Radiology Team 429

ANATOMY AND INVESTIGATIONS OF NERVOUS SYSTEM

Lecturer: Dr. HAMDY HASSAN

Lecture Date: 10-3-2012

Radiology Team 429

In this team we used the outlines from the:

Doctor's slides

Lecture notes are in red boxes

427 Radiology team

Diagnostic Imaging –PETER ARMSTRONG – 6Th Edition

Sorry we don't hold responsibility for any missing information or perhaps – perhaps -wrong material.

We tried our best to present this lecture in the best way, and we hope what we wrote is enough to cover the subjects.

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Notes are in red and orange

Best Wishes :)

Lecture Objectives

Students at the end of the lecture will be able to:

- Identify the different radiological modalities used for evaluation of CNS
- Identify the indication and contraindication for each modality
- Identify the radiological anatomy of brain and its vasculatures in different modalities.

The Radiological Investigation Used For Evaluation of The Brain and Skull

- **1.Plain x-ray Skull:** seldom used for imaging
- **2.CT Scan**
- **3.MRI**

The most important methods to asses the brain & skull

- **4.MRA** (Magnetic resonance angiogram), **MRV** (Magnetic resonance venography) **& CTA** (assigns the arteries using CT) :

MRA + MRV are non-invasive (without the use of catheter) vascular imaging

- **5.Catheter angiogram**
- **6.Duplex U/S of carotid arteries** (extra-cranial vessels)
- **7.Ultrasound for neonatal brain**

The Radiological Investigation Used For Evaluation of The Brain and Skull

- The newer imaging modalities have had a great impact on the diagnosis of diseases of the central nervous system.
- CT and MRI have become the standard investigations for disorders of the brain.
- Plain films are still the initial investigation for disorders of the bones of the skull – particularly fractures, but otherwise have limited uses.

1. Plain x-ray skull

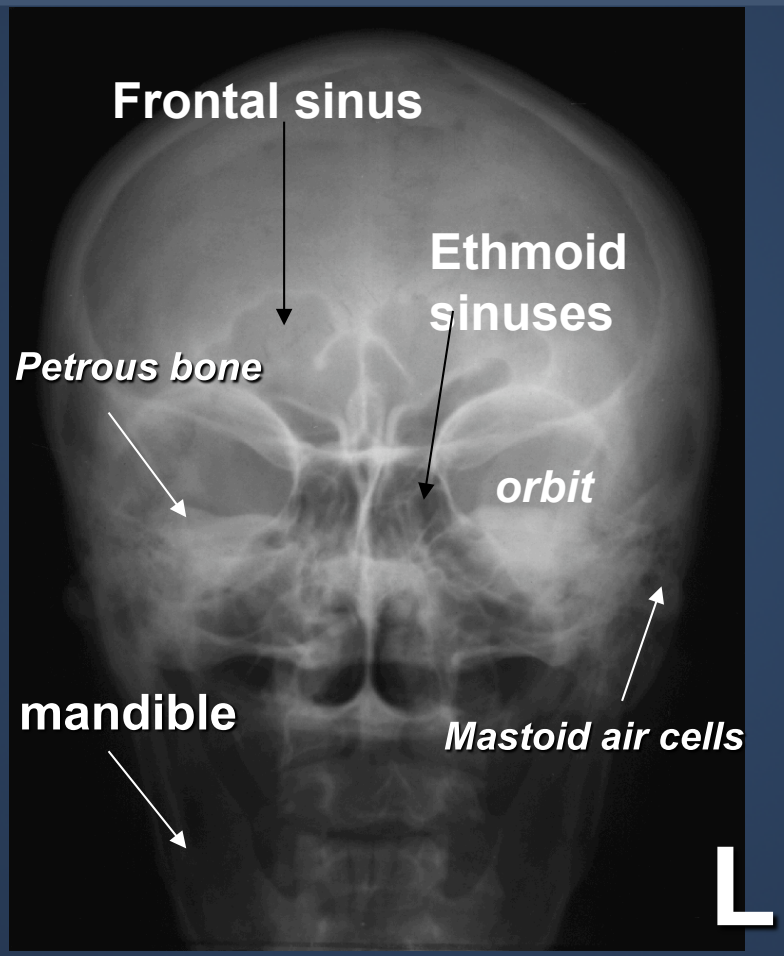
Indications:

- **trauma** (mild trauma CT now is used instead)
- **congenital** anomalies (e.g. microcephaly)
- **calcification: normal or abnormal (vascular ,neoplasm)**
- **metastasis to** skull**: lytic /sclerotic**
- **multiple myeloma**
- **metabolic disorders**
- Fractures of the skull

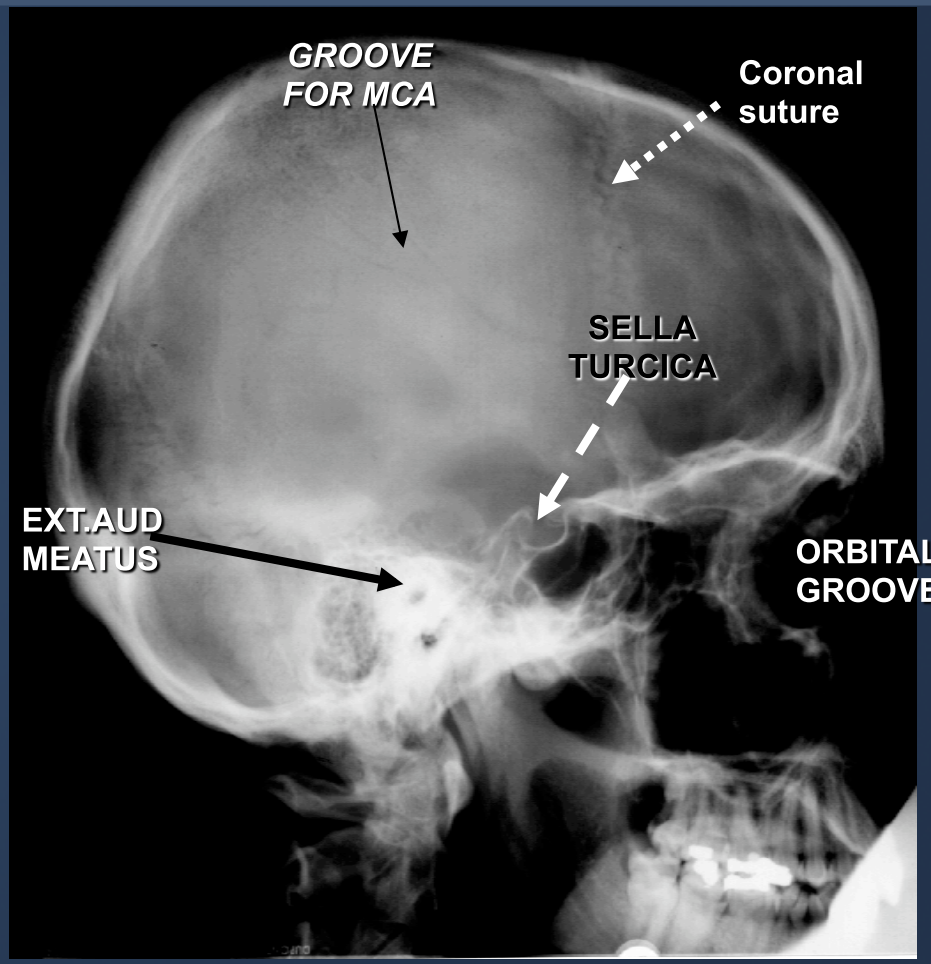
- Limited roles in fractures or trauma, congenital anomaly of the brain, intracranial calcification (better by CT)
- Views: lateral, occipital frontal, towens: foramen magnum

There will be no x-rays in the exam, focus on CT and MRI

1. Plain x-ray skull

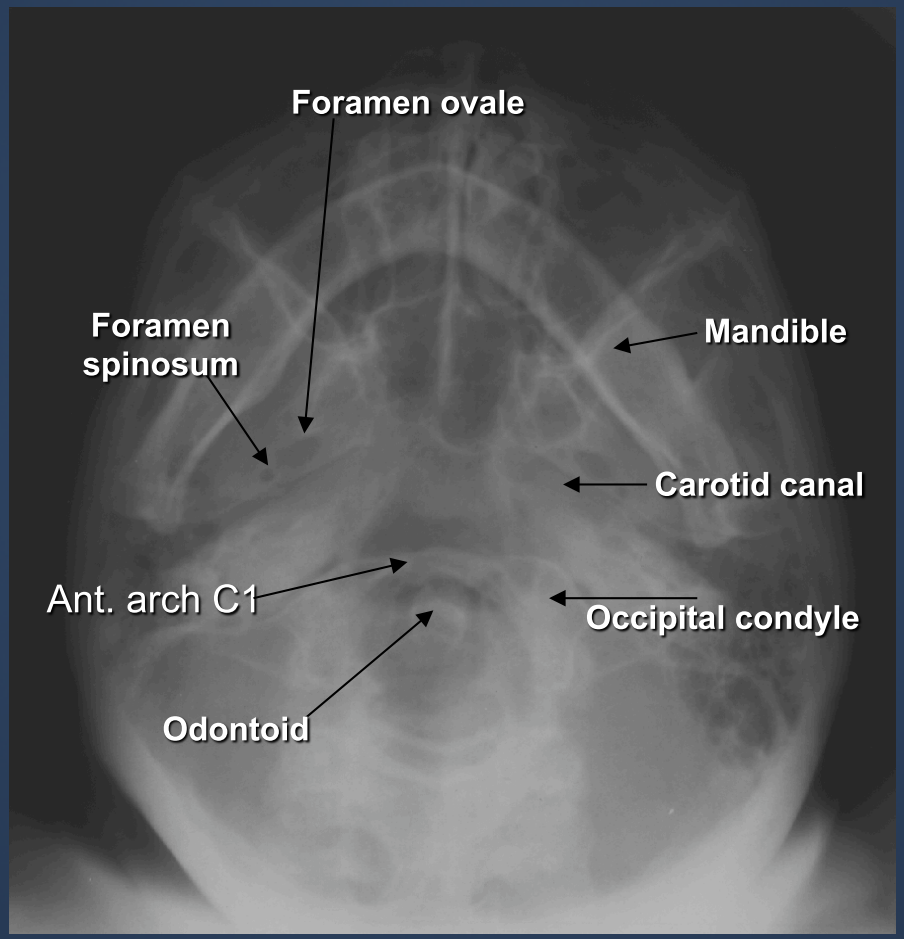


SKULL PA VIEW : also known as Occipito-frontal

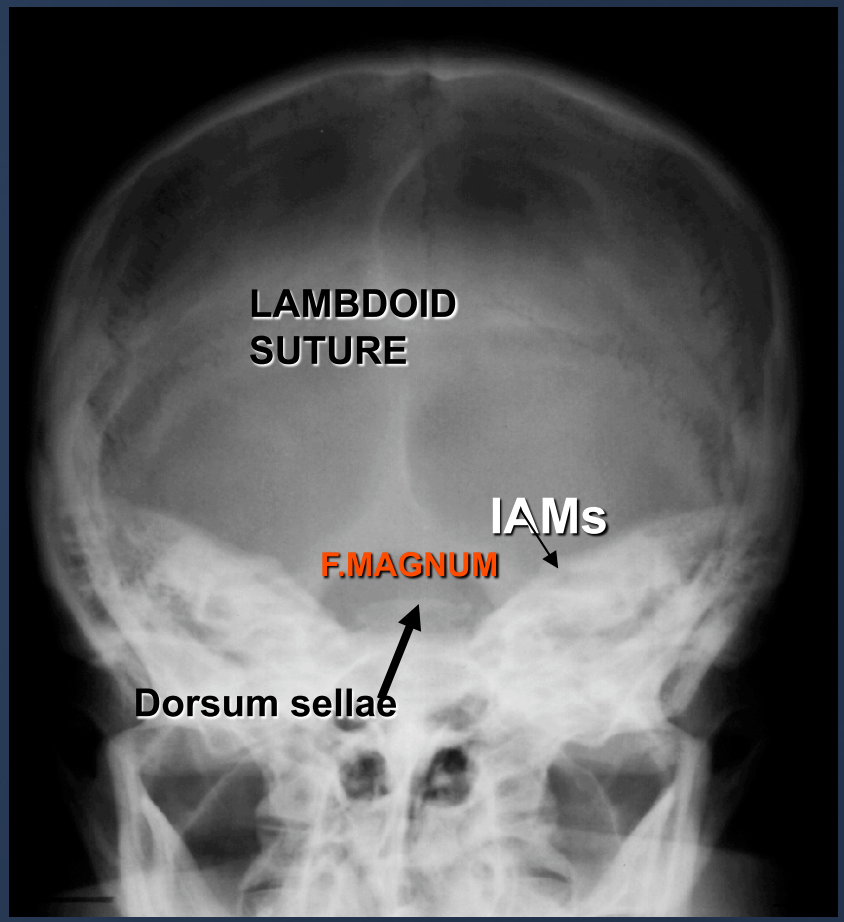


Skull X-RAY LAT. VIEW: Lateral view position is almost always the left position of the patient

