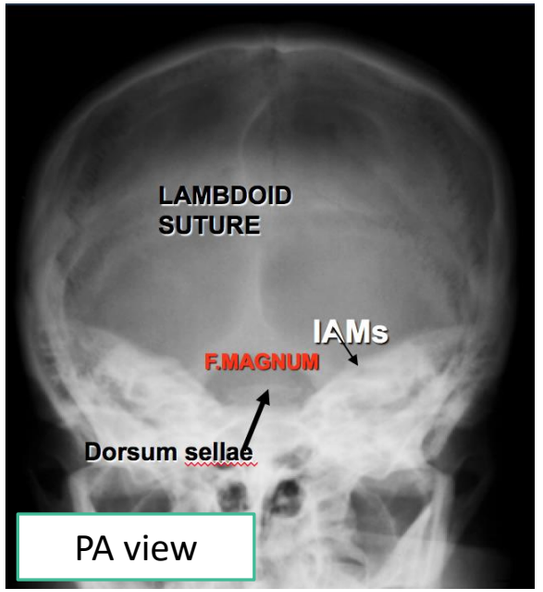
1. **Trauma**
2. **Congenital (size of the skull: either microcephaly or macrocephaly)**
3. **Calcification: normal or abnormal (vascular ,neoplasm)**
4. **Metastasis: osteolytic or osteoblastic /sclerotic**
5. **Multiple myeloma**
6. **Metabolic disorders**

There are certain views used for assessment skull x ray :
it depends on patient position how the patient lie or sitting
and x ray tube where is located or is it directed to the patient.
1)lateral view:Patient is sitting or standing in the lateral position: it demonstrates bone of the skull , suture , sella turcica .
2) occipitofrontal (posteroanterior) view : patient facing the film and x ray tube from the back of the skull .
3)Towens (anteroposterior) view : asses petrous bone .
4)Submentovertical view









2. CT scan 

- Spiral CT can be performed in 15 minutes (for whole body: from head to toe) pre & post contrast scans.
- The scan of the brain takes as little as 10 seconds.
- No preparation is needed for CT scan. But Some patients need preparation for contrast or anesthesia (not for the CT itself)
- **Type of the contrast medium:** iodinated contrast (same that used in IVU=intravenous urogram) , (non ionic L.O.C.M) .
- **Disadvantages:** Using ionizing radiation.
- **Contraindication:** pregnancy (but it's relative contraindication and can be preformed with using apron).
- The axial plane is the routine projection, but it is sometimes possible to obtain direct coronal but tell now we cant get sagittal cut from CT scan but we can obtain sagittal cut by reformatting imaging .
- The window settings are selected for the brain, but may be altered to show the bones.
- CT scan for brain has 2 windows: brain & bone window , so if we need to asses brain parenchyma this called brain window , if we need to asses the bone this called bone window .

Indications for CT scan	
Trauma	1st line for trauma in EG
Detection of blood	Detect hematoma, stage of hematoma & place of it.
Strokes (CVA)	1st choice for imaging especially in emergent causes (MRI is more sensitive to detect early strokes. But CT can is faster and time is brain).
Tumors	Can be detected easily by CT scan, and has almost same sensitivity as MRI.
Infection	
Vascular disorders	

2. cont. CT scan

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

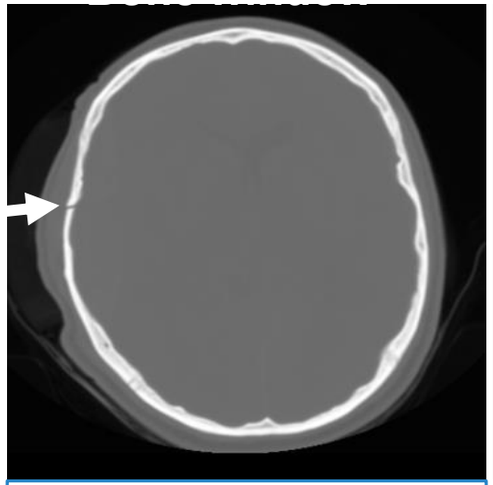
Planes used in CT

Sagittal reconstruction

Coronal reconstruction

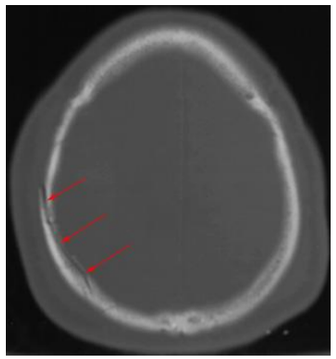
Axial plane

Windows of the CT



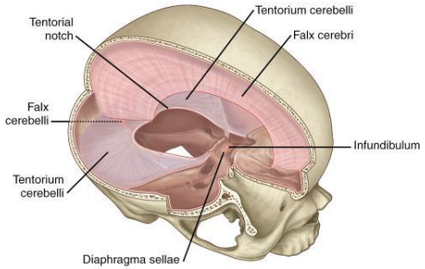
Bone window shows fracture (see the arrow)

