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The Basics of Neuroimaging: Techniques, Basic Anatomy and Pathology

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RAD-AID

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THE BASICS OF NEUROIMAGING

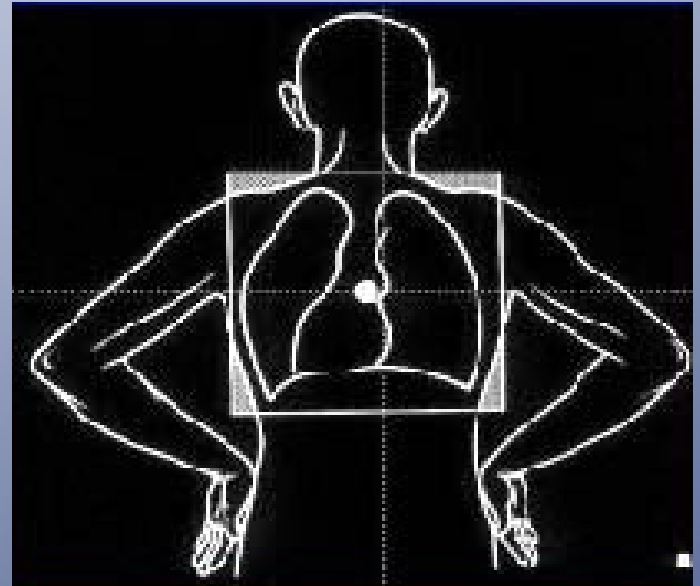
Techniques, Basic Anatomy and
Pathology

William Fleming

RAD-AID

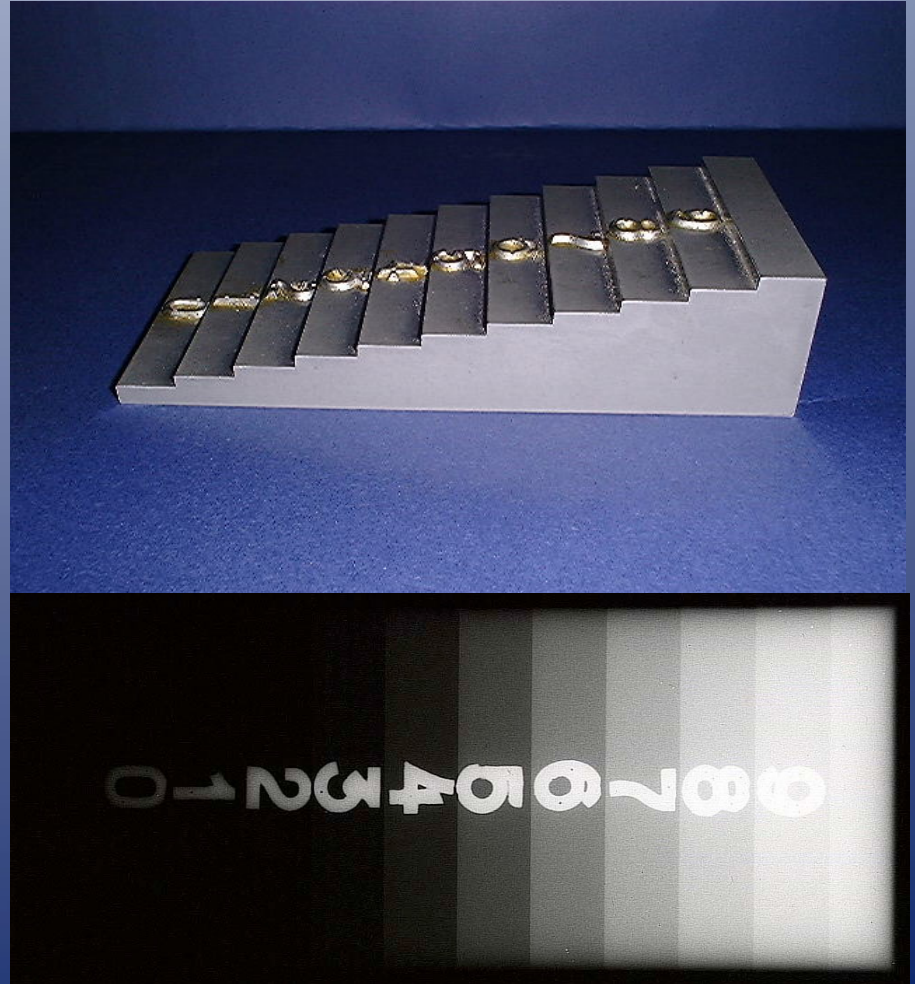
Structure

- 1.X-rays
- 2.Computerised Tomography
- 3.Magnetic Imaging
4. Angiography
- 5.Pathology



X-rays - attenuation

The greater the tissue density, the more the X-rays are attenuated so the fewer reach the film to expose it and turn it black



X-rays – radiographic density

Air	Black
Fat	Dark Grey
Muscle	Grey
Bone	Light Grey
Metal	White

Lateral view of cervical spine



Where do X-rays excel?

- Rapid and preliminary assessment of bone pathology
- Rapid and preliminary assessment of chest pathology
- Post-operative assessment of surgical hardware

X-rays - role

Trauma - fractures

Arthritis

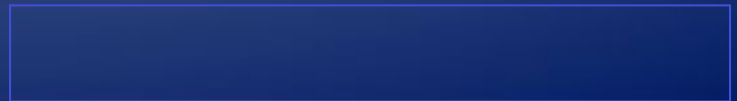
Metastases

Osteoporosis

Position of hardware

Foreign bodies

Lung abnormality



X-rays

ADVANTAGES

- Fast
- Cheap
- Readily available
- Good bone detail
- Dynamic images

DISADVANTAGES

- 2-D
- Poor soft tissue detail
- Ionising radiation
(X-Ray dose)

Ionising radiation

- Absorption of X-ray radiation energy in tissues causes damage
- Critical molecules are proteins (eg enzymes) and nucleic acid (mainly DNA)
- 2 categories of effect
 - SOMATIC
 - GENETIC (HEREDITARY)

- SOMATIC EFFECTS

- Occur in individual exposed to X-rays
- Eg. Cataracts, leukaemias, solid tumours

- GENETIC EFFECTS

- Occur in descendants of the individual exposed to X-rays as a result of lesions in the germinal cells eg. congenital defects

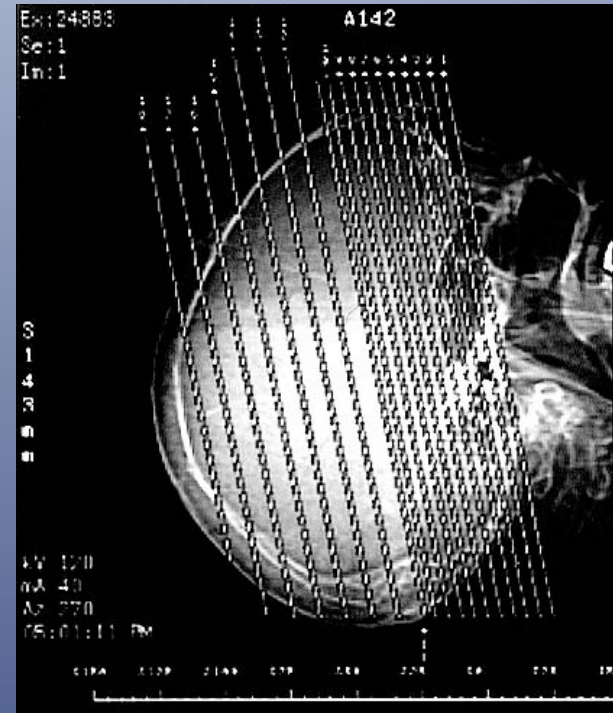
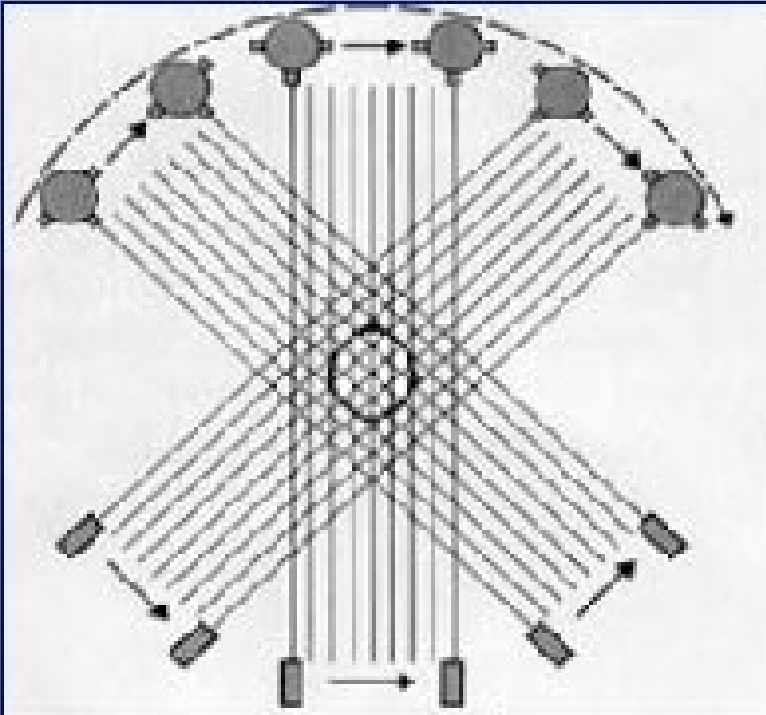
Computerised Tomography





64-slice and 128-slice CT
scanners

CT - technique



- X-ray tube and detectors helically circle around body repeatedly
- Stack of axial images of varying thickness

CT - technique

Digital map of tissue density measured in Hounsfield Units and converted into grey scale