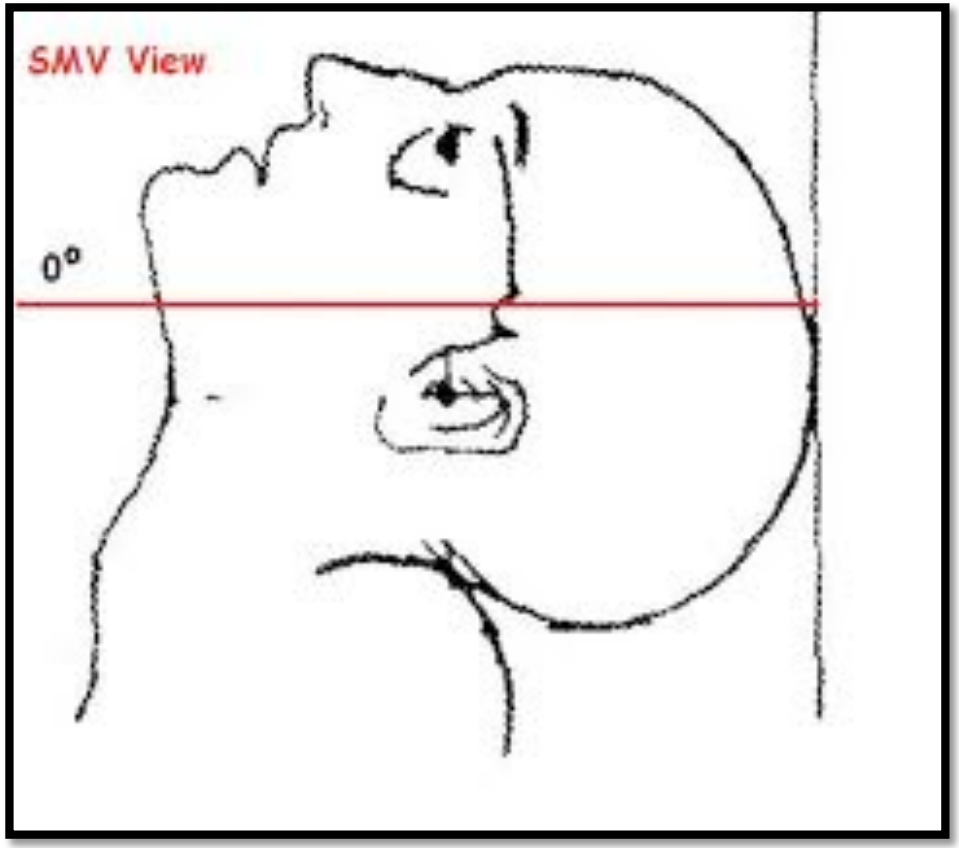
1. Plain x-ray skull



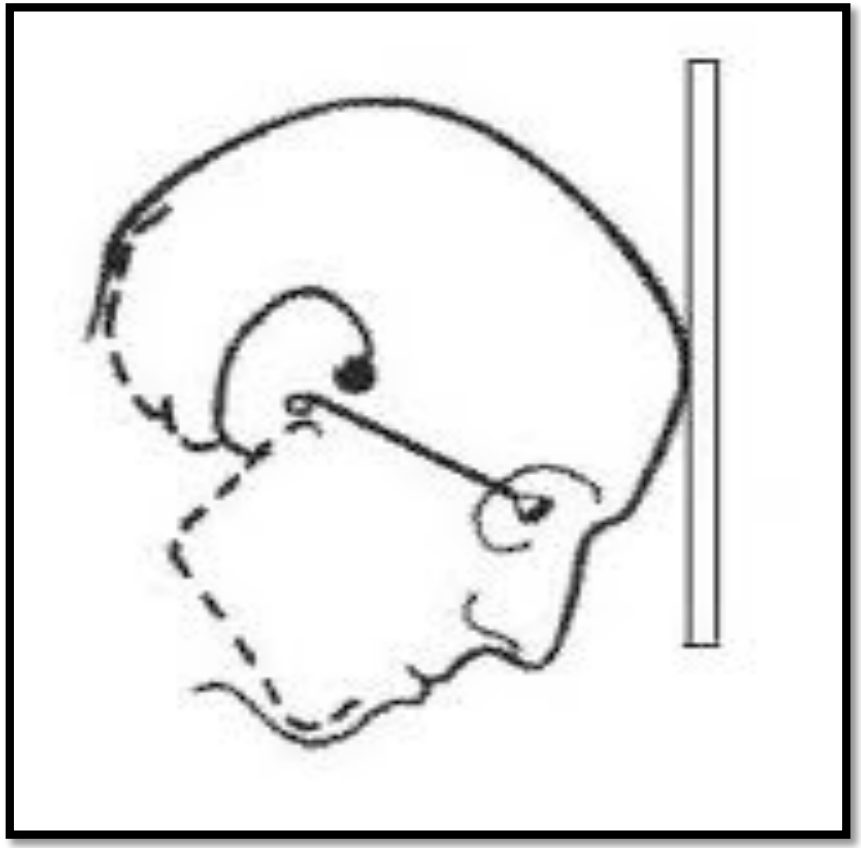
Submentovertical VIEW



TOWENS VIEW (AP)



Submentovertical VIEW



TOWENS VIEW (AP)

2. CT SCAN

2. CT SCAN

- **Using ionizing radiation** → one of the disadvantages

- **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** except if we need to give contrast →fasting needed , otherwise , no preparation

- **Type of the contrast medium: iodinated contrast**
- **(non ionic L.O.C.M)**

2. CT SCAN

Indications:

- **Trauma** (Most important → CT is the initial study for traumas)
- **Detection of blood** (acute **(white bright)** vs. sub acute vs. chronic **(dark like CSF)**
- **Strokes:** if stroke is suspected and symptoms occur, CT is used initially. If you want an early (3-4hrs) detection of infarction before its occurrence, MRI is better
- **Tumours**
- **Infection**
- **Vascular disorders**

Contraindications

Disadvantages

2. CT SCAN

- **The axial plane is the routine projection but it is sometimes possible to obtain direct coronal scans.**
- **The window settings are selected for the brain, but may be altered to show the bones.**

There are no saggital section images in CT, it is done by CT reconstruction. Window setting are for reconstruction for better visualization **to show the selected area :**

- Brain window for brain parenchyma
- Bone window to assess the outline of the bone, will show the one excluding the brain hence better visualizatioin

2. CT SCAN

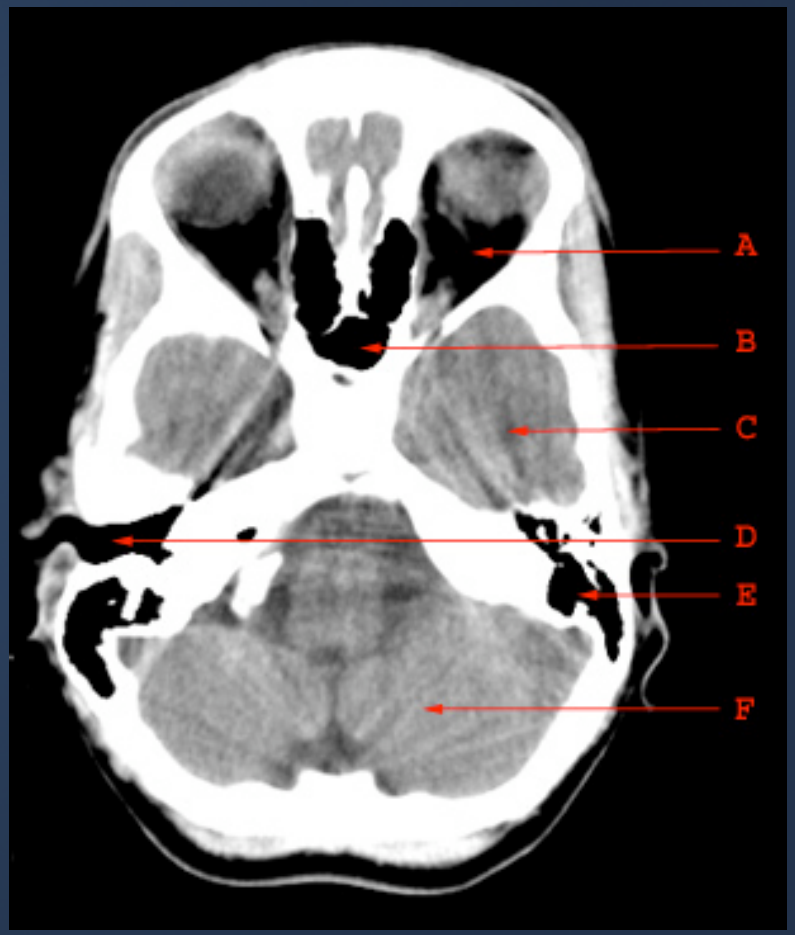
NORMAL CT BRAIN

Small lesions are best images by MRI to avoid artifacts in CT imaging

- 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). *MCQ
- The falx 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.