Brain window shows acute extradural hemorrhage (see the arrow)



Bone window shows fracture (see the arrows)

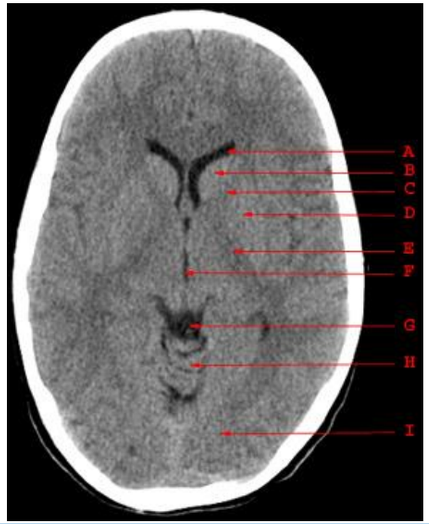
2.1 Normal CT scan



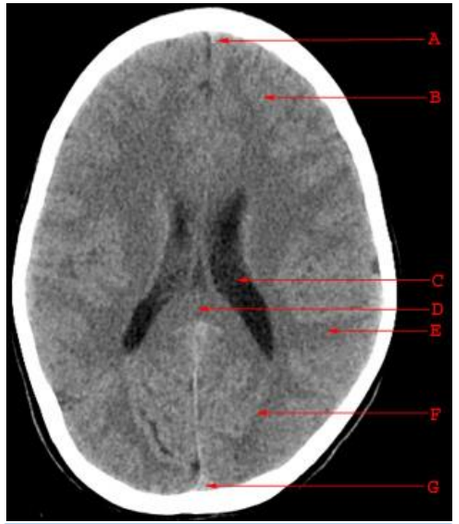
- **CSF** is seen as water density (**black**) within ventricular system and subarachnoid space.
- Grey matter is differentiated from white matter (**white matter is relatively darker than grey matter**).
- The **falx (midline)** is **denser than the rest of the brain parenchyma .**
- Large arteries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

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

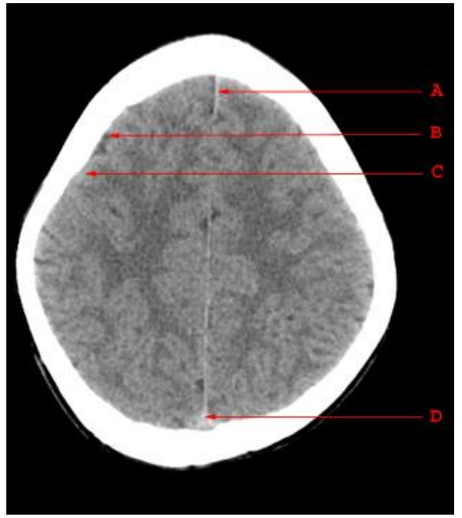
A. Frontal Lobe
B. Frontal Bone (Superior Surface of Orbital Part)
C. Dorsum Sellae
D. Basilar Artery
E. Temporal Lobe
F. Mastoid Air Cells
G. Cerebellar Hemisphere



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



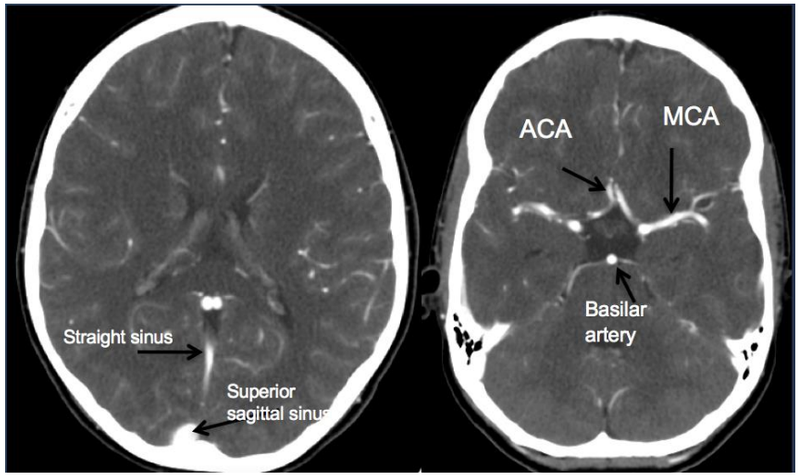
A. Falx Cerebri
B. Frontal Lobe
C. Body of the Lateral Ventricle
D. Splenium of the Corpus Callosum
E. Parietal Lobe
F. Occipital Lobe
G. Superior Sagittal Sinus