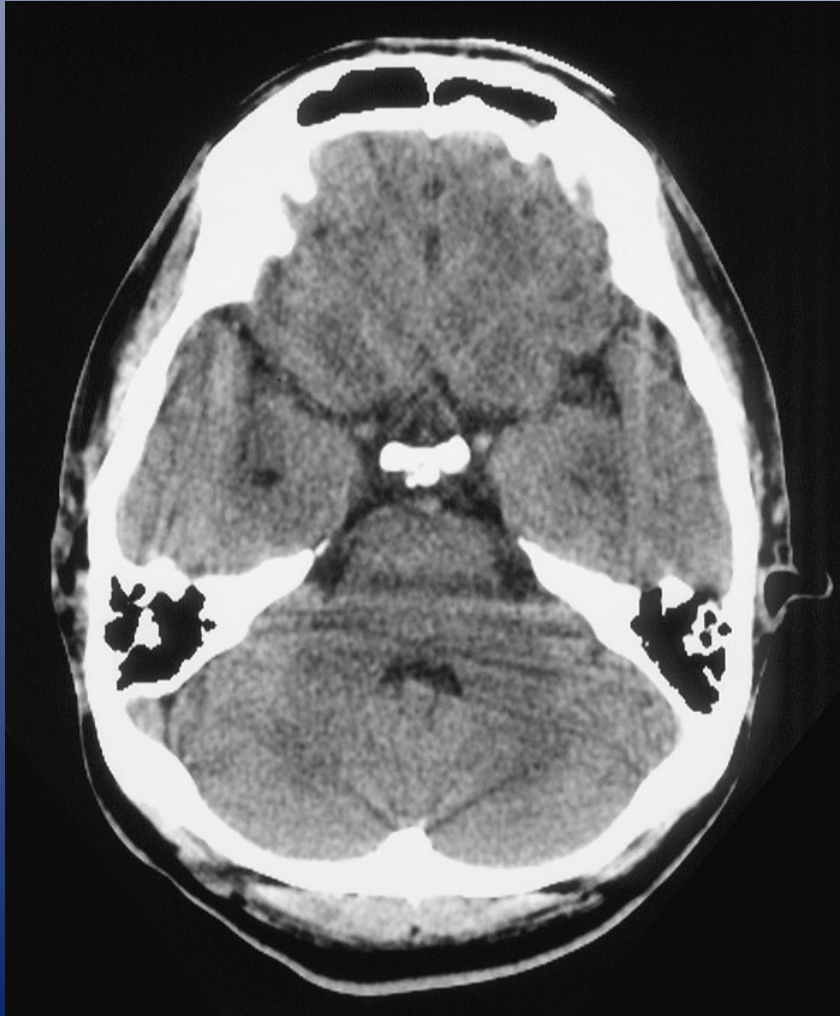
Air	- 1000	very black
Fat	-100	black
Water	0	dark grey
Brain	+40	grey
Blood	+90	white
Contrast	+100	white
Bone	+1000	very white

CT Role

- Central role in management of accidents and emergencies
 - Trauma – cranial, visceral and bone injury
 - Stroke – hyperacute and acute stroke assessment and haemorrhage
 - Severe headache – subarachnoid haemorrhage, meningitis
 - Unconscious patient

- CT guided interventional and minimally invasive procedures
 - Diagnostic procedures
 - Eg. Biopsy
 - Therapeutic procedures
 - Eg. Vertebroplasty

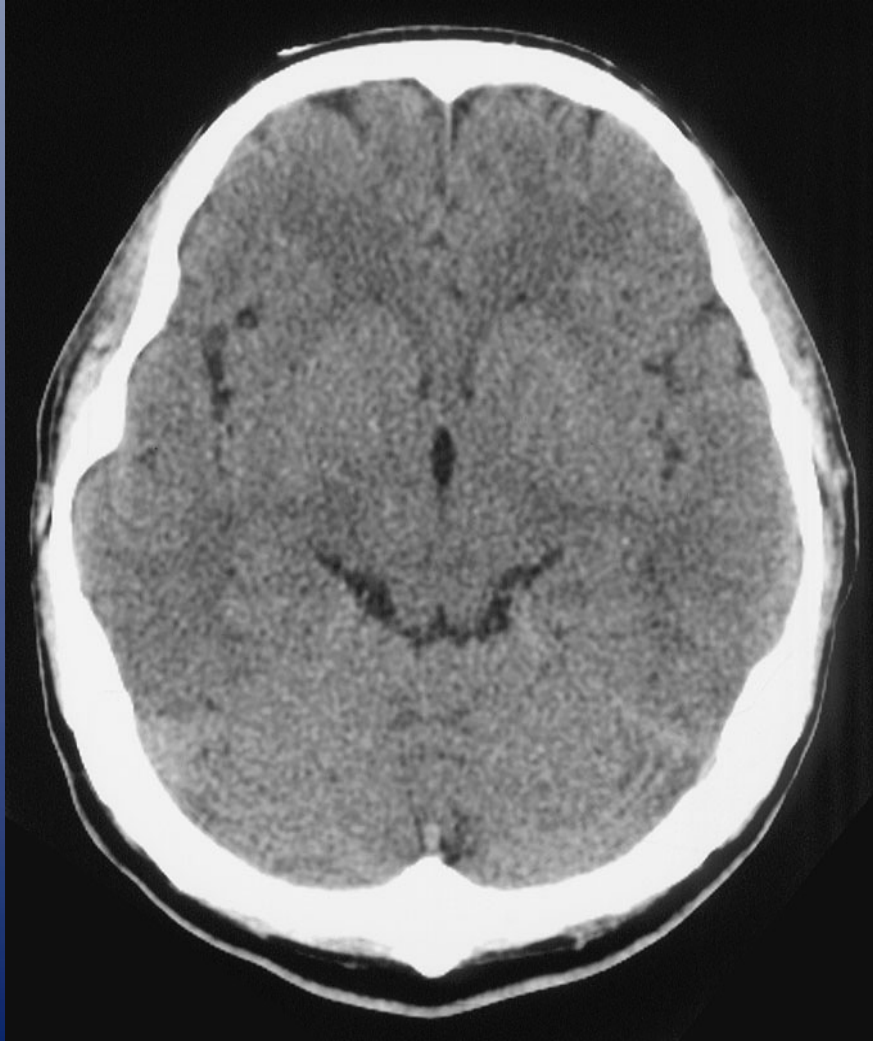
Normal Anatomy



Normal Anatomy



Normal Anatomy



CT - 2 D reformats



Coronal



Sagittal

CT – intravenous contrast

- Iodine-based injection
- May cause hot flush sensation, odd taste in mouth
- Appears white (very hyperdense) on CT – “enhancement”

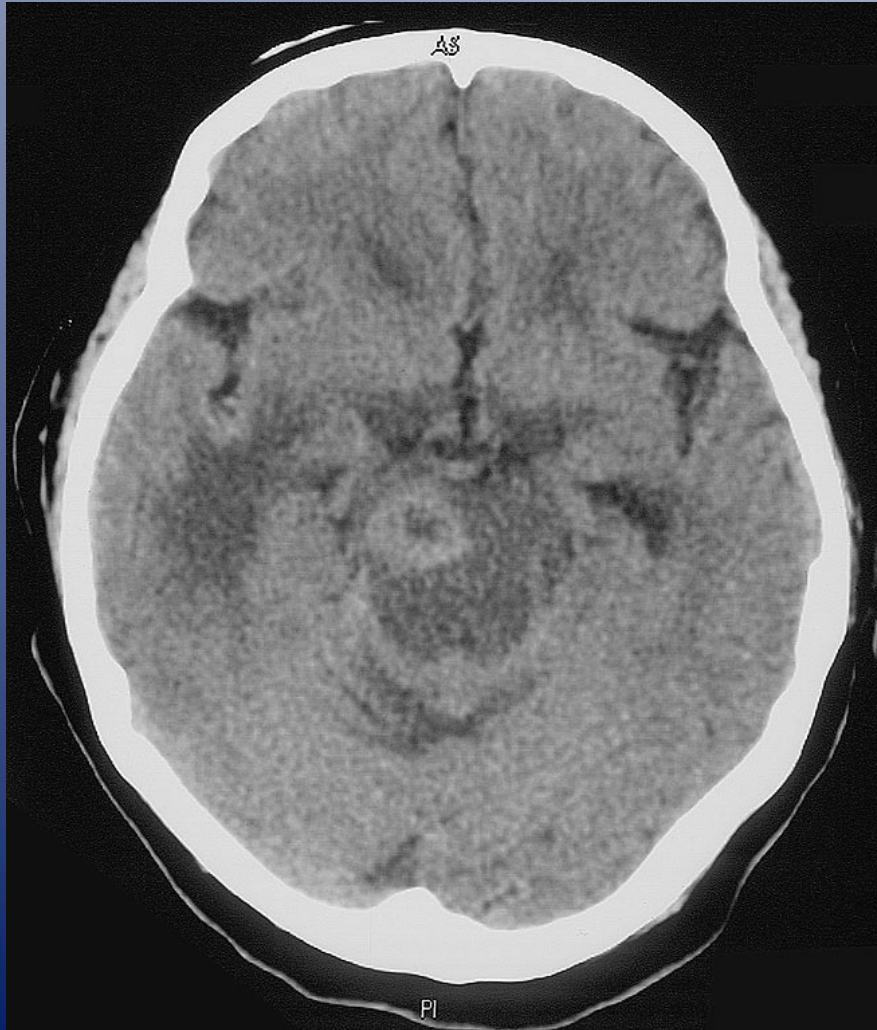
- Pathology → abnormal leaky blood-brain barrier => pathology will enhance
- Normal enhancement seen in some areas – vessels, pituitary, choroid plexus
 - Why? – because at these sites, a blood-brain barrier does not exist

Risks

- Allergic reactions
- Less common with newer non-ionic compounds

INCIDENCE OF GRADE 3
ALLERGIC REACTION ie.
ANAPHYLAXIS 0.02 – 0.04%

CT - intravenous contrast



CT - angiography



CT

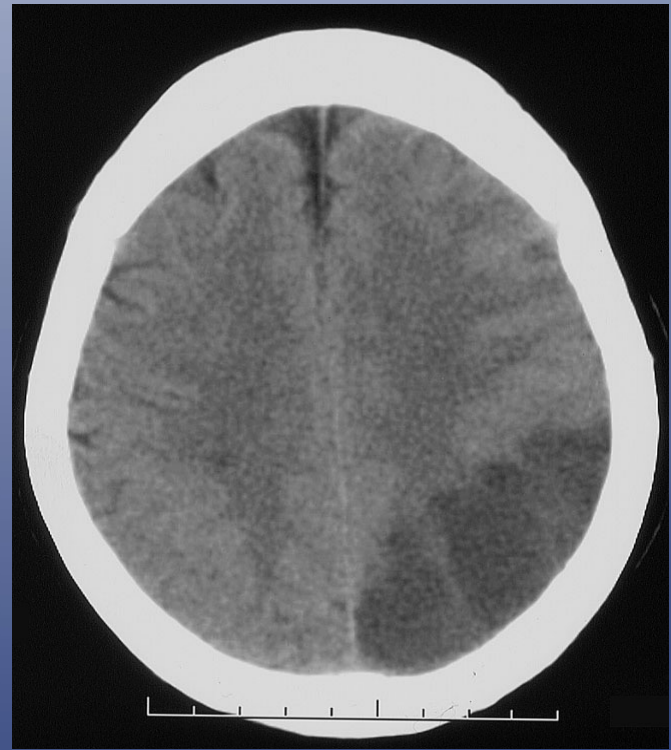
ADVANTAGES

- Excellent bone detail
- Good for blood + Ca +
- Good soft tissue detail
- Quiet and spacious
- CT guided biopsy
- 3-D reconstructions