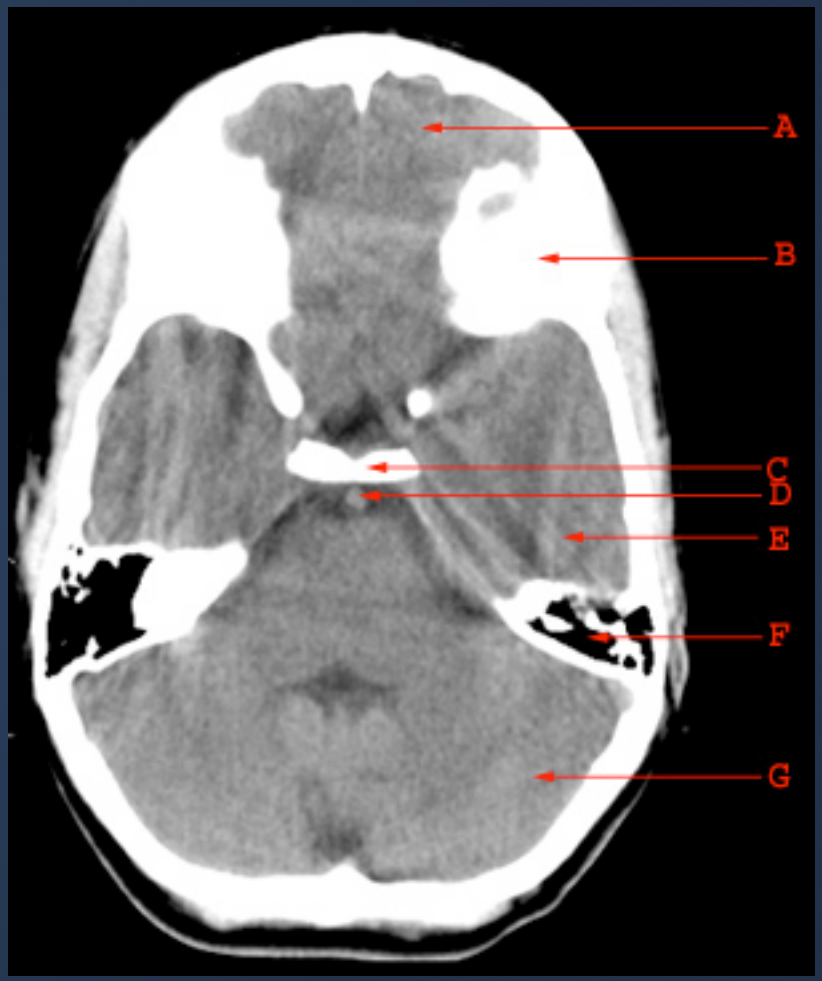
2. CT SCAN
Anatomy

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



2. CT SCAN Anatomy

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



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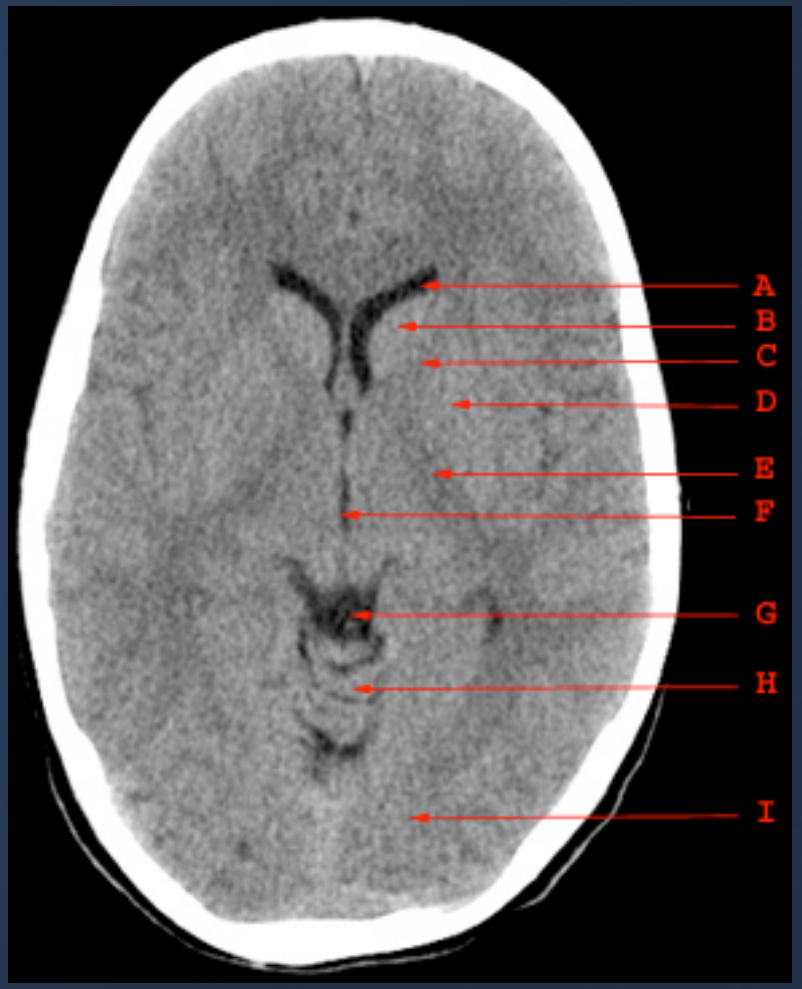
2. CT SCAN Anatomy

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



Internal capsule is white matter

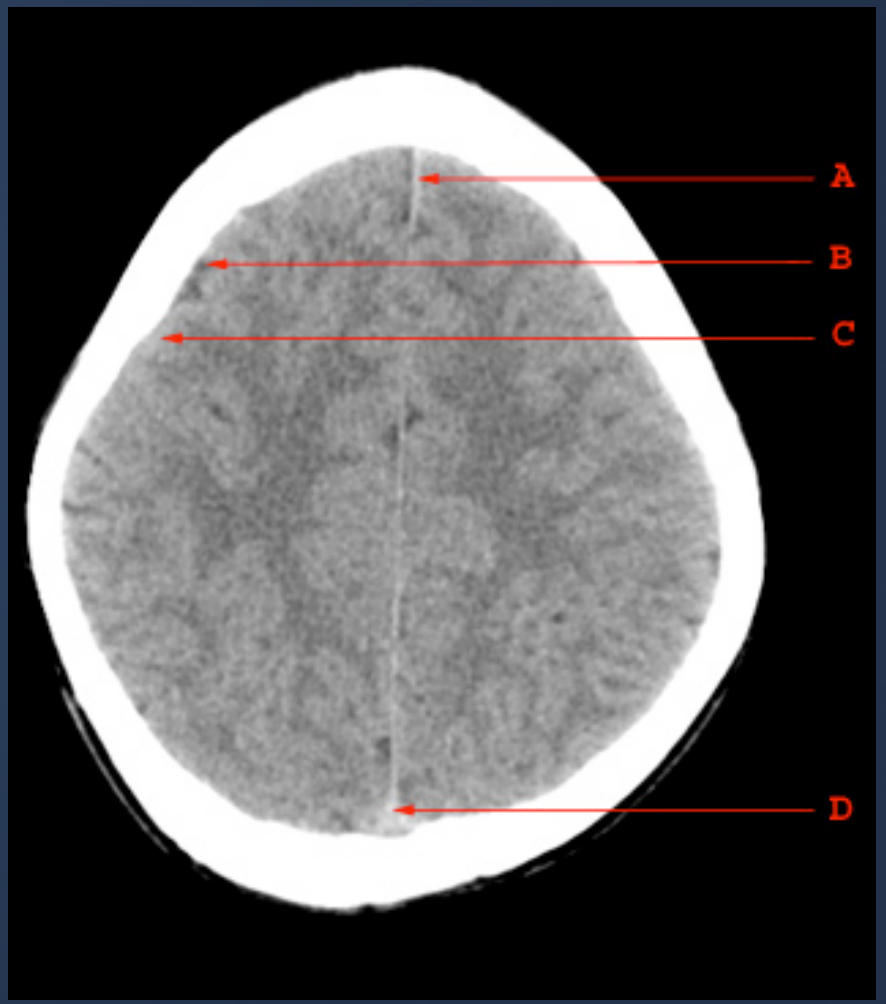
2. CT SCAN
Anatomy

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

2. CT SCAN
Anatomy

Supra ventricular level

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

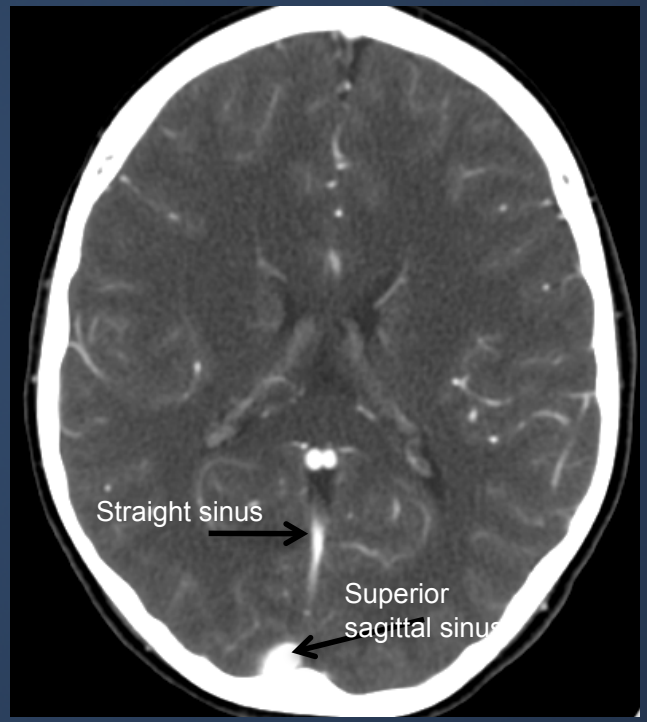


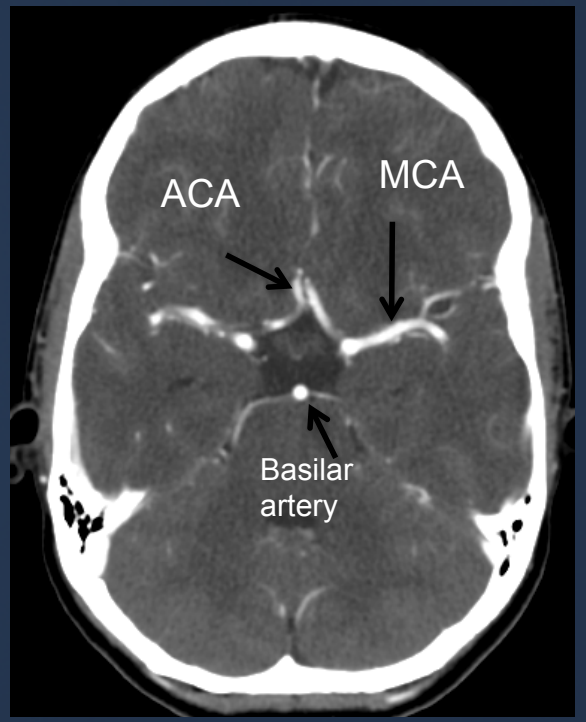
2. CT SCAN

Contrast enhanced CT:
IV injection of contrast medium is often given because the abnormality is not seen in pre contrast scans. It 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).

Also it is helpful in demonstrating blood vessels

Contrast enhanced CT





The parenchyma is not enhanced (except in abnormalities. e.g. infections) due to the protective function of BBB

2. CT SCAN

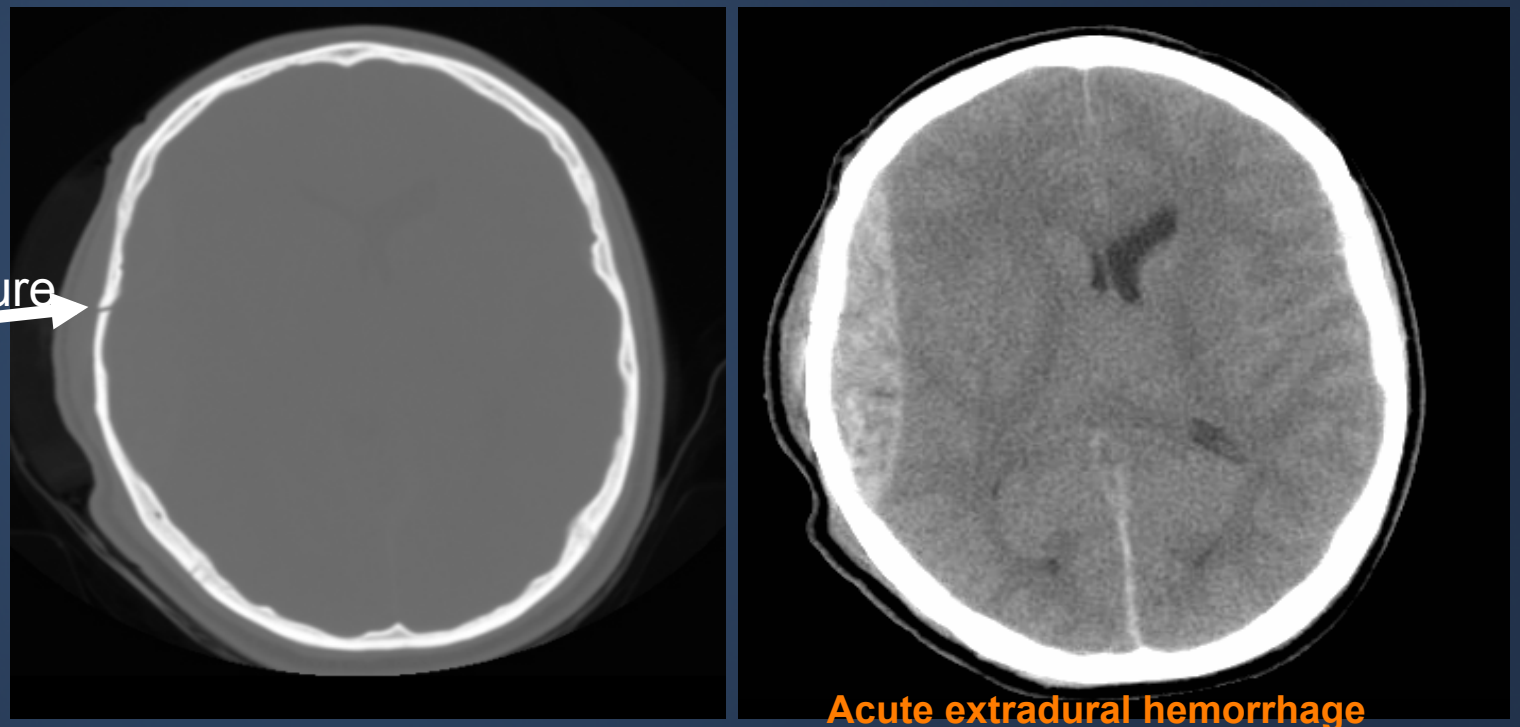
Computer reconstructions can in selected circumstances be made from the axial sections which then provide images in coronal or sagittal planes.