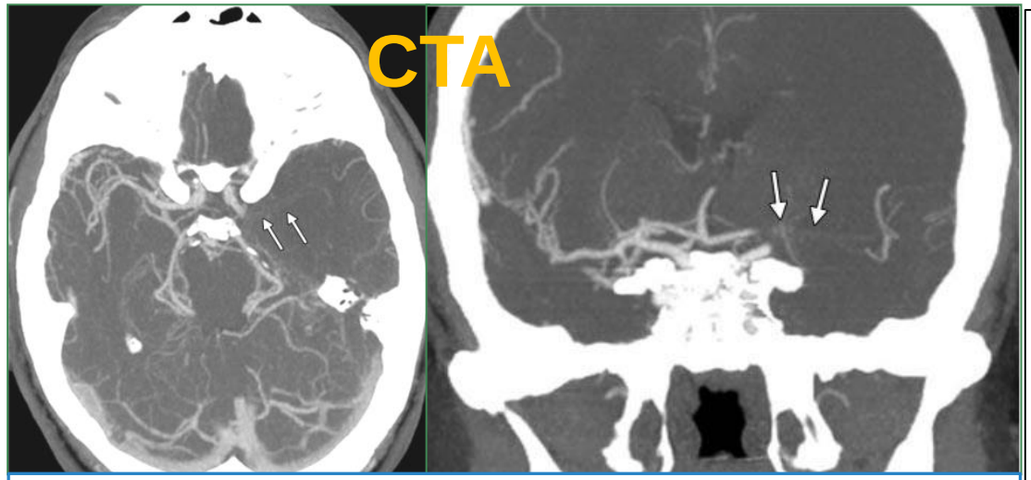
A. Falx Cerebri
B. Sulcus
C. Gyrus
D. Superior Sagittal Sinus

2.2. contrast-enhanced CT scan

- 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.
- **Type of the contrast medium:** iodinated contrast (same that used in IVU=intravenous urogram) , (non ionic L.O.C.M) .
- Also 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).
- is helpful in diagnosis of vascular diseases and abnormalities such as stenosis, occlusion or vascular malformation.