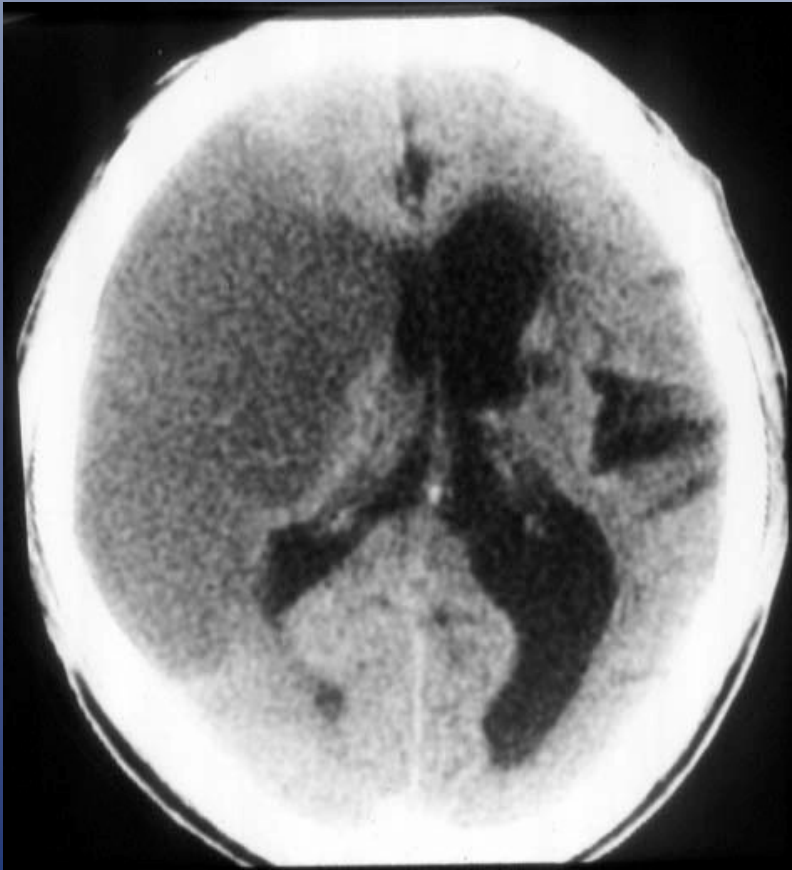
DISADVANTAGES

- Ionising radiation dose
- Soft tissue resolution limited
- Cost
- Use of contrast

Vascular - infarction



Vascular - infarction

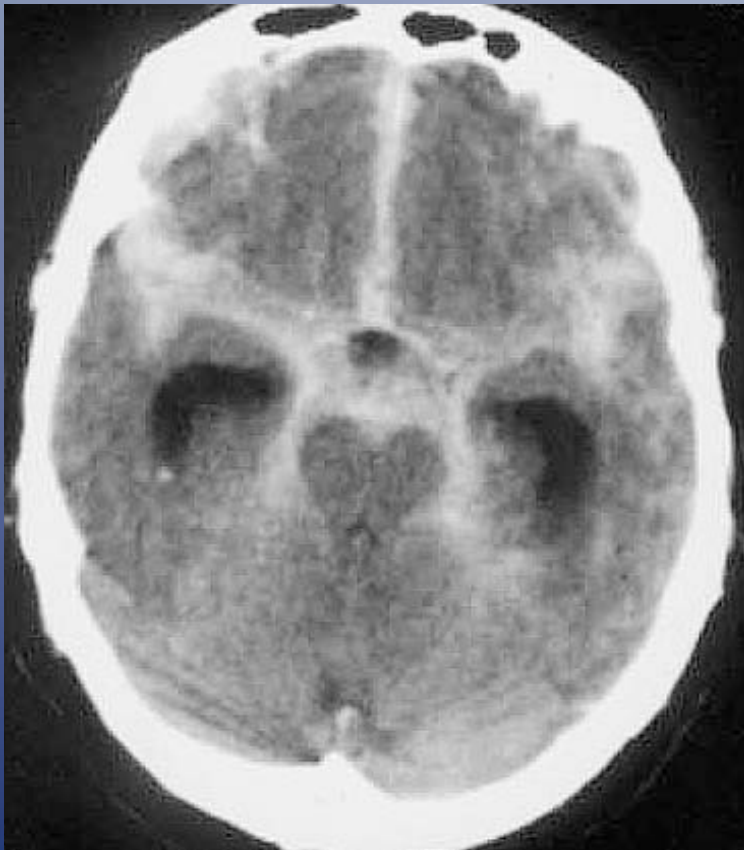


Acute



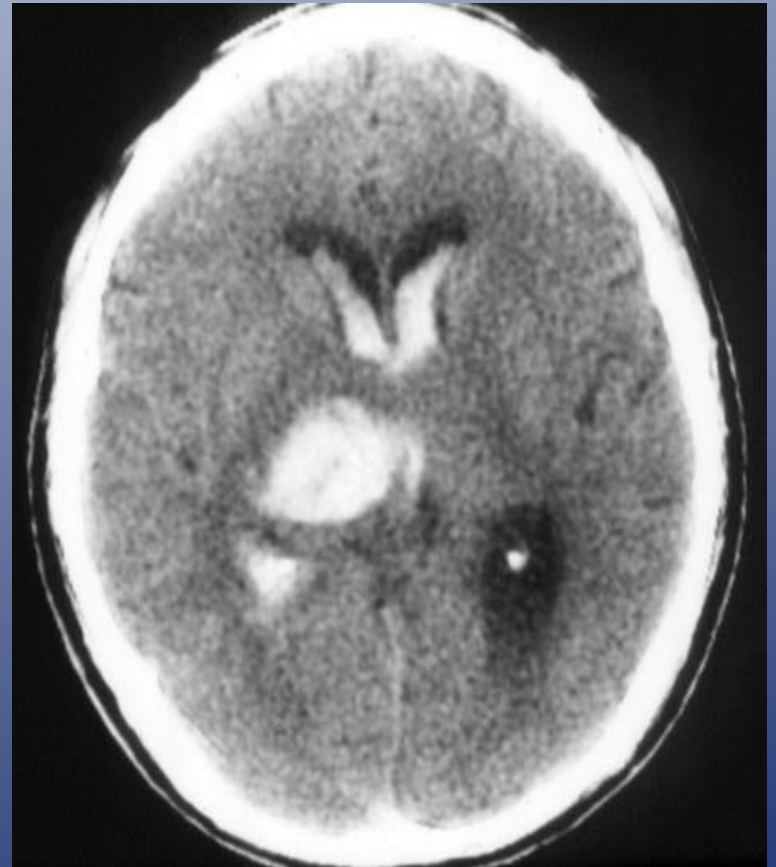
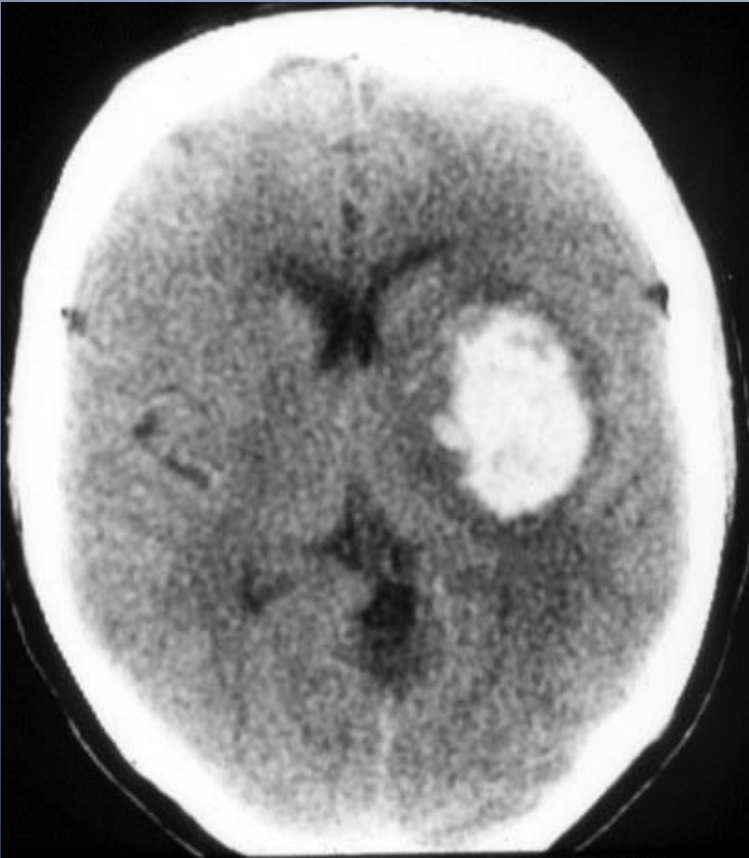
Chronic

Vascular - subarachnoid haemorrhage



Grade 4 SAH with hydrocephalus

Vascular – intraparenchymal haemorrhage



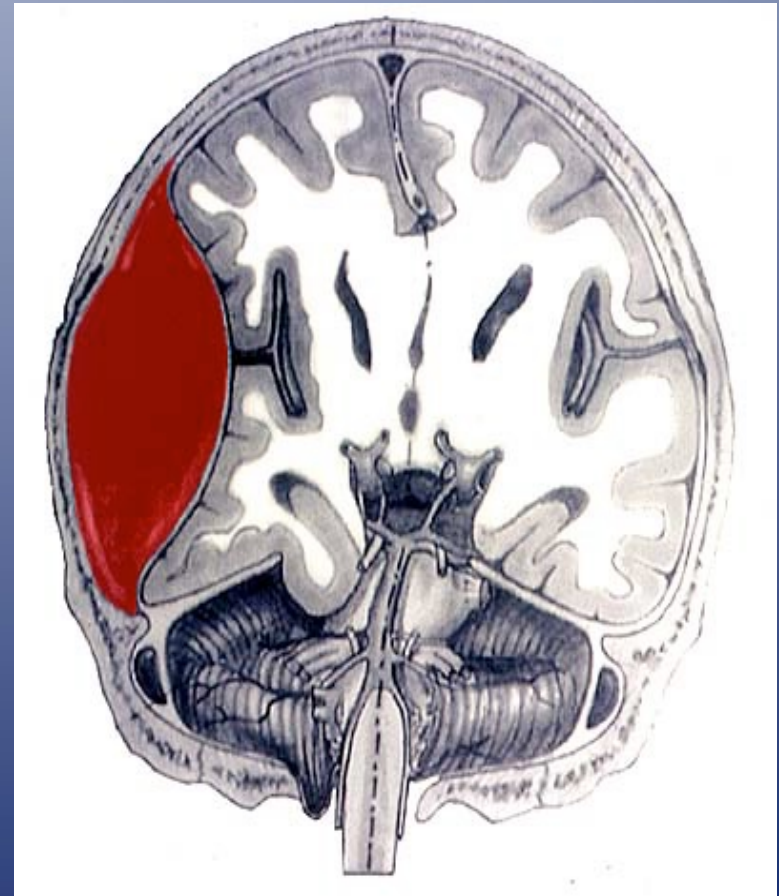
Effects of intracranial masses

- Intracranial masses enlarge at the expense of normal structures
- → displacement or herniation of brain parenchyma from its normal position
- Mass effect and herniation
 - Subfalcial (subfalcine)
 - Uncal/parahippocampal
 - Transtentorial – ascending or descending