Sagittal reconstruction

Coronal reconstruction

2. CT SCAN

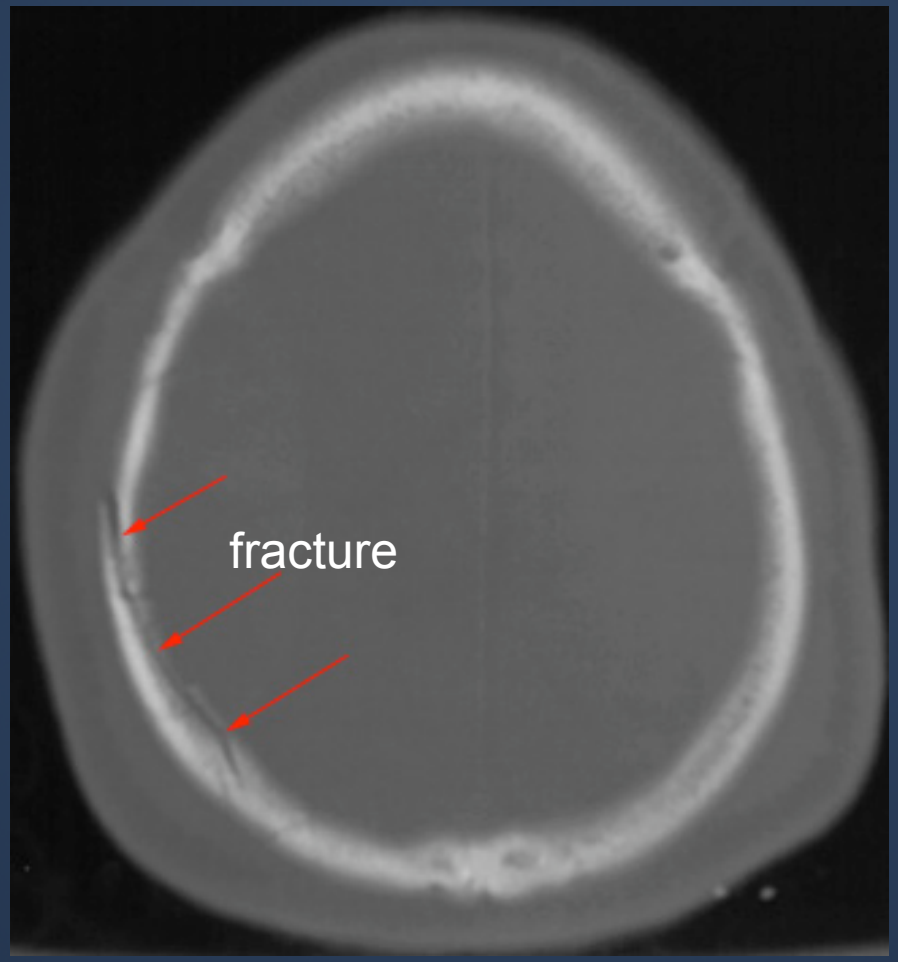
Bone window **Brain window**



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

***MCQ** Know the difference between bone and brain window

2. CT SCAN
Bone window

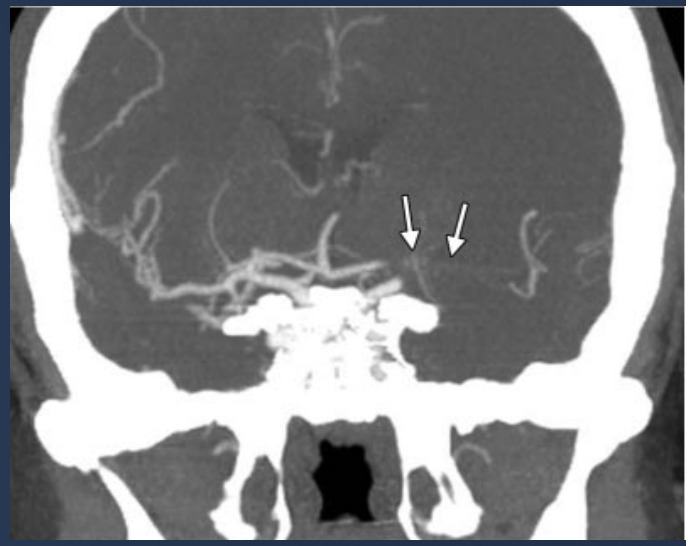


How to differentiate between the bone window and the brain window in an image ?

- adjustment of image to see different structures is called window settings
- brain window is selected when we want to assess the brain parenchyma , presence of hemorrhage
- bone window is selected when we want to look to the bone to assess the outline.
- both are computer study and there is no need to expose the patient for another scan
- in the brain window we cannot see the bone fracture while in the bone window we missed the hemorrhage

2. CT SCAN
CTA

CTA is used to assess the vessels inside the brain to diagnose vascular anomalies. After injecting contrast at a specific speed and time, the technician can take image and concentrate on vessels or brain parenchyma. Time is a factor for controlling the appearance of the vessels, so when the time is delayed that will lead to CTV (CT venography)
The appearance of the vessels can be divided into 2 phases(image taken will depend on the time that it will be taken in):
1- arterial phase (early) : where the arteries start to appear
2- venous phase (delayed) : when the veins start to appear

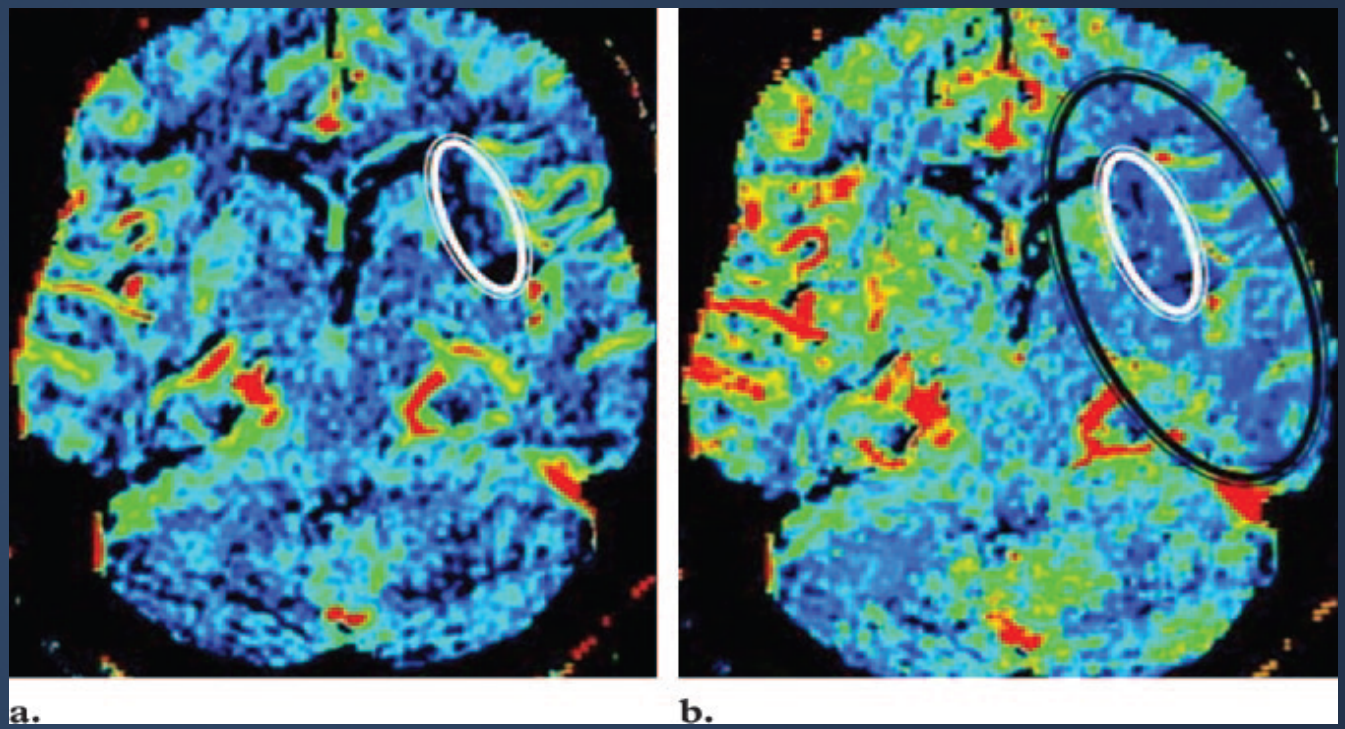


Occlusion of left middle cerebral artery
middle cerebral artery is seen on the right side but not seen on the left because it is occluded

CT angiography is helpful in diagnosis of vascular diseases and abnormalities such as stenosis, occlusion or vascular malformation

(read only Not in the exam)

2. CT SCAN
CT PERFUSION



cerebral blood volume cerebral blood flow

Another technique in CT is called CT perfusion :
The important thing to know here is the name of study and its value .
CT perfusion: assesses the perfusion of blood in relation to the lesion and assess the tissue at risk (penumbra) to see if this tissue will get benefit from the early treatment.

2. CT SCAN

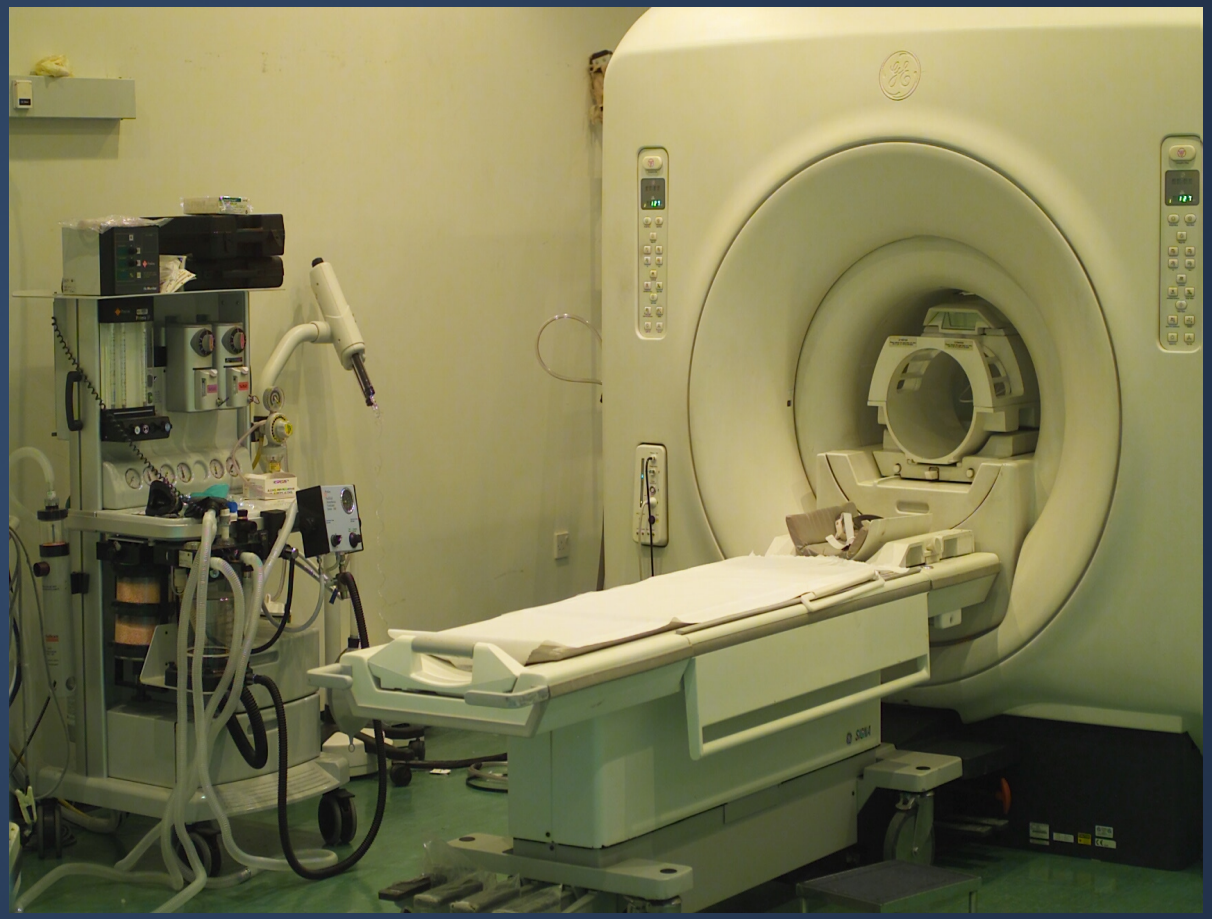
CT PERFUSION

CT perfusion color, assess perfusion of blood in association with a lesion

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 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, and 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.

3. MRI



MRI : this type of MRI called closed MRI, closed MRI is better than the open MRI. Open is used when the patient has phobia from closed places and cannot complete the study in the closed MRI.

3. MRI

- **No ionizing radiation:** MRI not using ionizing radiation → safer than CT
- **Patient preparation: Nil** no preparations needed **unless fasting for general anaesthesia and** in case of contrast. a contrast (gadolinium) will be used, only need to check if there is renal problems.
- **Contrast medium: Gadolinium**

same indications for CT but the difference is in the priorities :
1-assess the stroke as early as possible as 1-2hours **(MCQ)** in early diagnosis of infarction which imaging module will be used ?
2-tumers,infection and vascular anomalies
3- MRI is better than CT to assess the white matter diseases.
4- in early stages of trauma we need CT as initial study not MRI to assess blood and hemorrhage in late stage of trauma we need the MRI for example to assess diffuse axonal injury
MCQ in cases of trauma which technique do you prefer? CT scan

3. MRI

Indications:

- **Stroke**
- **Tumor**
- **Infection**
- **Vascular disorders**
- **White matter disease** appears better in MRI than CT
- **Some cases of trauma**

All contraindications may lead to complications

Contraindications:

- **cardiac pacemaker absolute contraindication**

Relative contraindications :

- **cochlear implants**
- **ocular prostheses**: it will move inside the eye and cause problems
- **intraocular ferrous foreign body**
- **neurostimulators**
- **pregnancy (1st trimester),** however 2nd and 3rd trimester is permissible with caution
- **claustrophobia**

MRI

- 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) The different sequences of MRI differ from each other by the time they were taken.