- ACA: Anterior cerebral artery
- MCA: medial cerebral artery

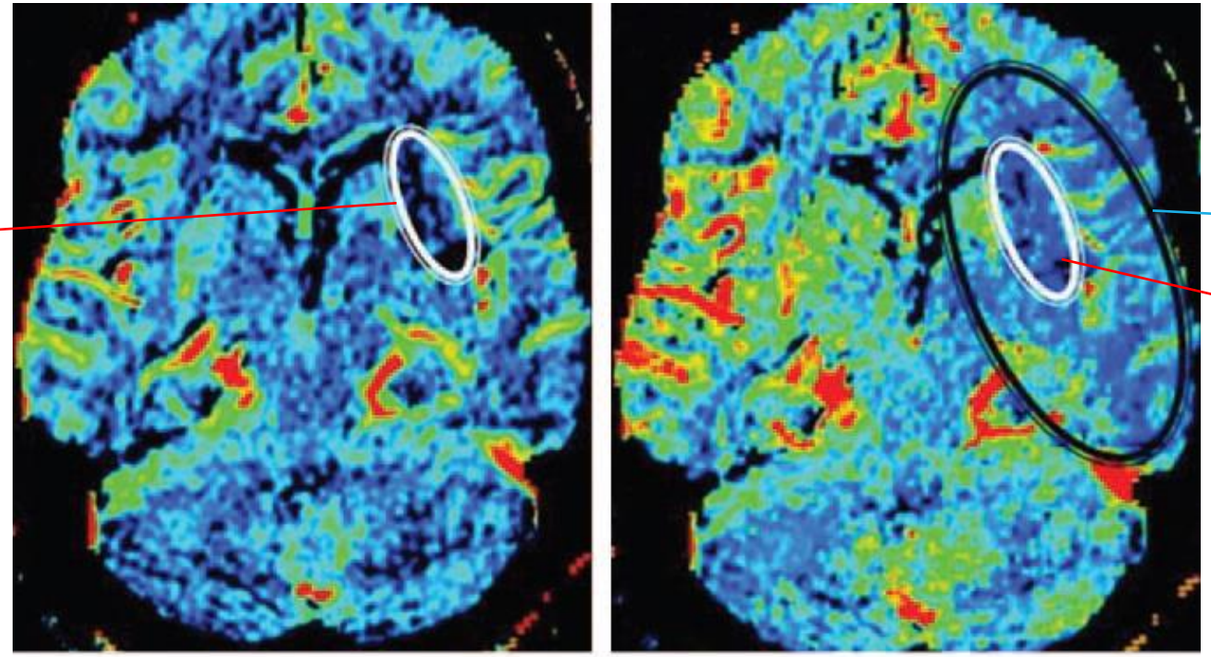


Occlusion of left middle cerebral artery

CT angiography is helpful in diagnosis of vascular diseases and abnormalities such as stenosis, occlusion or vascular malformation.
CTA is used to asses a case of acute stroke and localized which vessel is occluded and if patient needs intervention we can shift to the angiogram .

2.3 CT Perfusion

- Asses perfusion of the blood through the brain parenchyma.
- In acute stroke, very early cranial CT may be normal.
- Perfusion CT shows great promise in refining the selection of patients suitable for thrombolysis, as it can accurately determine infarct core from potentially salvageable ischemic penumbra.
- Some cerebral tumors are associated with angiogenesis and a breakdown of the blood-brain barrier. Angiogenesis can be detected as an increase in flow and volume parameters, and blood-brain barrier breakdown can be quantified as contrast accumulates in the interstitial space. Such aggressive features can distinguish malignant from benign tumors when standard imaging may not.



a. cerebral blood volume

b. cerebral blood flow

CT perfusion is a very important technique to help clinician in emergency to know if this patient can benefit from thrombolytic agent or not .

3. MRI

- Non-ionizing radiation
- Patient preparation: Nil unless fasting for general
- Anesthesia.
- Contrast medium: Gadolinium (reaction is less)
- MRI is a multiplanar technique (can produce 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.
- MRI is a multisequential technique (can create images in T1WI, T2WI, FLAIR, gradient and other sequences).
- It is possible to recognize flowing blood and therefore large arteries and veins stand out clearly without the need for contrast medium injection.

IMPORTANT !

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

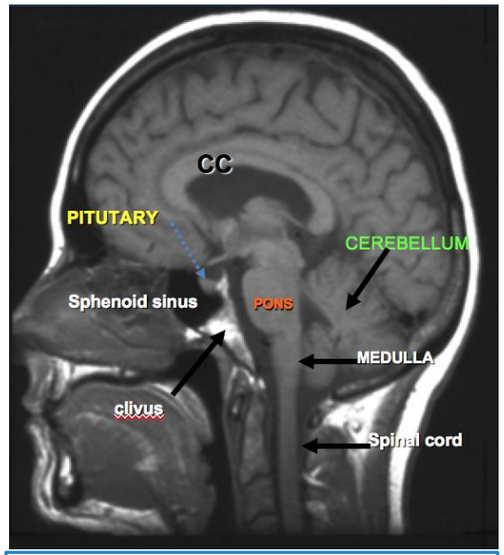
	Grey matter	White matter	CSF
T1WI	Grey	light	Dark
T2WI	Light	Dark	White
FLAIR	Light	Dark	Dark*

*All fluids that present within ventricular systems are dark in FLAIR, except interstitial fluids (e.g., edema) appear very bright. that's why FLAIR is better in detection of brain edema .
-T2WI is the only sequence that has white CSF / FLAIR is similar to T2WI except the CSF

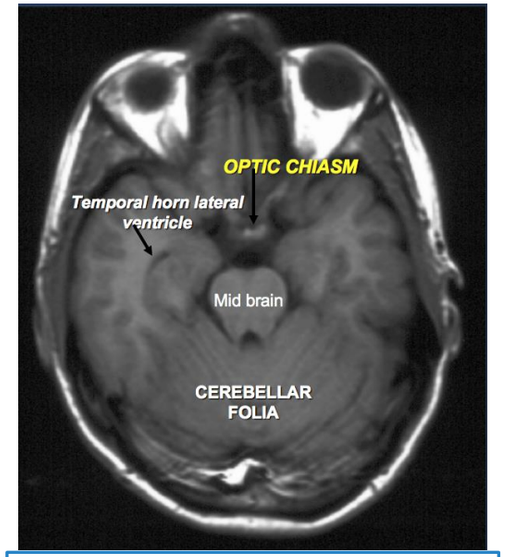
Indication almost the same as indication in CT but arrangement is different.
In CT the first priority is trauma but in MRI is stroke .

Indications of MRI scan	
Strokes	More sensitive than CT & can detect the stroke earlier
Tumors	Detect hematoma, stage of hematoma & place of it.
Infection	
Vascular disorders	
White matter disease	One of the diseases which is nicely demonstrates by MRI .
Some cases of trauma	If the clinical scenario doesn't correlate with CT e.g. diffused axonal injury.