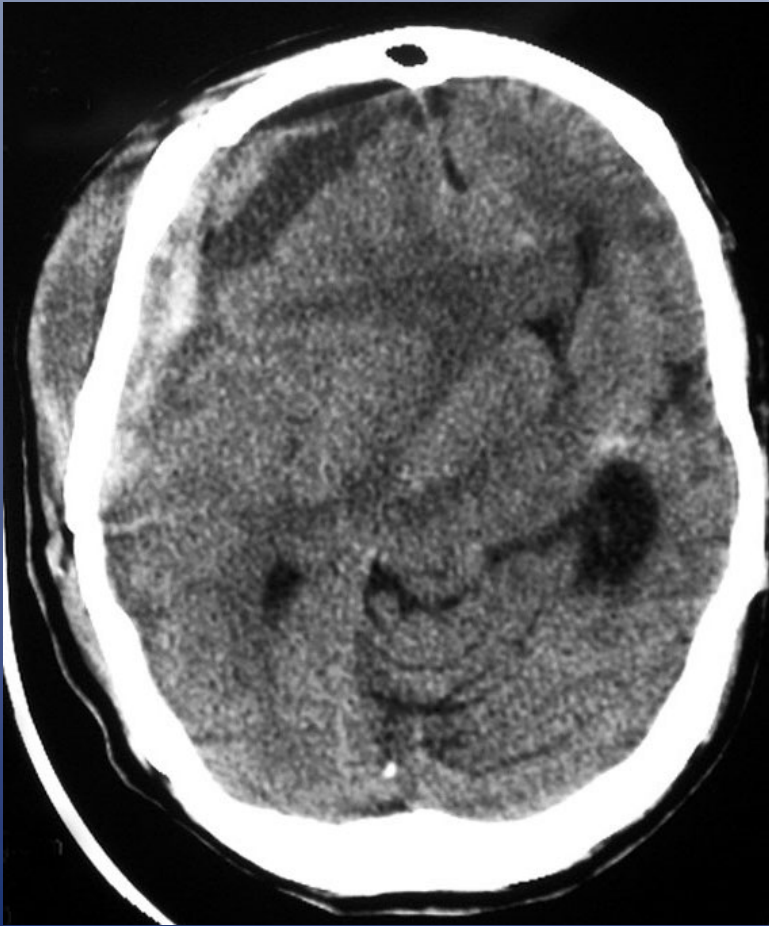
- Tonsillar descent
 - Inferior protrusion of cerebellar tonsils through the foramen magnum
- Effacement of basal cisterns (CSF spaces at base of brain eg. suprasellar cistern, perimesencephalic cistern, quadrigeminal plate cistern)
- Hydrocephalus – communicating or non-communicating

Mass effect and herniation

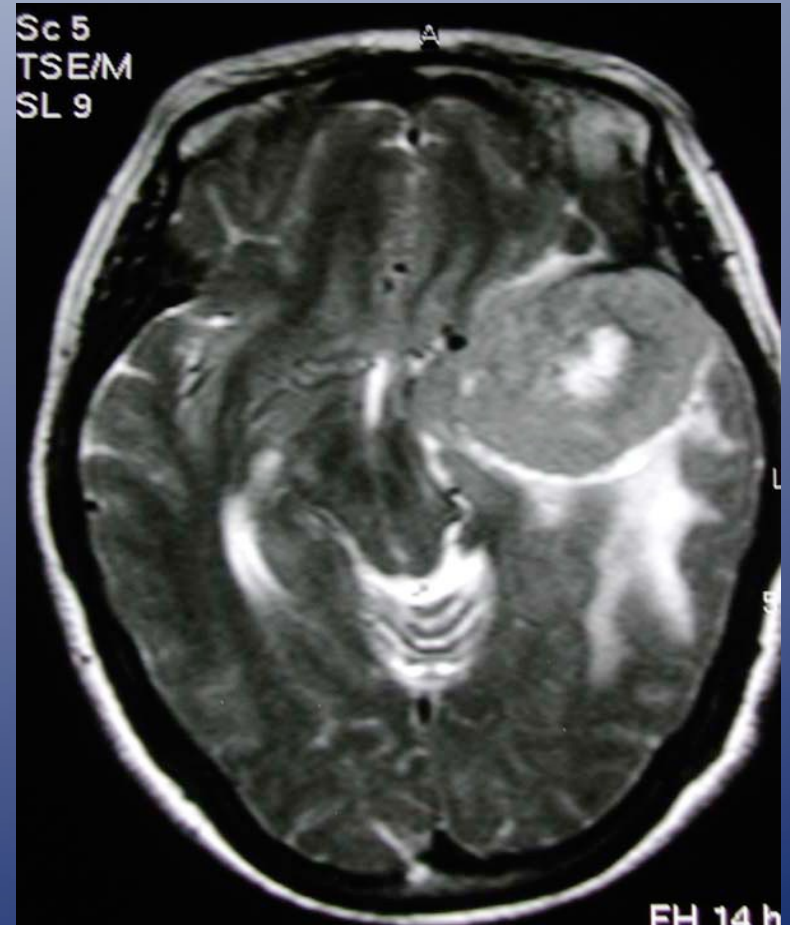
- Uncal/transtentorial
- Tonsillar
- Subfalcine



Mass effect and herniation

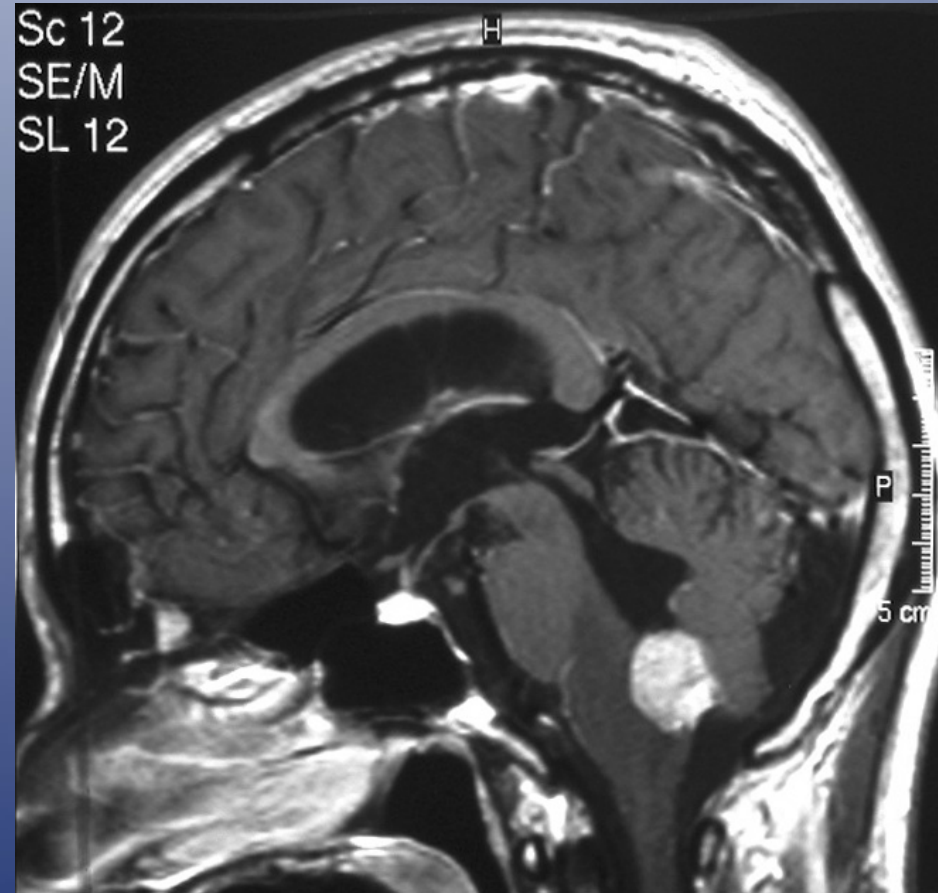
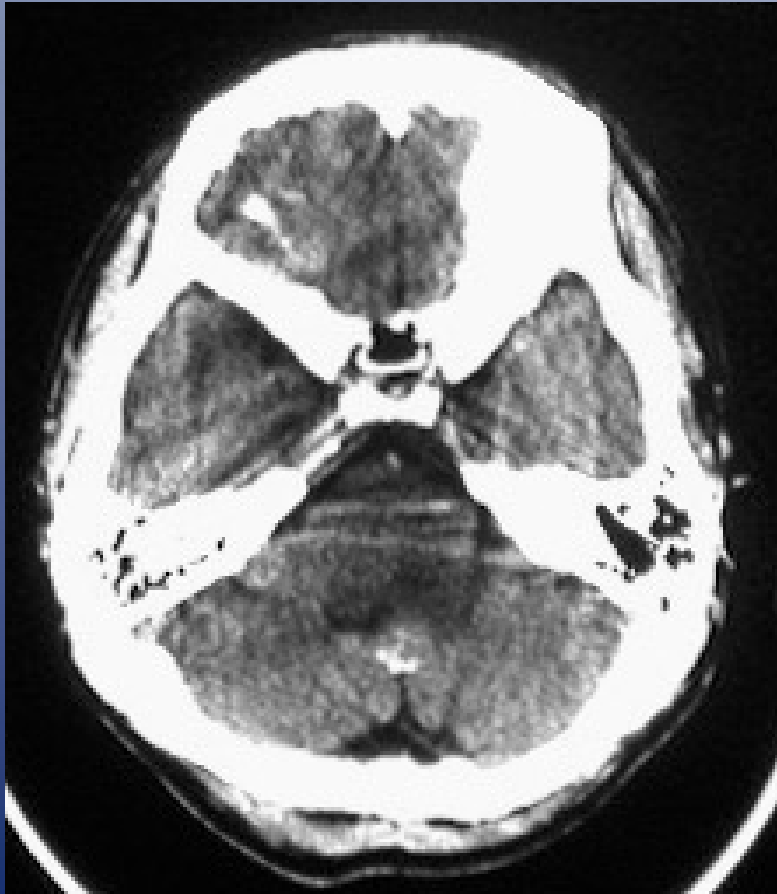