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

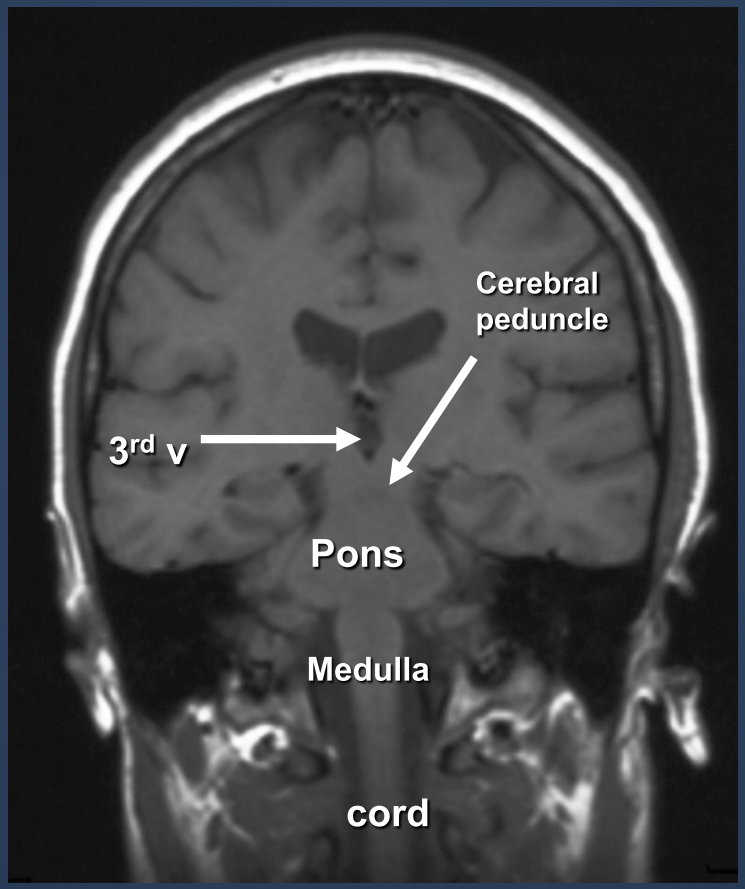
Advantages of MRI on CT :
1- MULTIPLANAR TECHNIQUE direct saggital ,direct coronal
2- Multisequential
3- High resolution, high contrast discrimination (the difference between grey and white matter is better than CT).
4- HELPFUL IN assessment of brain stem and posterior fossa which was difficult in CT **(MCQ).**

MRI

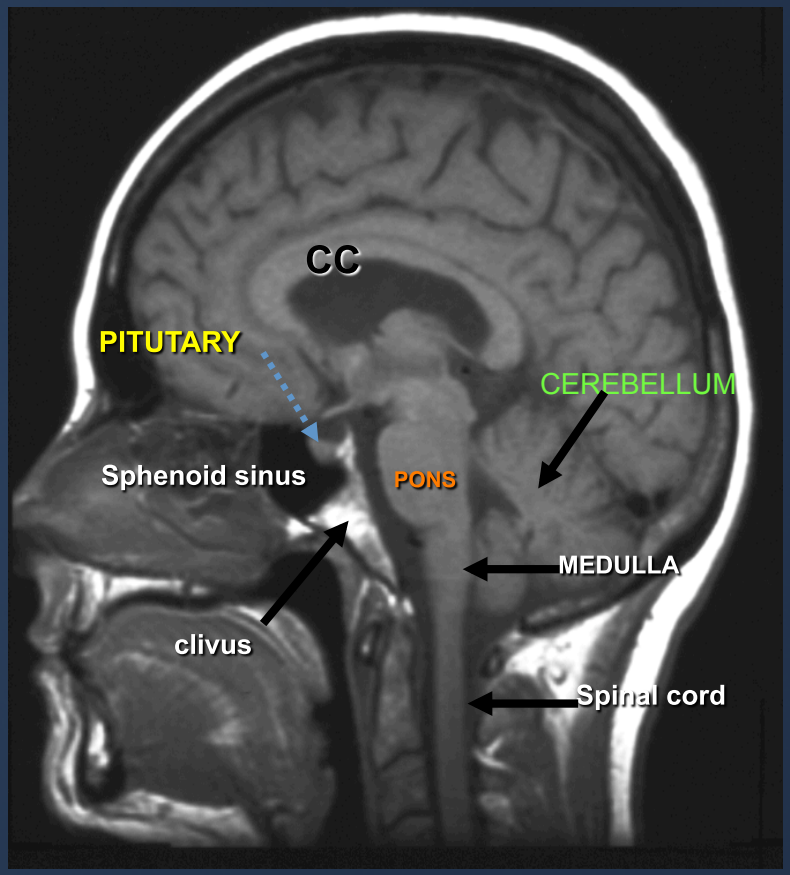
The Characteristic signal intensity of brain structures in different MRI sequences:

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

MRI



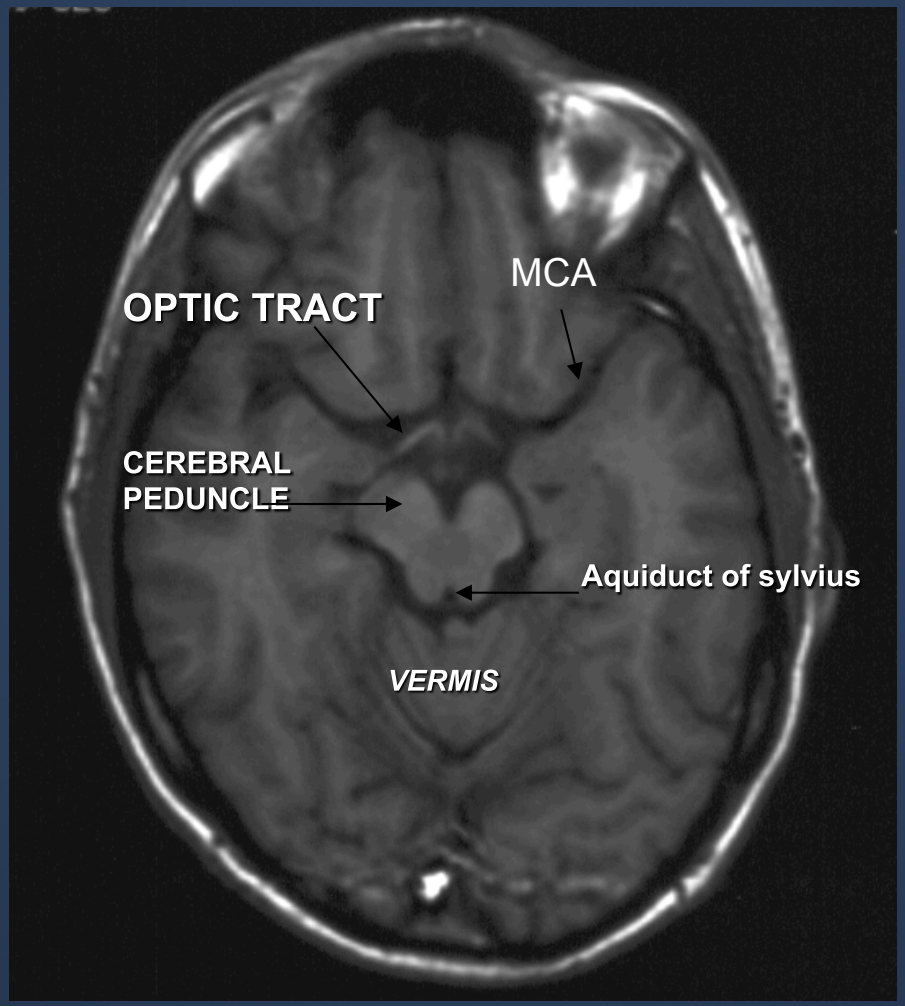
MRI BRAIN (CORONAL T1WI)

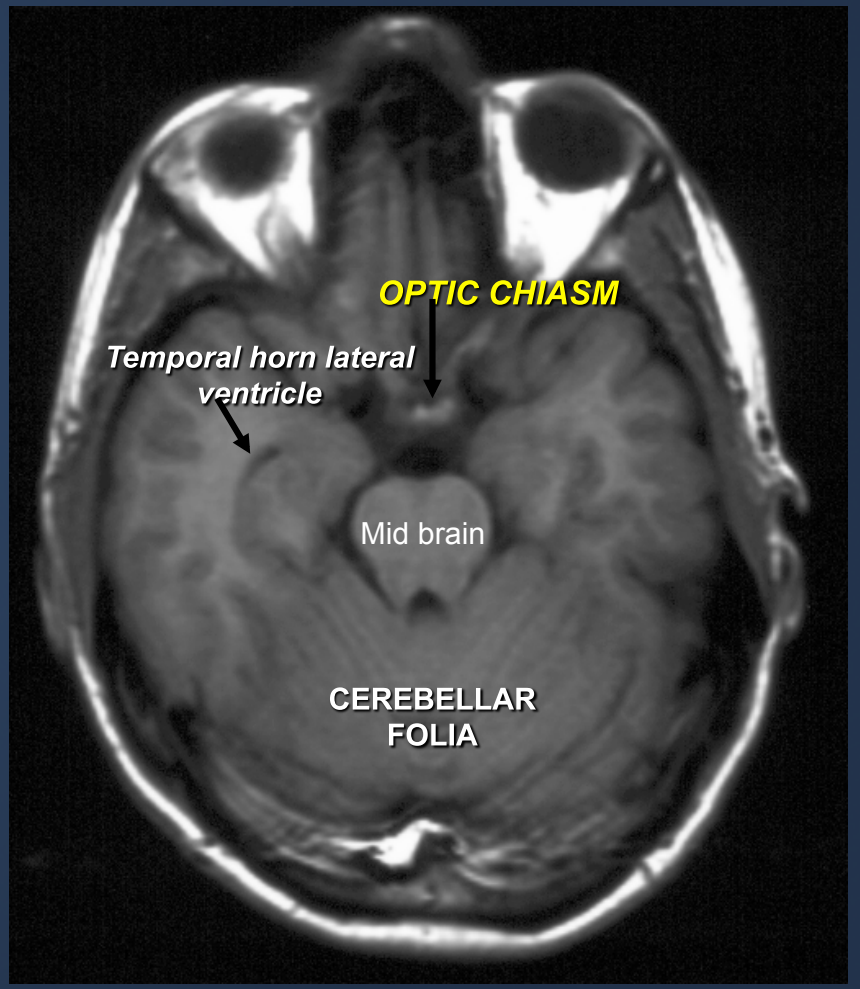


MRI BRAIN (SAGITTAL T1WI)

MRI can demonstrate brain stem , spinal cord, assess ventricles, brain stem, posterior fossa and other parts of the brain very detailed images more than CT scan.