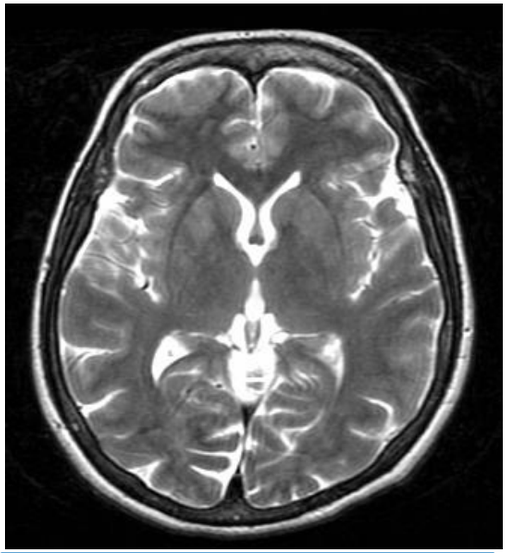
Contraindication for MRI scan	
cardiac pacemaker	Relative contraindication (depends on the type of cardiac pacemaker some are MRI-compatible.
cochlear implants	Relative contraindication
ocular prostheses	
intraocular ferrous foreign body	Absolute contraindication
neurostimulators	
pregnancy (1st trimester)	Relative contraindication
claustrophobia	Can use open-MRI



MRI BRAIN (SAGITTAL T1WI)



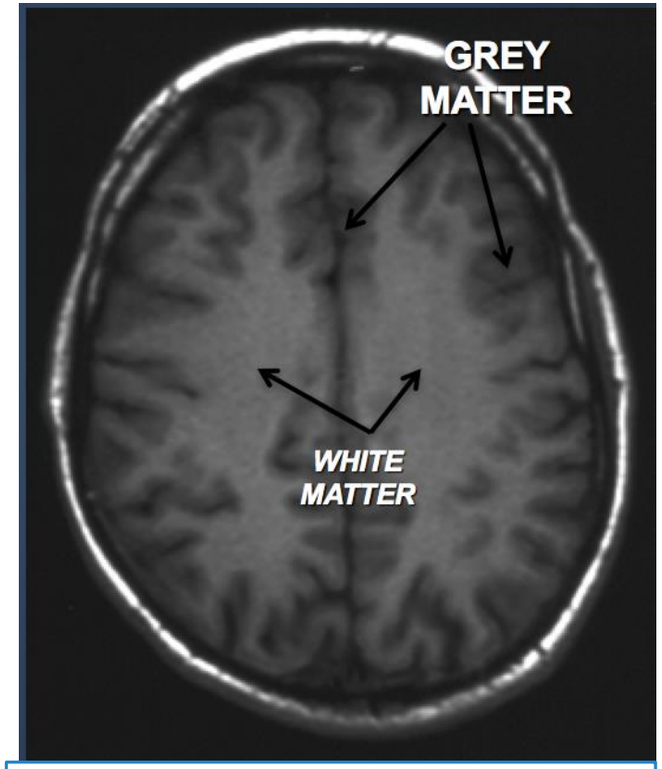
MRI BRAIN (AXIAL T1WI)



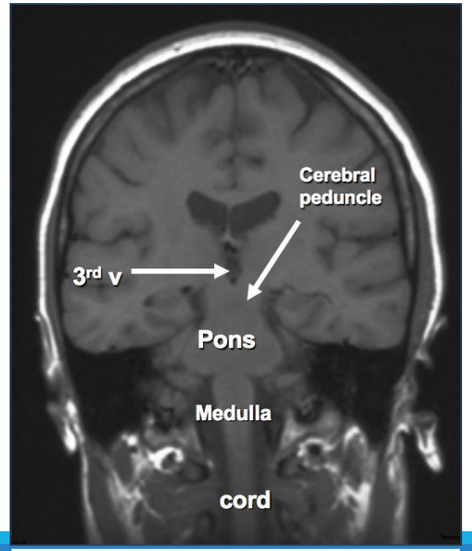
T2WI

Radiology team 433 in CNS block:

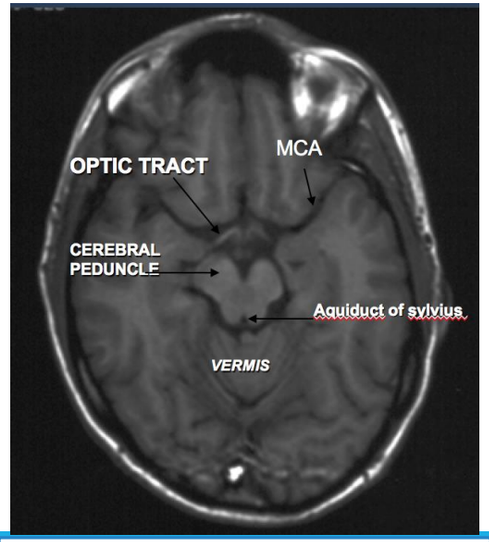
T2WI lights up CSF: You can use this phrase to help you remember – "T2 H2O."