Trauma

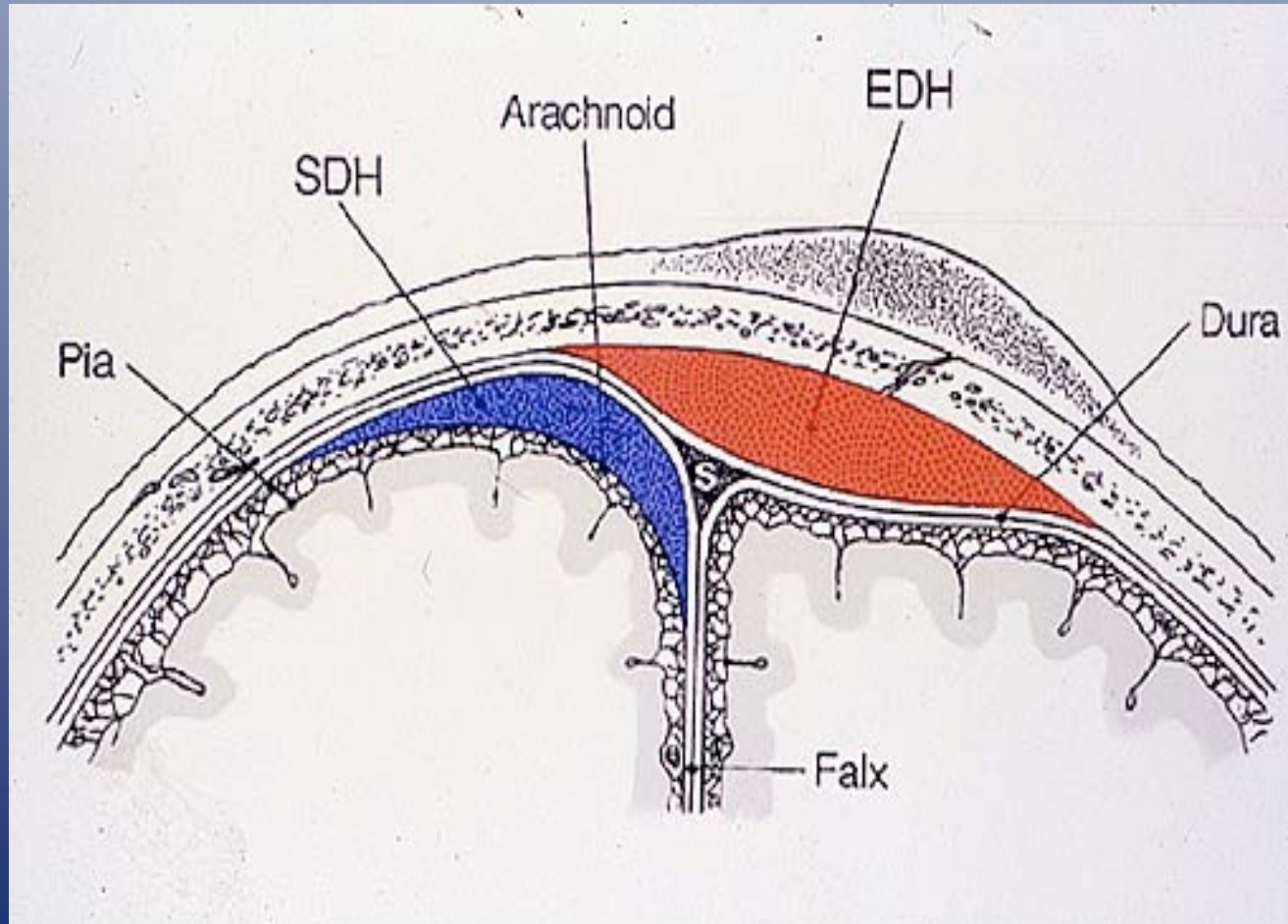


Tumour

Hydrocephalus - ependymoma



Trauma - extra-axial haematomas

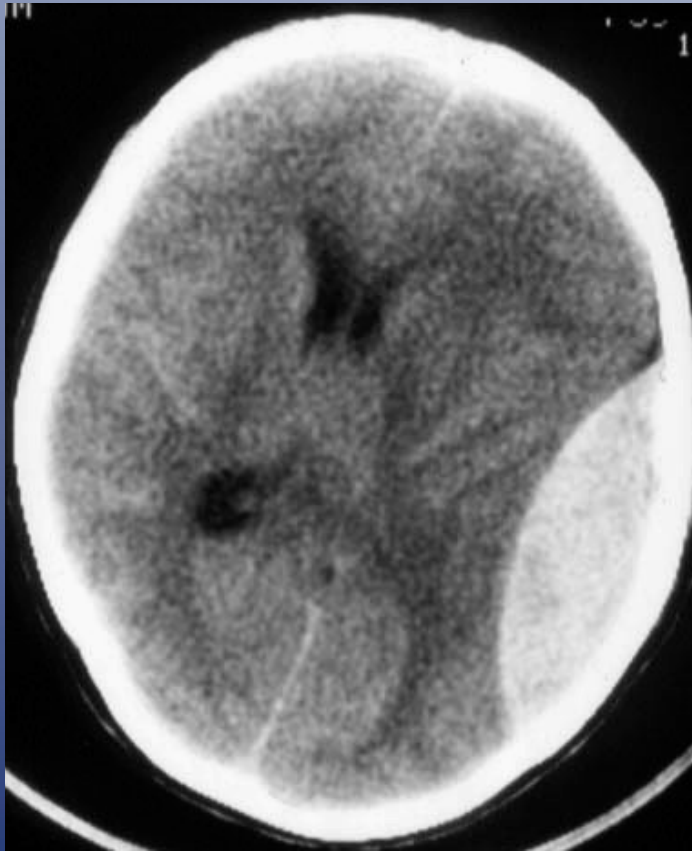


Extradural haematoma

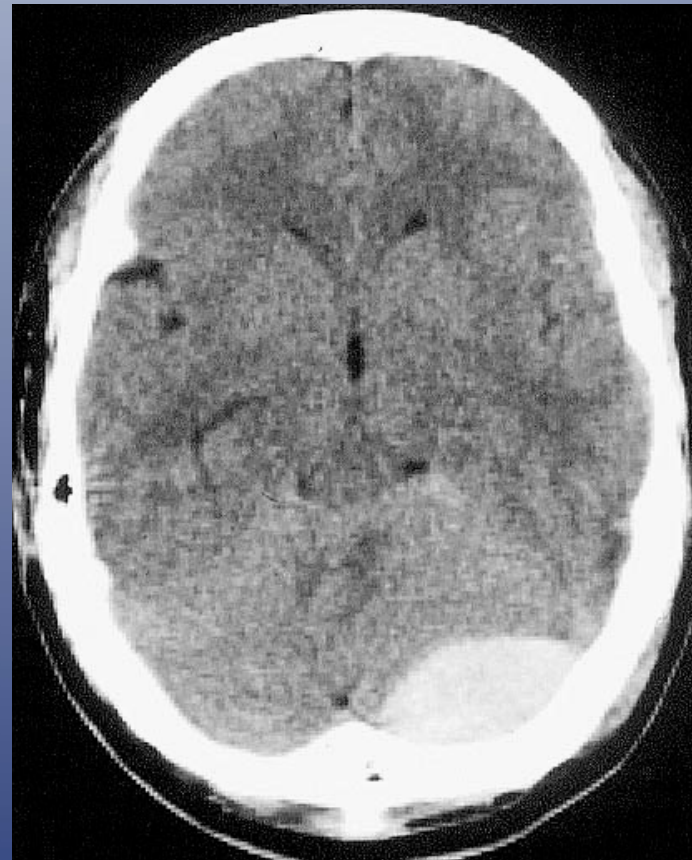
- Coup
- Do not cross sutures
- Can cross tentorium
- Usually lens-shaped (lenticular)
- Often underlying fracture
- May see contralateral subdural



Extradural haematoma



Pterional

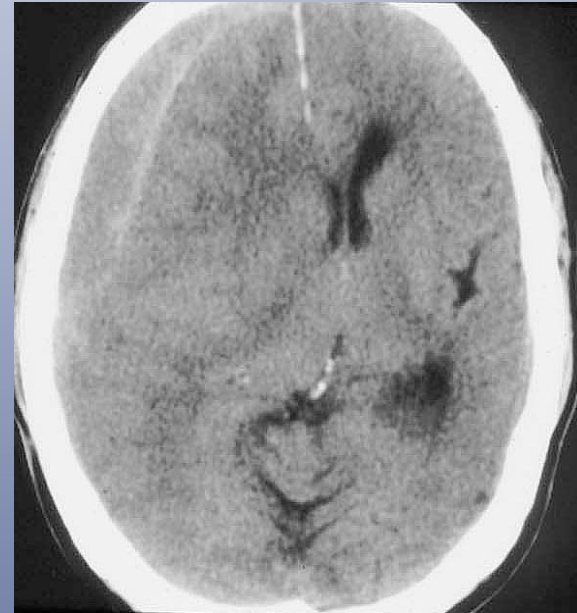
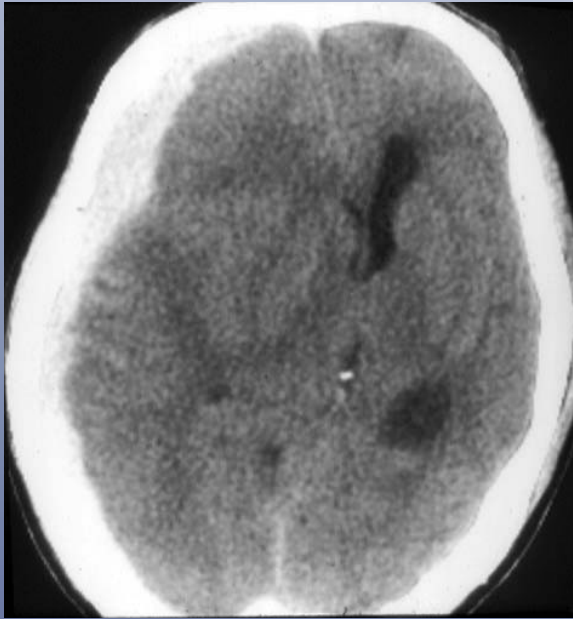