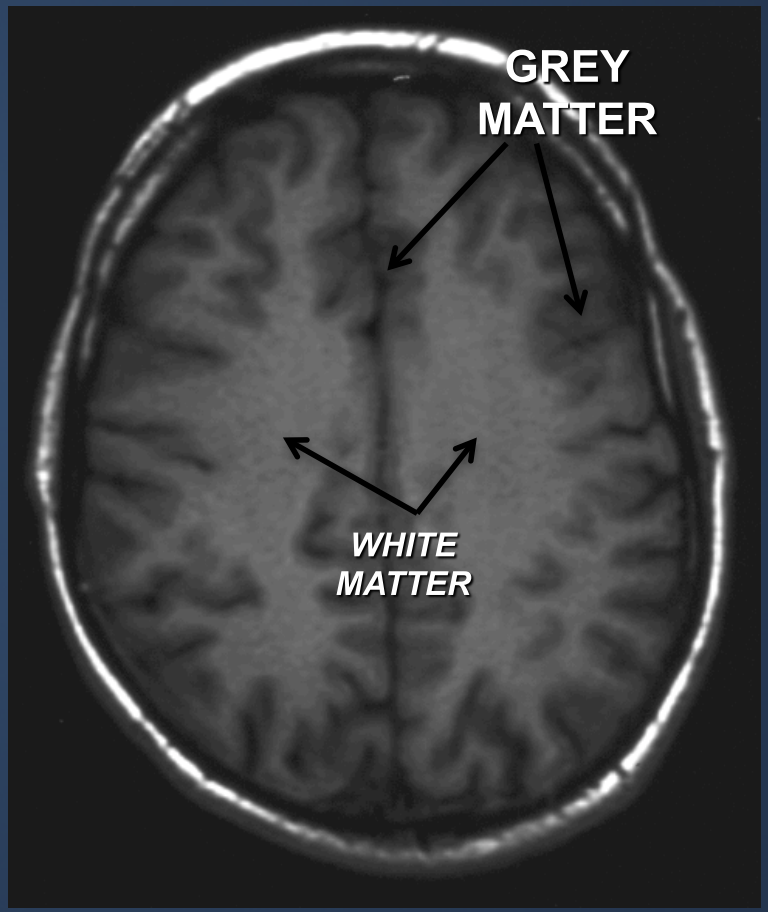
MRI





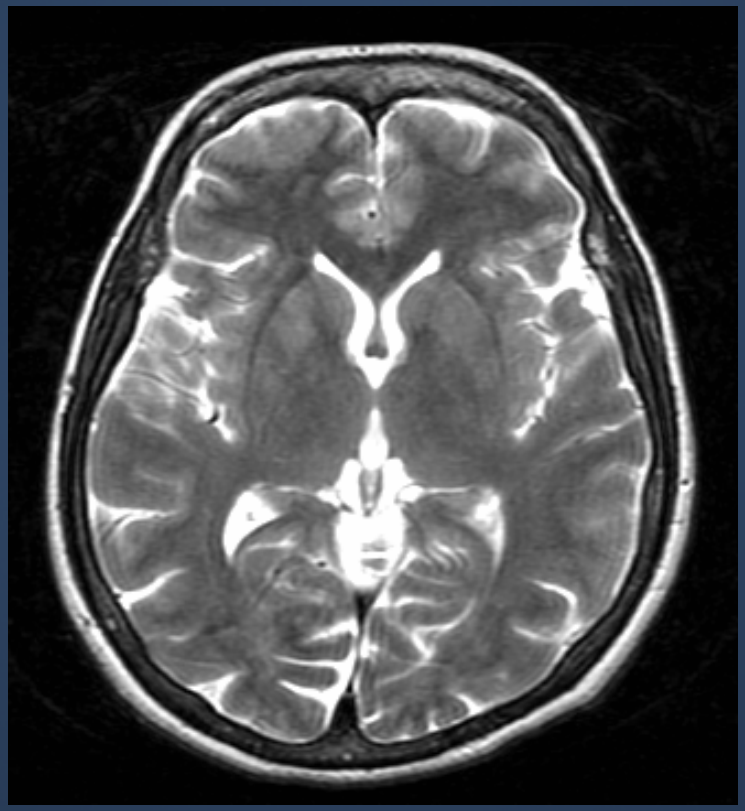
MRI BRAIN (AXIAL T1WI)

MRI

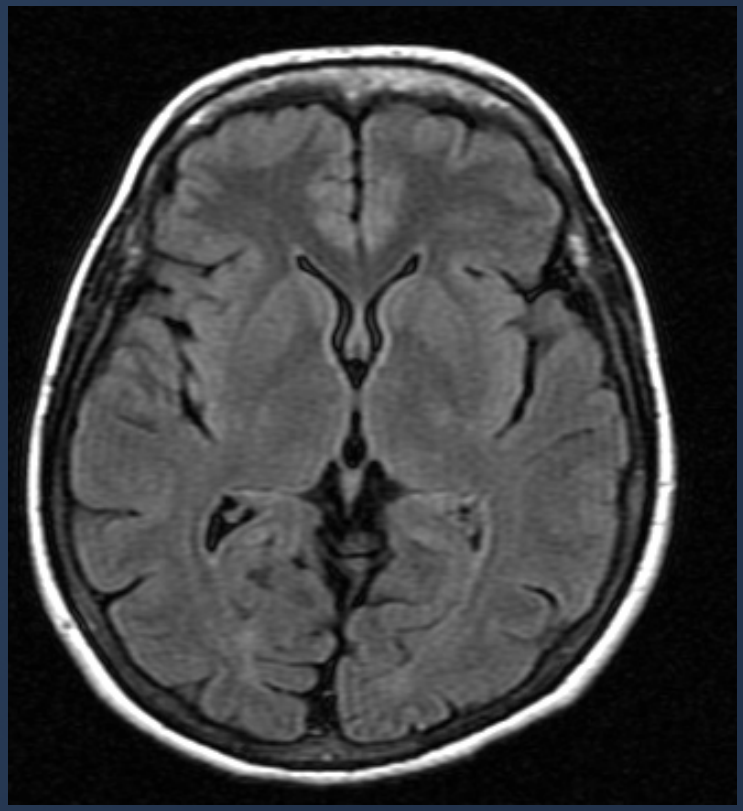


MRI BRAIN (AXIAL T1WI)

MRI



T2WI



FLAIR

MR Angiography

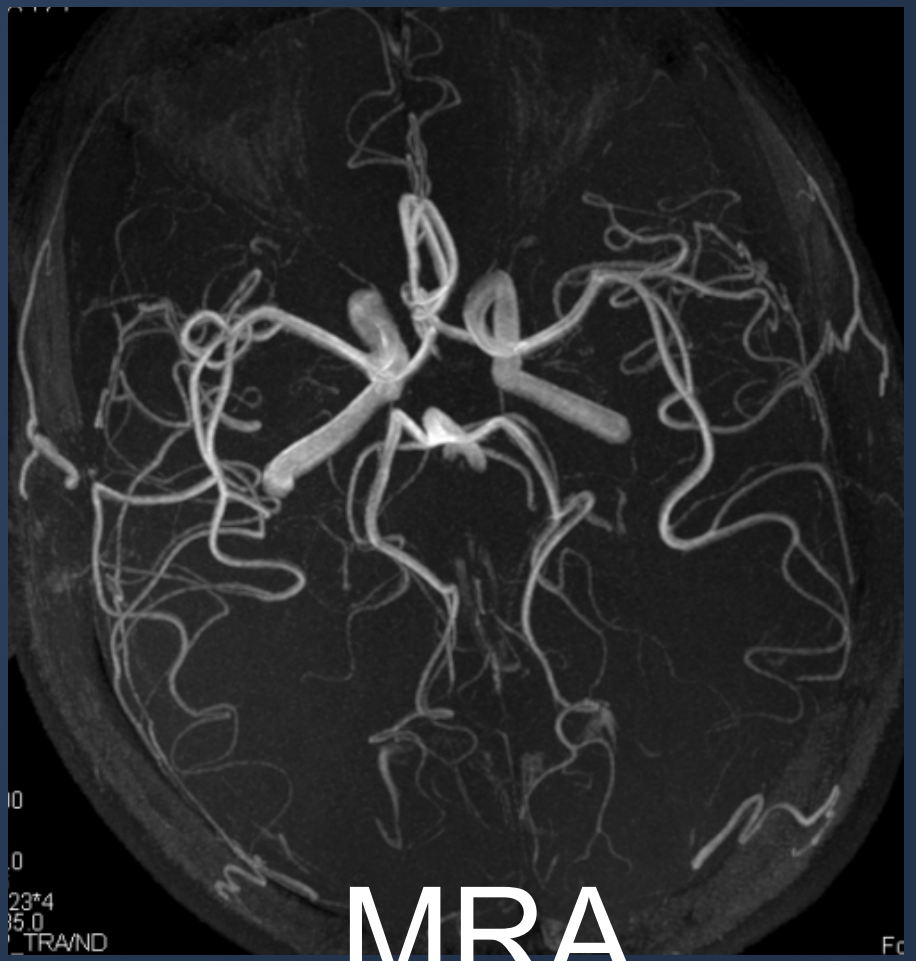
MRA

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.

Same indications as CT

CTA must be done with contrast , unlike MRA



MRA

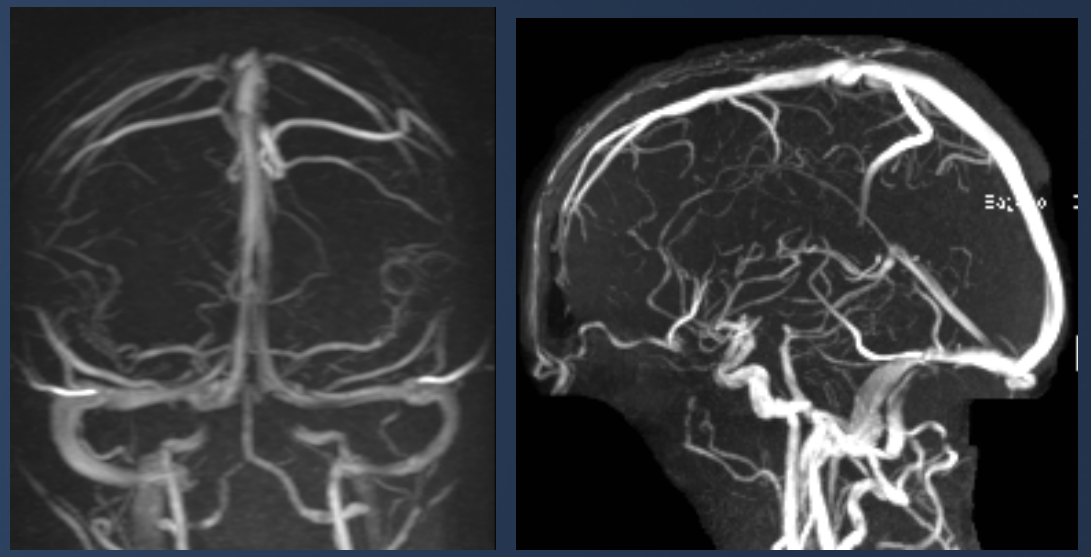
MR Venography

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



MRV

MRV with or without contrast, shows all the venous sinuses

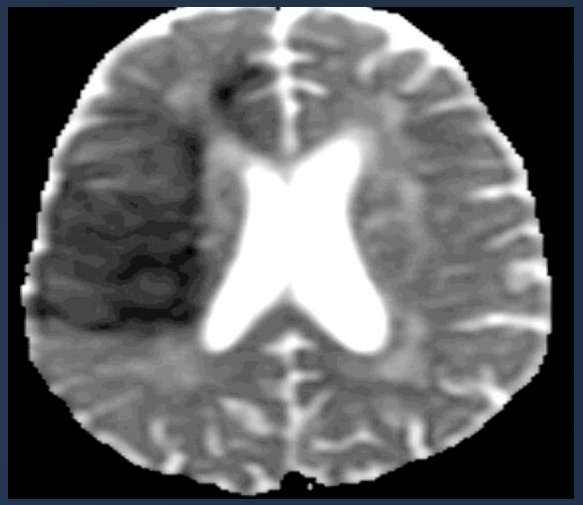
MRI Diffusion

MR diffusion

Very helpful in assessment and detection of:

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

DWI



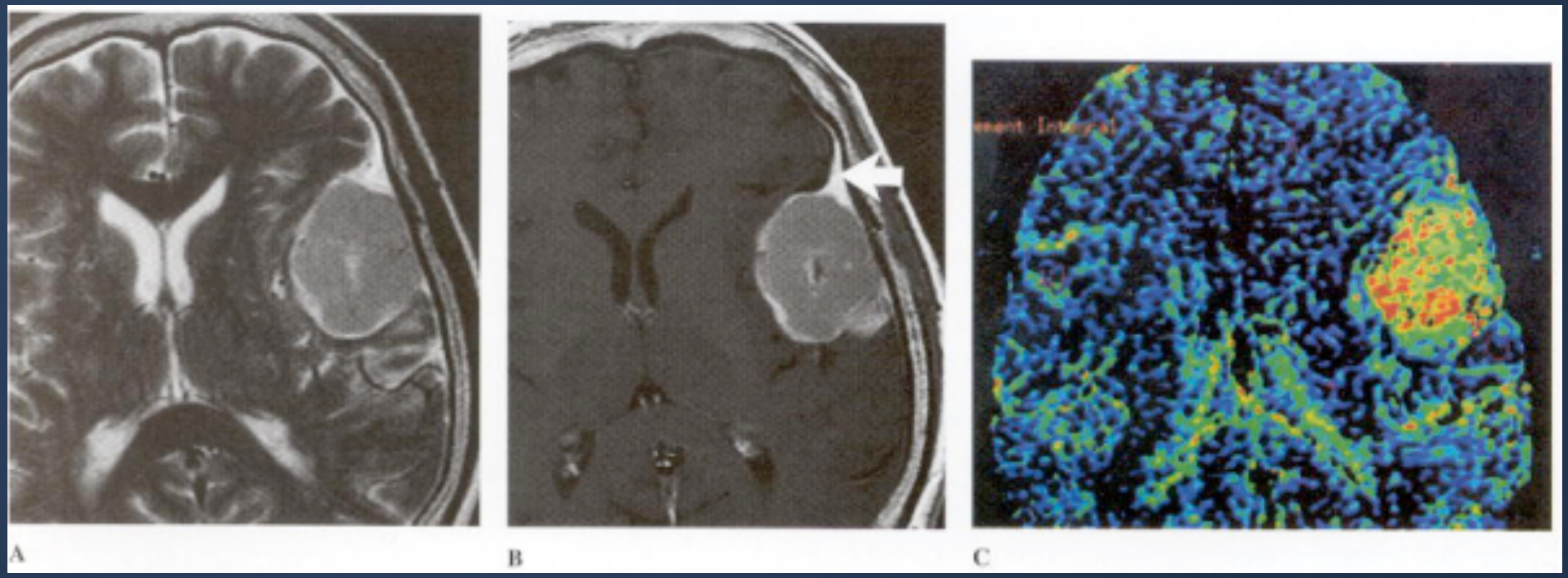
ADC map

*__MCQ__: A patient with acute onset of hemiplegia.
What will you use to detect infarction? MR diffusion

Best sequence to detect infarction/stroke is Diffusion MRI (can be detected as early as 2 hrs), then Flair MRI, and lastly T2 MRI. However, in real life, CT is routinely done first.