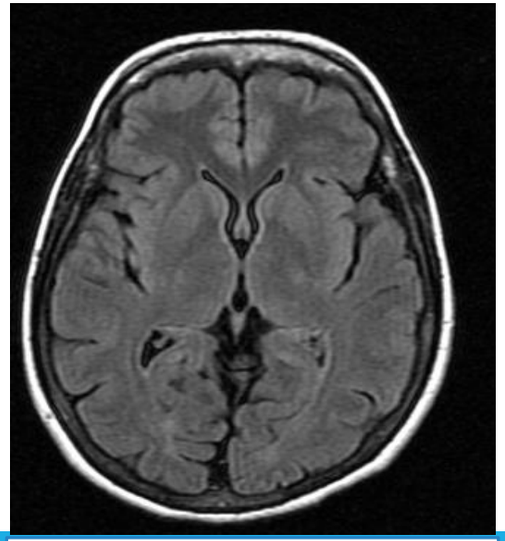
MRI BRAIN (AXIAL T1WI)



MRI BRAIN (CORONAL T1WI)



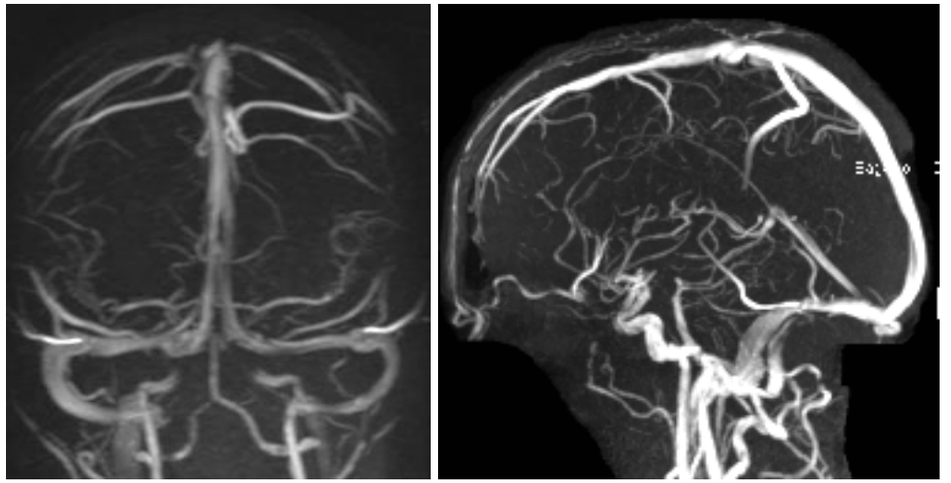
MRI BRAIN (AXIAL T1WI)



FLAIR

3.1 MR Angiogram & Venogram

- **MRA**
  - Unlike CTA, it Can be done with or 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.
- **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 .
  - 2 techniques of MRV : **Contrast enhanced MRV with contrast and phase contrast MRV without contrast.**

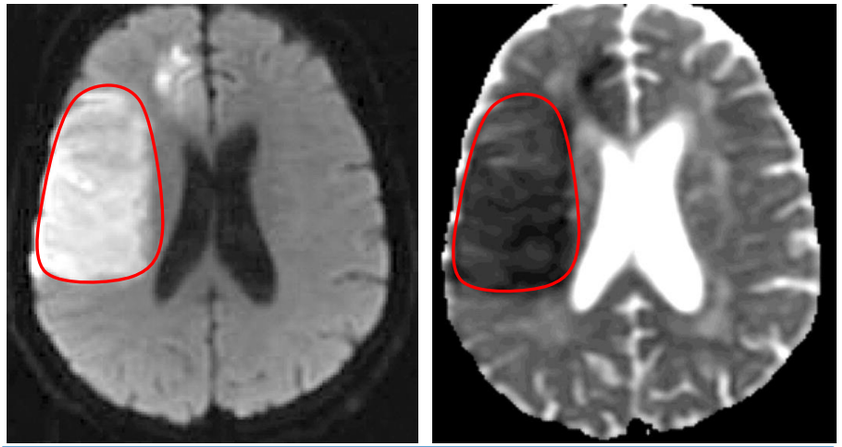


MRV

For pregnant women, we can use MRA or MRV without contrast and there are superior to CT which required contrast .