Posterior fossa

Subdural haematoma

- Contracoup
- Crescentic and thin
- Can cross sutures except sagittal
- Do not cross tentorium

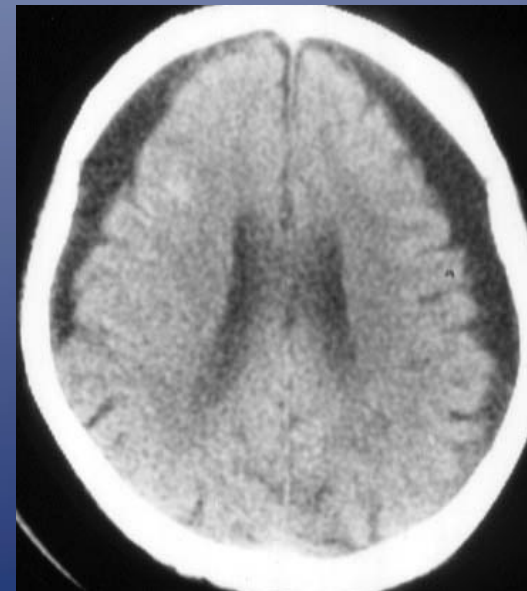




Acute <1 week:
Hyperdense

Subacute 1-3 weeks:
Isodense

Chronic >3 weeks:
Hypodense



Magnetic Resonance Imaging

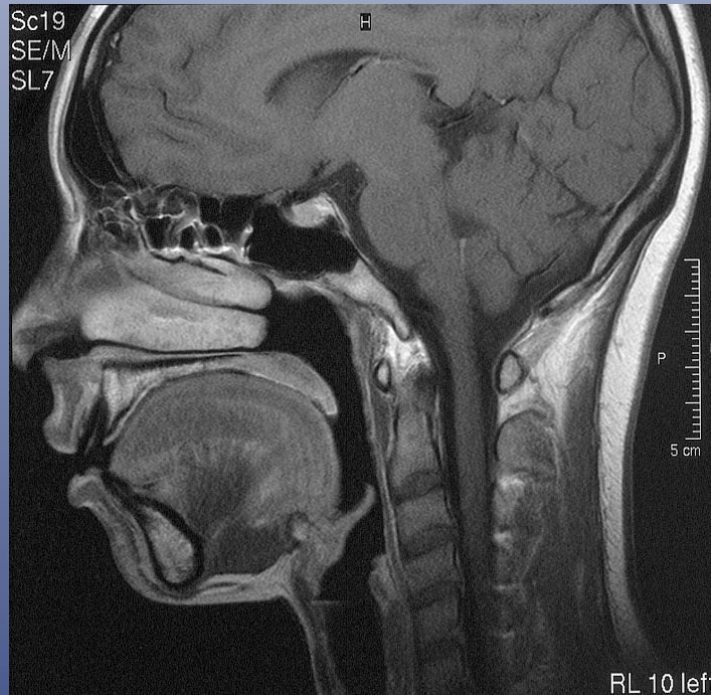
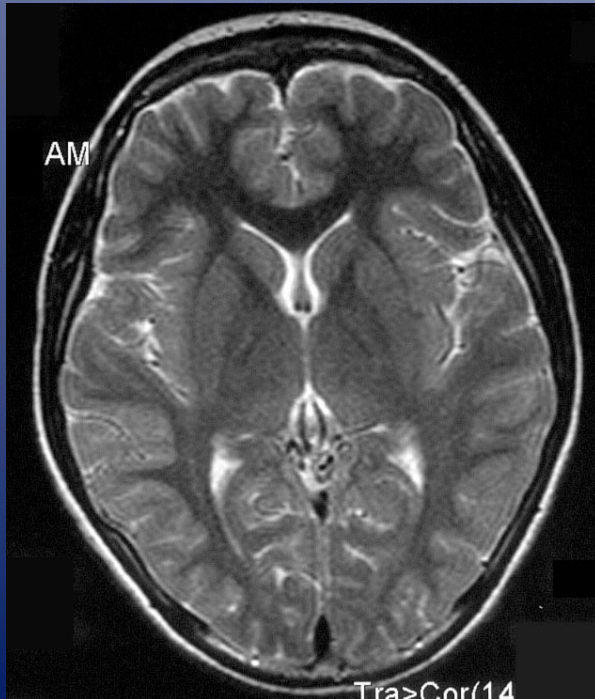


MRI - technique

- Protons line up in strong magnetic field
- RF pulsed in energises protons
- RF pulse turned off
- Protons 'relax' emitting RF signal
- 3D map of signal intensity \rightarrow k-space
- Different RF pulses give different sequence
- Displayed as grey scale images in any plane