MRI

Meningioma

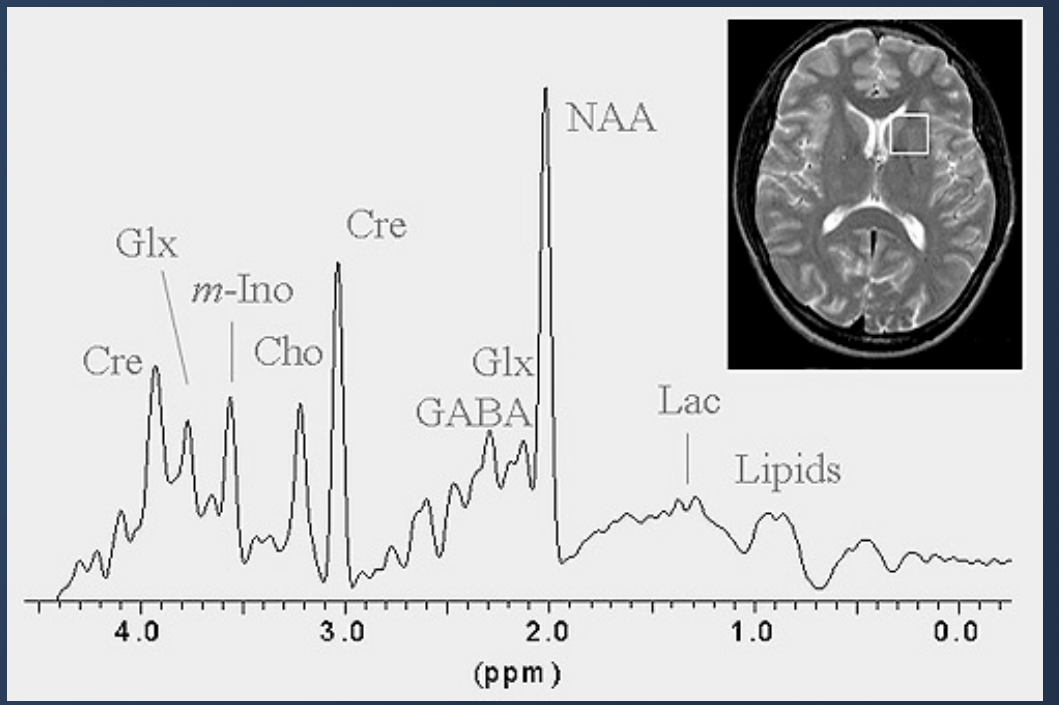


T2 Contrasted T1 Perfusion-Weighted

Not in the exam

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; *myo*l, *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.



Investigations of brain injury by magnetic resonance imaging (MRI) and spectroscopy (MRS)
Prof Andrew M. Blamire

Newcastle Magnetic Resonance Centre Newcastle University, Campus for Ageing & Vitality Newcastle upon Tyne, NE4 5PL United Kingdom.

MR Spectroscopy

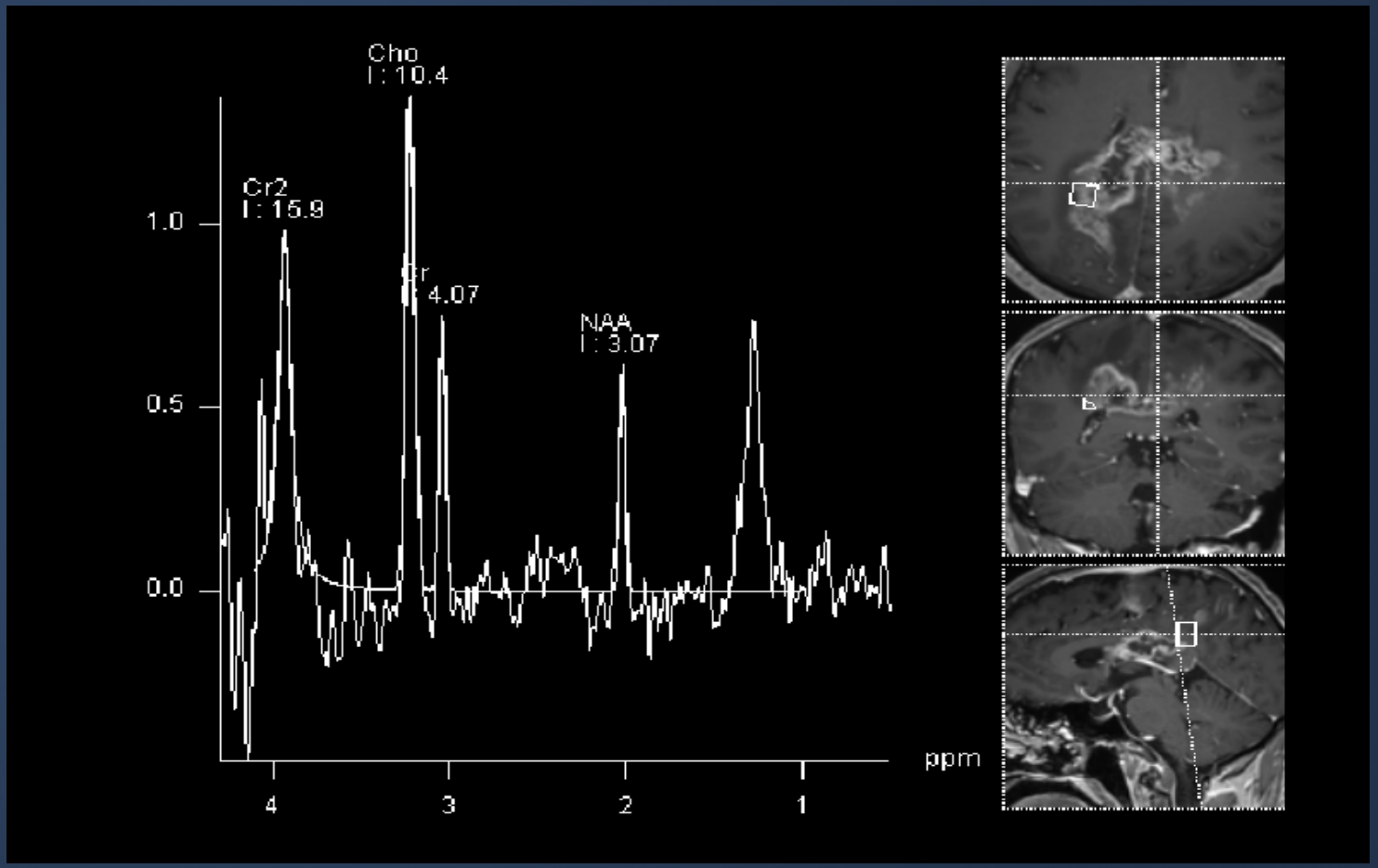
MR Spectroscopy

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

Cho – NNA levels are reversed → most likely tumor



MR Spectroscopy in GBM

CEREBRAL ANGIOGRAM

It is the gold standard technique for assessment of intra and extra cranial vessels. It was used as a first line to detect abnormalities but now it is used if other modalities do not show abnormalities.

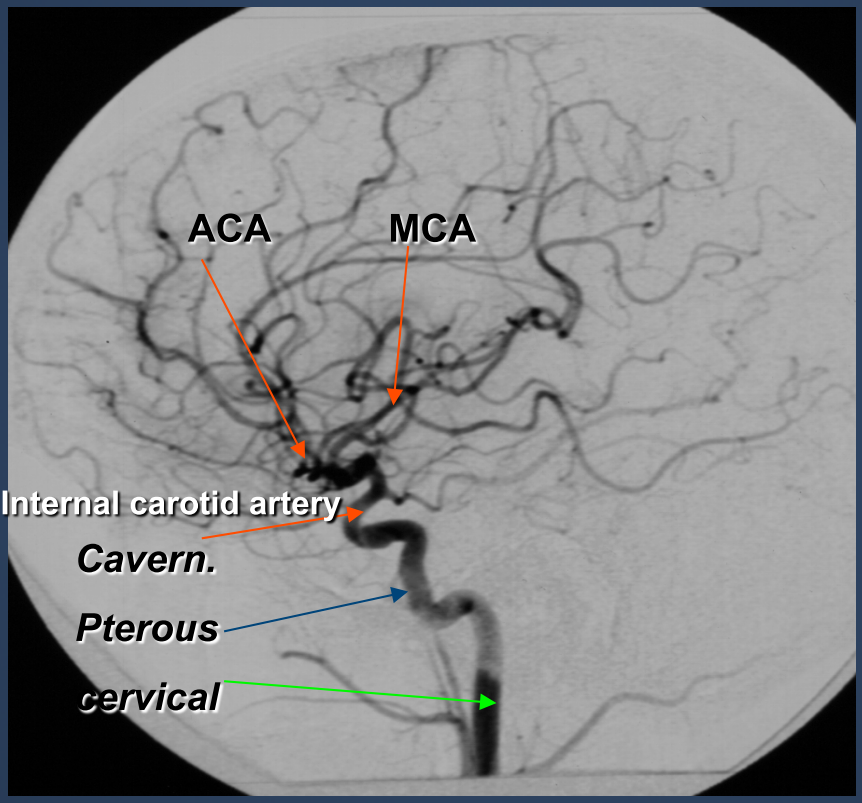
It can demonstrate different vascular diseases (stenosis, occlusion, vascular malformation and blood supply of brain tumors)

It is an invasive technique.

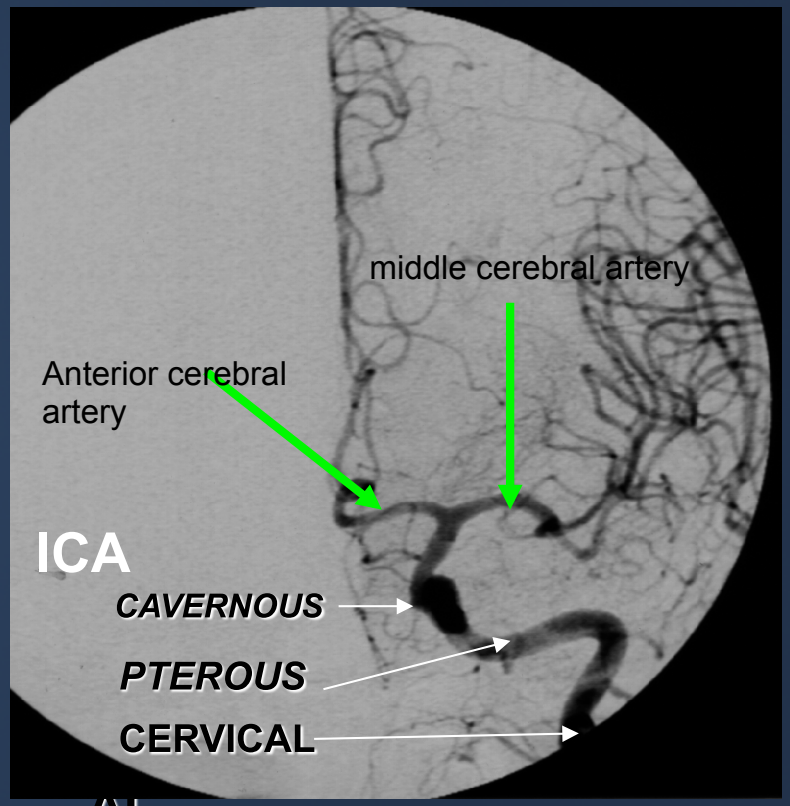
Recently its main role for intervention purposes such as treatment of vascular malformaion (aneurysm/arterovenous malformation) or pre operative embolization of vascular supply of tumor.