3.2 MR diffusion

- **MR diffusions very helpful in assessment of:**
  - Interpretation for the picture in the right: TRUE diffusion restriction (white in DWI & Black ADC map).
  - TDR indicates certain types of pathology: **acute infarction** (The most sensitive technique to detect early infarction), certain type of brain tumors , pyogenic brain edema and brain abscess .



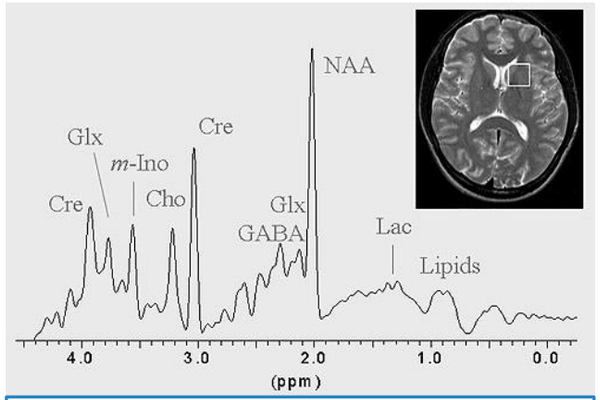
DWI ADC map

MRI diffusion

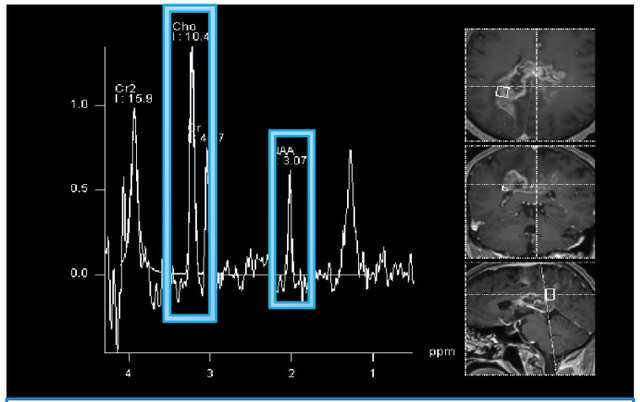
MRA

3.3 MRI 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; myoI, 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.
- 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 neurodegenerative diseases



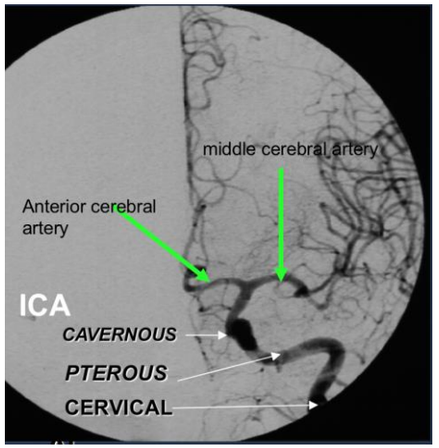
Normal MRI spectroscopy



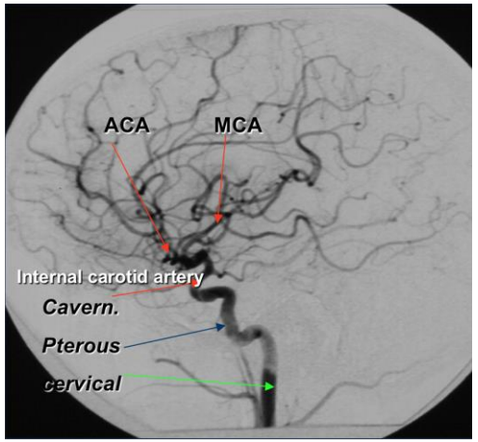
Glioblastoma (High choline and low NAA)

4. Cerebral Angiogram

- It is the gold standard technique for assessment of intra and extra cranial vessels.
- Invasive technique & not used frequently anymore.
- It can demonstrate different vascular diseases (stenosis, occlusion, vascular malformation and blood supply of brain tumors.
- Recently its main role for intervention purposes such as treatment of vascular malformation (aneurysm/arteriovenous malformation) or pre operative embolization of vascular supply of tumor.