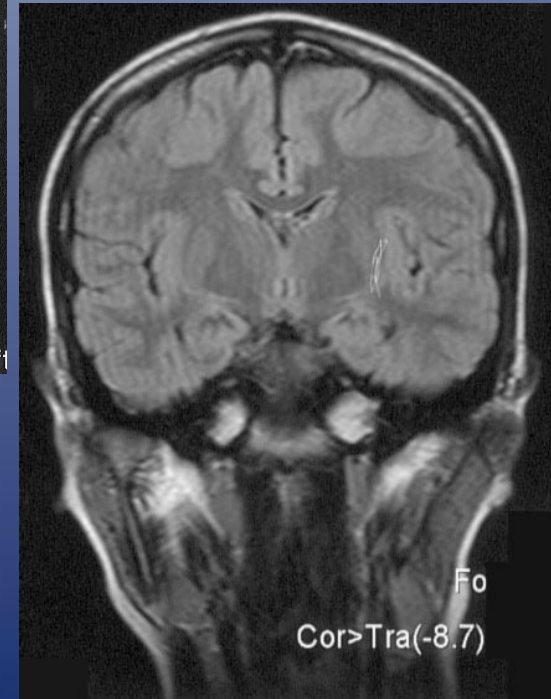
MRI – multiple planes

Axial

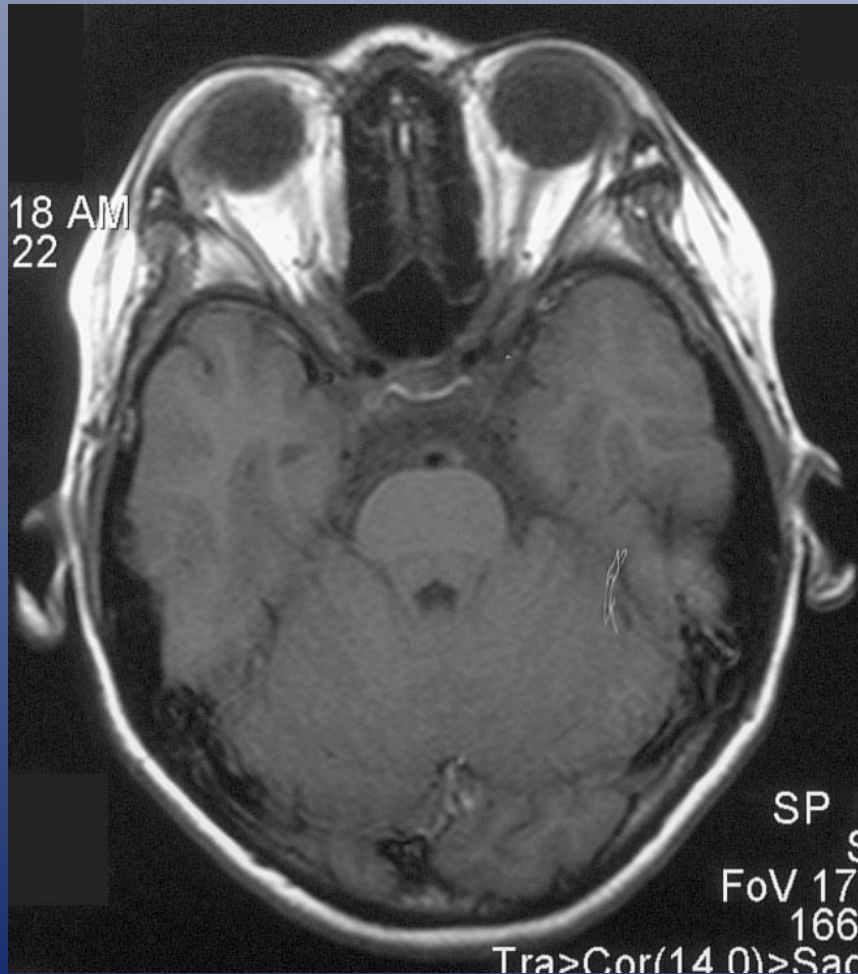


Sagittal

Coronal



MRI – multiple sequences

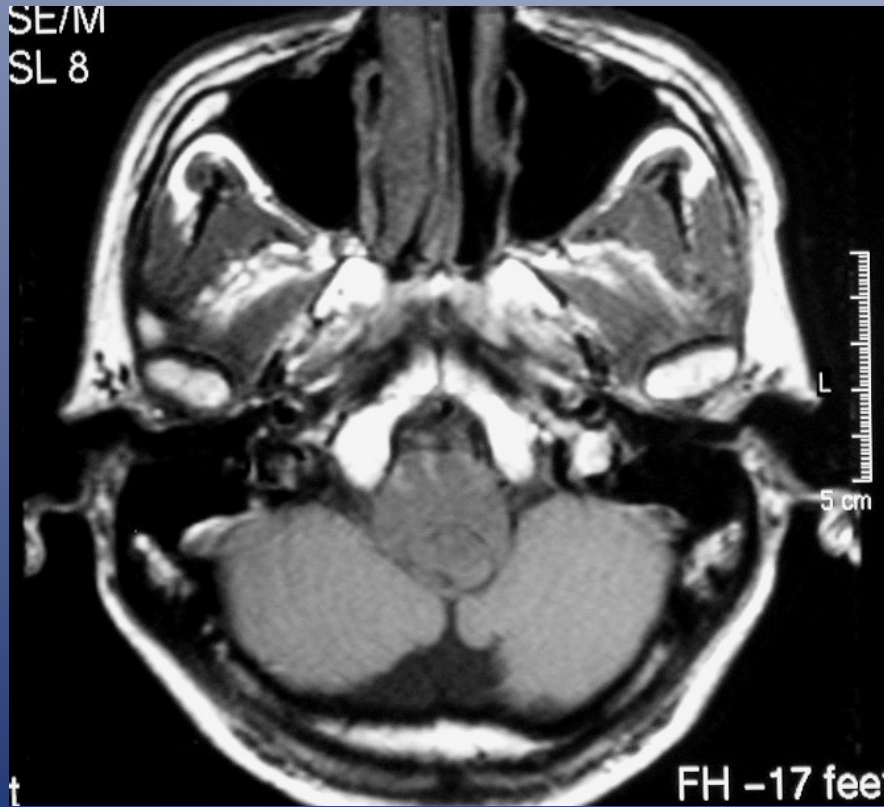


T1W

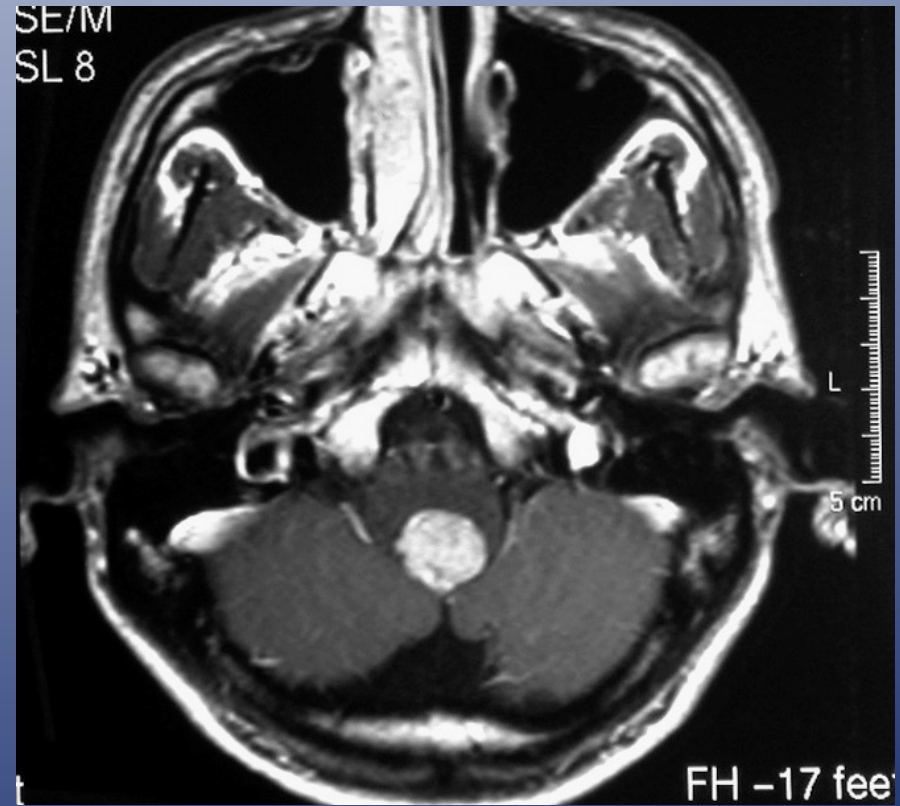


T2W

MRI – contrast



T1W

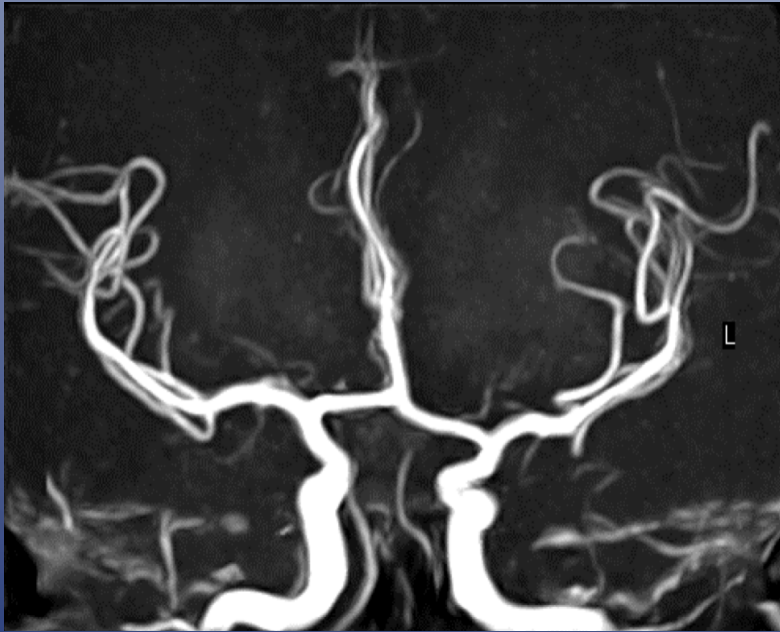


T1W + Gadolinium

Functional MRI

- Newer technology now utilised in clinical radiology
 - Diffusion-weighted imaging and fibre tracking
 - MR spectroscopy
 - Dynamic contrast-enhanced perfusion MRI

MRI - angiography



MRA Circle of Willis



MRA neck vessels

MRI

ADVANTAGES

- Does not utilise ionising radiation
- Exquisite anatomy
- Excellent soft tissue detail
- Inherent multiplanar acquisition

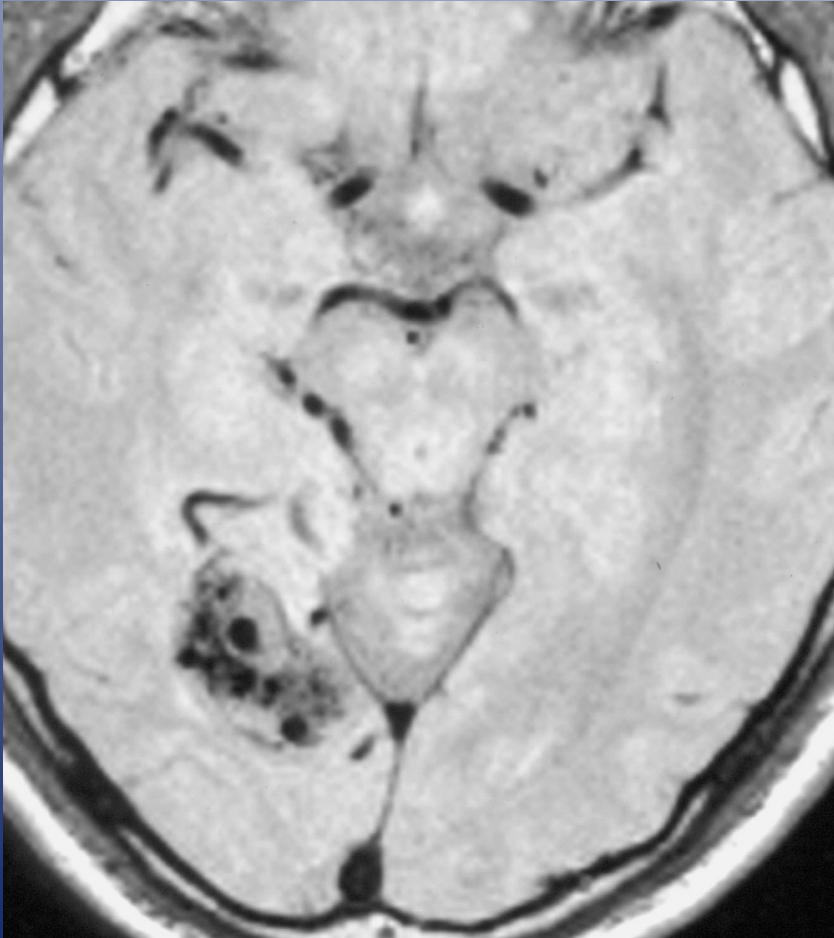
DISADVANTAGES

- Very slow
- Very expensive
- Claustrophobic + noisy
- Poor bone detail
- Availability
- Contraindications
 - Metal implants and foreign bodies, pacemakers

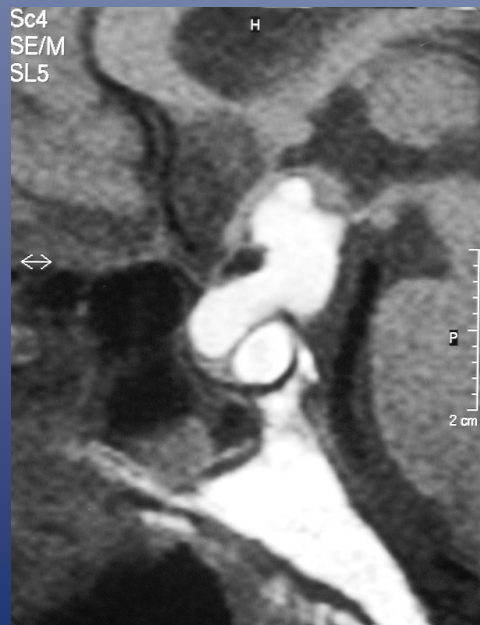
MRI role in neurosciences

- Subtle or small cerebral pathology
 - Infective, inflammatory, neoplastic, vascular, developmental
- Surgical planning and follow-up
- Radiotherapy planning and follow-up
- Non-accidental injury
- Post-mortem imaging and virtopsy