Chronic progressive headache = space occupying lesion (tumor, small hematoma)
Acute sever headache = stroke
Headache + fever = infection

CEREBRAL ANGIOGRAM

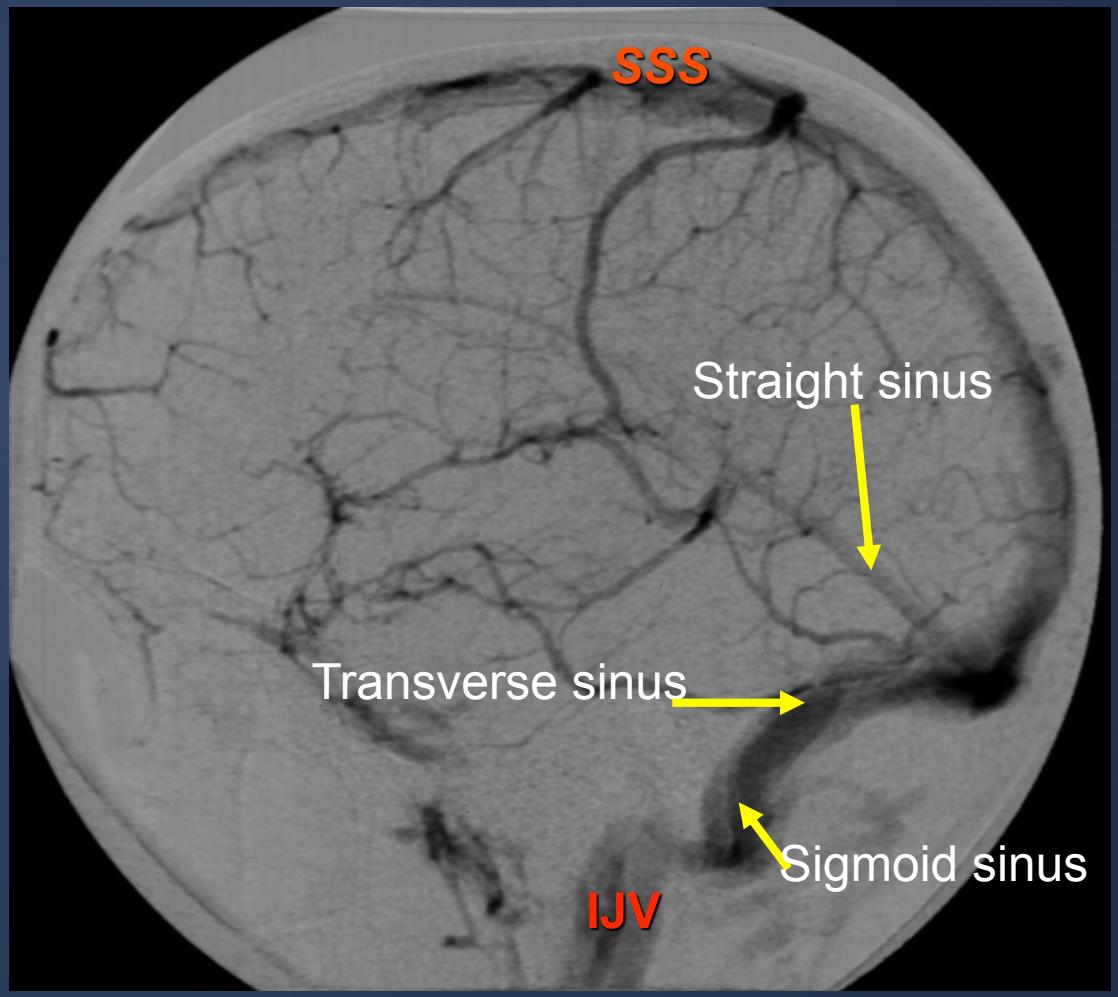


Internal carotid angiogram lateral view

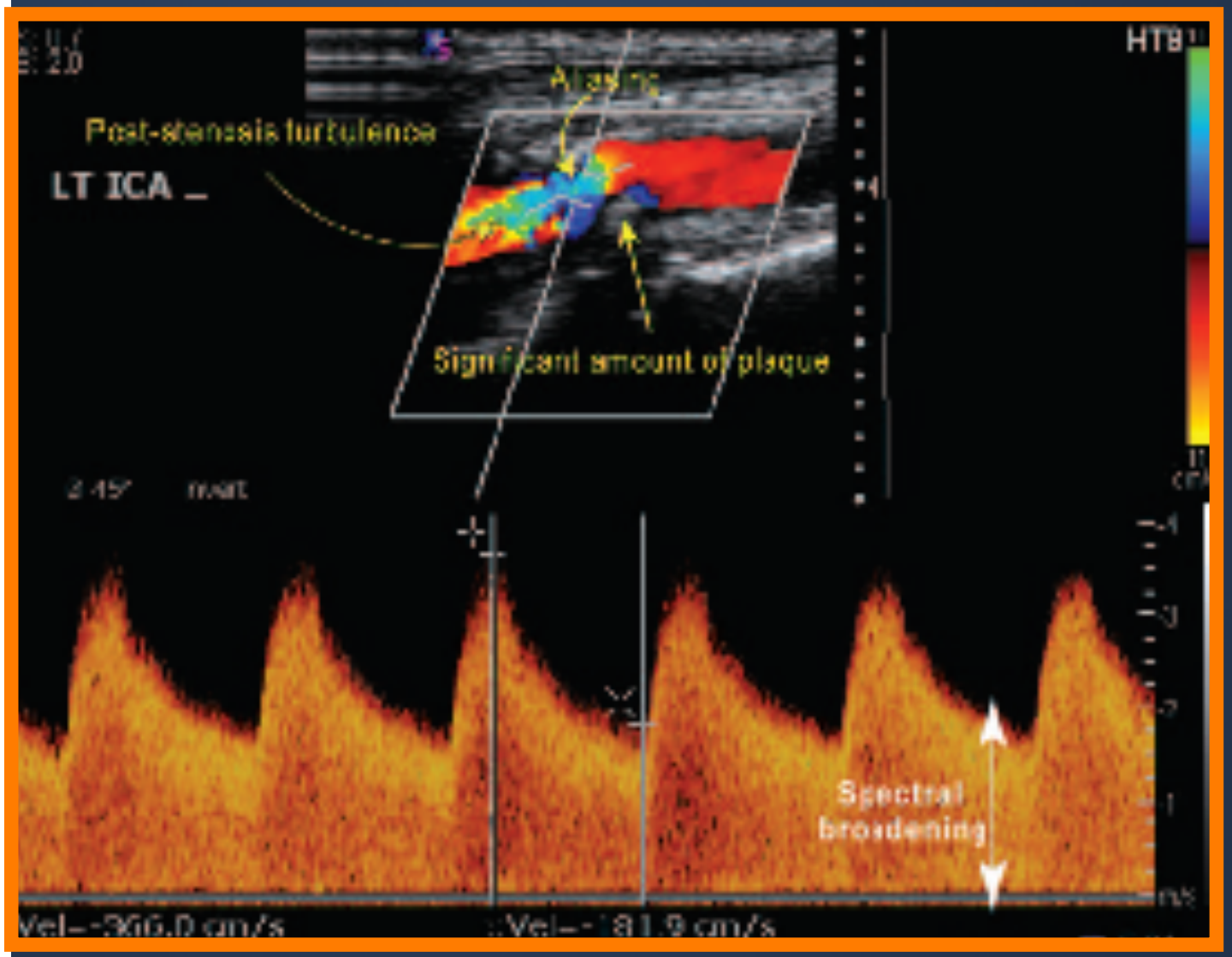


Internal carotid angiogram AP

VENOUS PHASE CEREBRAL ANGIOGRAM



CAROTID DOPPLER



stenosis or thrombosis of carotid artery

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.

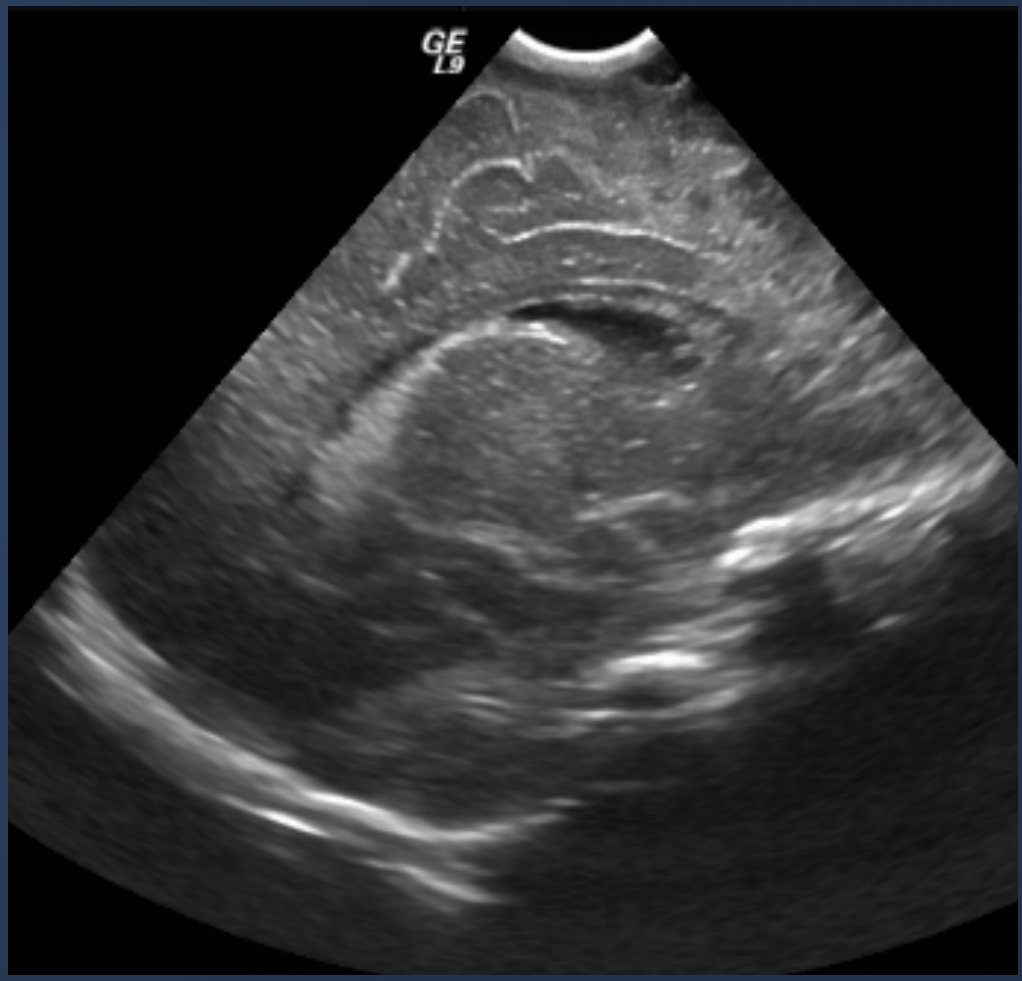
Little discomfort to the baby.

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

ULTRASOUND NEONATAL BRAIN

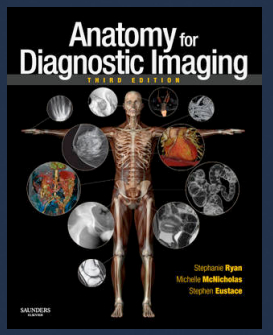
CORONAL



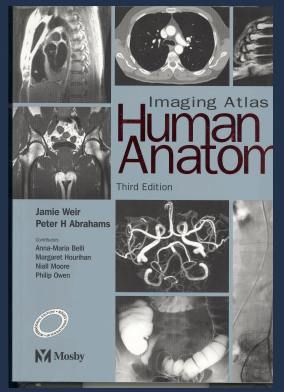
SAGITTAL

Reference book and the relevant page numbers..

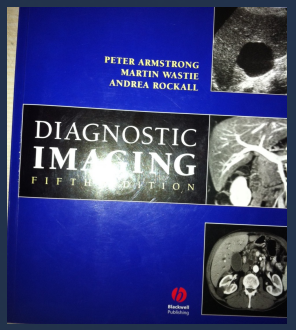
- Stephanie Ryan, "**Anatomy for Diagnostic imaging**", 2nd Edition, Pages 61-66



- Jamie Weir, Peter Abraham, "**Imaging Atlas of Human Anatomy**" 3rd Edition, Pages 34-41



- Peter Armstrong, "**diagnostic imaging** ", 5th Edition, Pages (396-404)



Thank You ☺

(Rad 365, Radiology)

Dr. HAMDY HASSAN

10-3-2012