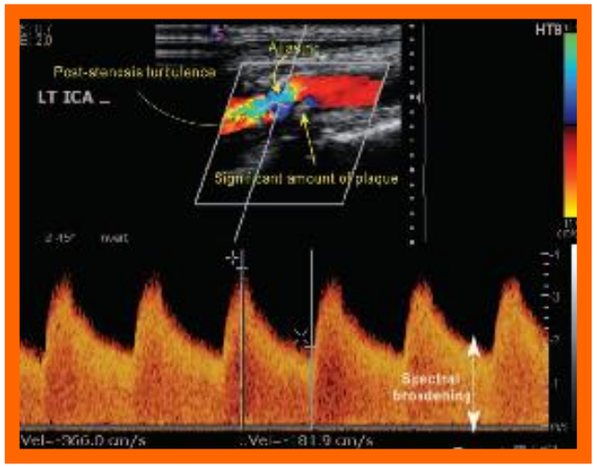
Internal carotid angiogram AP



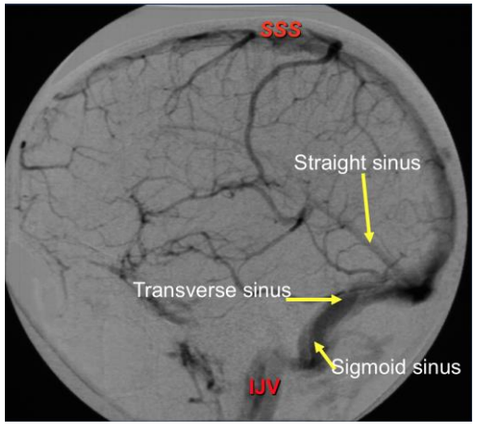
Internal carotid angiogram lateral view

5. Carotid Doppler

- Easiest way to assess the extra cranial vessels of the neck .
- Gives information about:
  - Diameter of the vessels
  - Flow of the blood
  - Estimate degree of the stenosis
  - Etiology of the stenosis



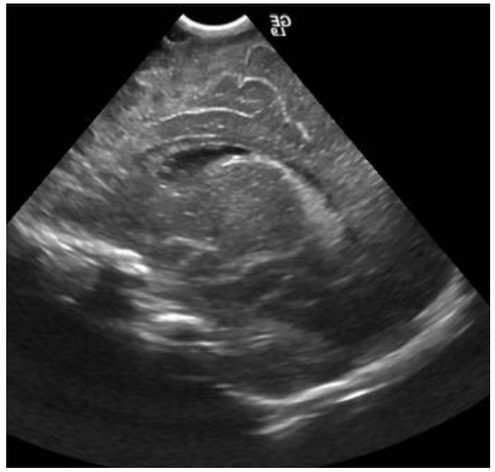
Carotid Doppler



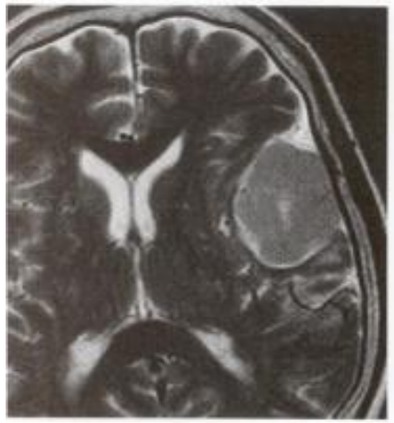
Venous phase

6. Ultrasound Neonatal Brain:

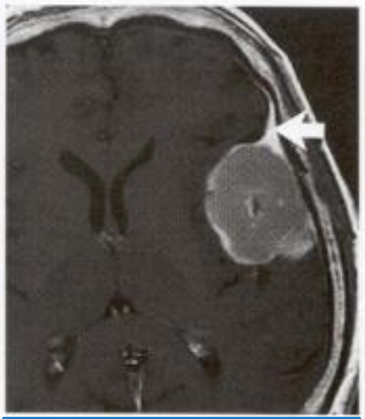
- It is a simple and easy way to scan the head of neonates and young babies.
- Not using ionizing radiation
- Scanning is best done through an open fontanelle.
- Little discomfort to the baby.
- Readily carried out even on ill babies in intensive care units.
- It has proved particular useful in detecting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



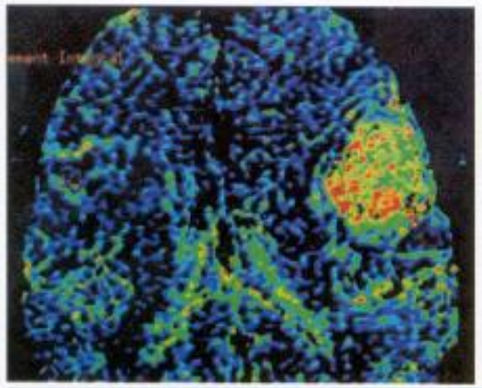
Case of meningioma:



T2



Contrasted T1



Perfusion-Weighted

Thank You!

We hope you found this helpful and informative.

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