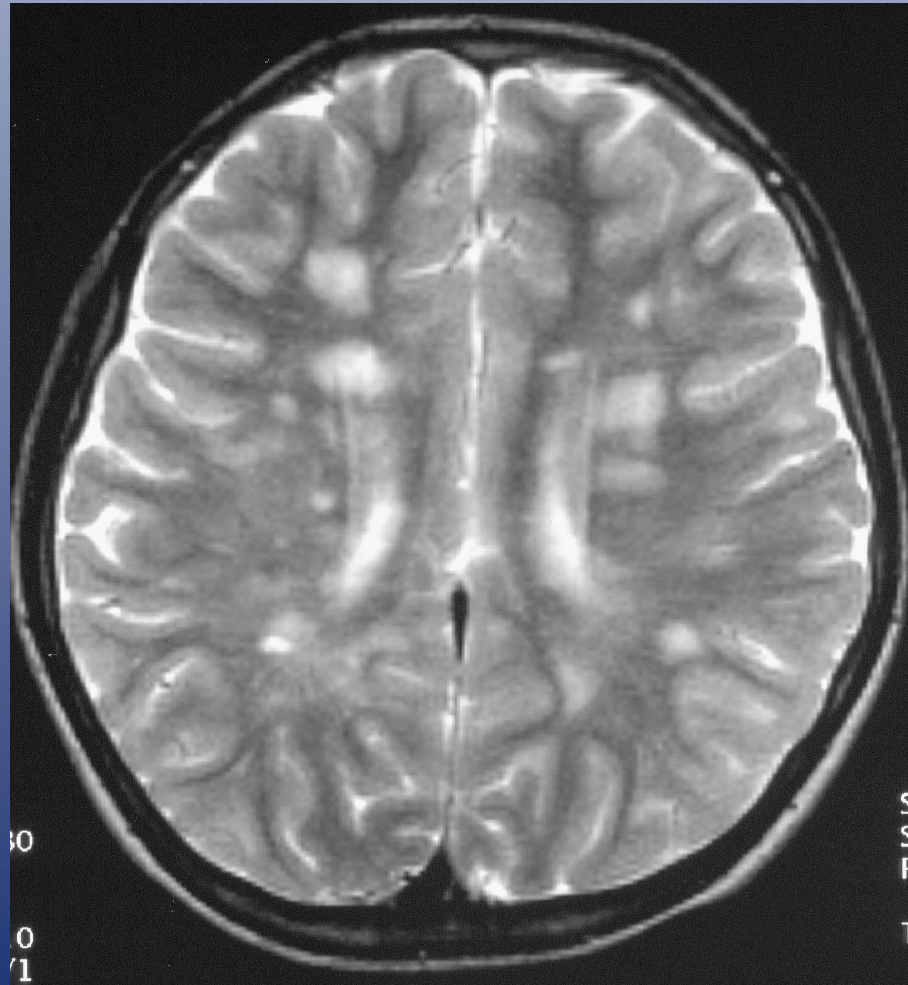
Vascular - arteriovenous malformation



Tumour - craniopharyngioma



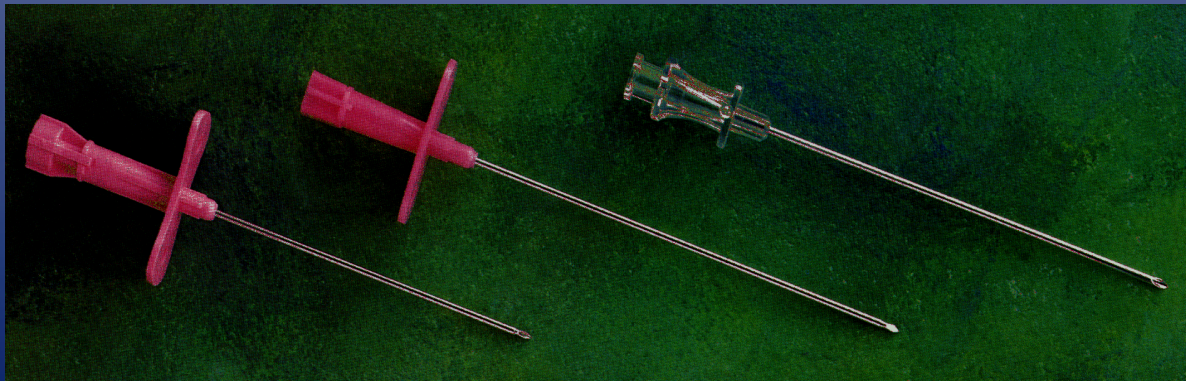
Inflammatory - multiple sclerosis



Digital Subtraction Angiography

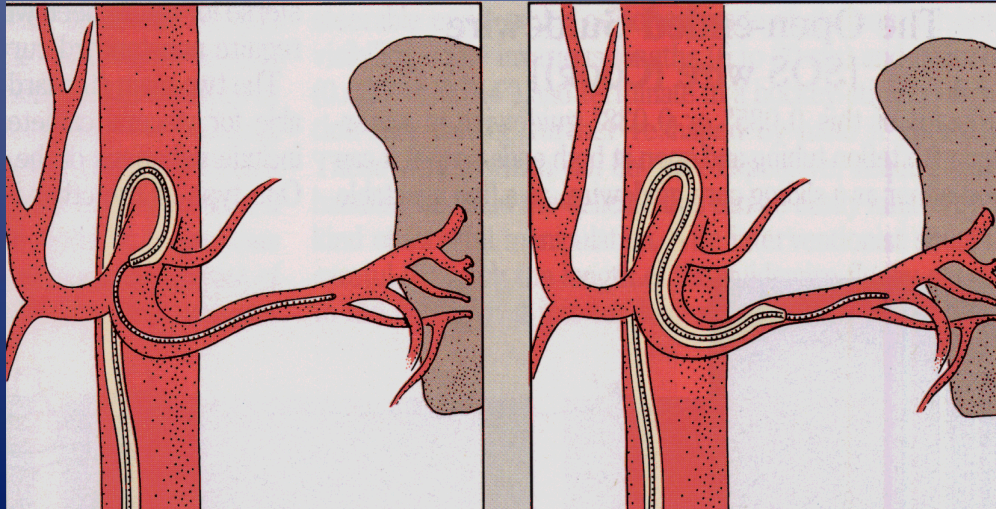
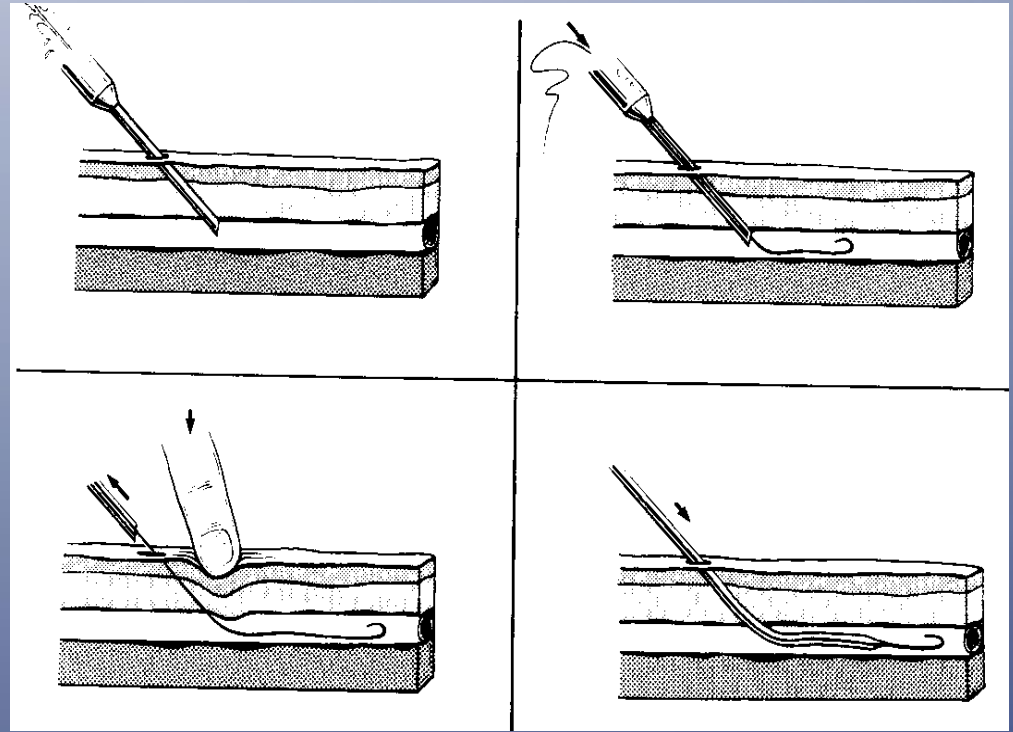


DSA - technique



DSA - technique

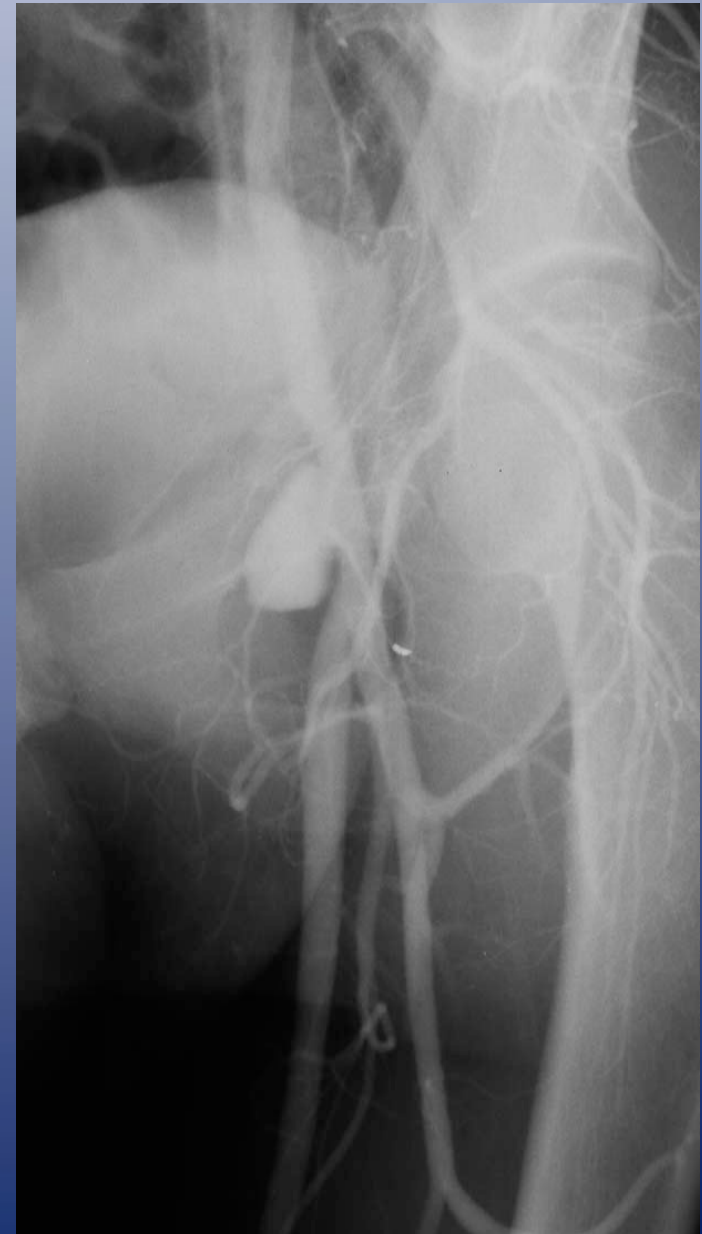
Femoral artery puncture



Selective catheterisation

DSA - complications

- Contrast reaction
- Puncture site: dissection, haematoma, pseudo-aneurysm, arterio-venous fistula, thrombosis and distal embolism
- Catheter-related: dissection, thrombosis, embolism, vasospasm, haemorrhage



DSA – role

- Assessment of vascular inflammatory disease where CT angiography is inconclusive (may avoid open brain biopsy)
- Endovascular therapeutic procedures
 - Aneurysm coiling
 - Arteriovenous malformation embolisation
 - Internal carotid artery stents
 - Intra-arterial thrombolysis management in acute stroke

DSA



Common carotid artery angiogram

DSA



Left internal carotid artery angiogram

SUMMARY

- Neuroimaging is central to diagnostic and therapeutic patient management
- Awareness of some of the imaging modalities available, advantages, limitations and potential risks
- Awareness of neuroanatomy
- Awareness of neuropathology

Thank you