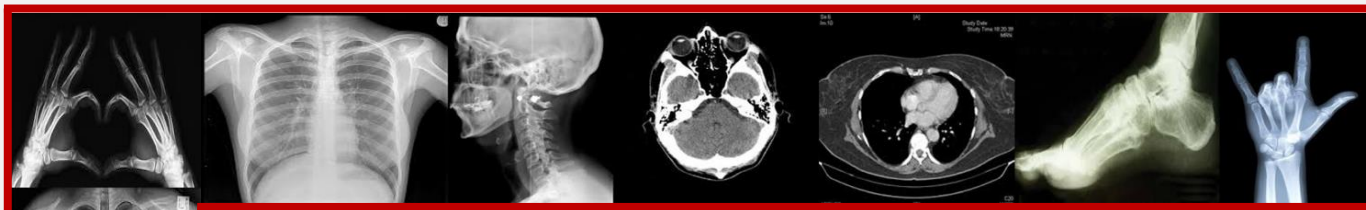
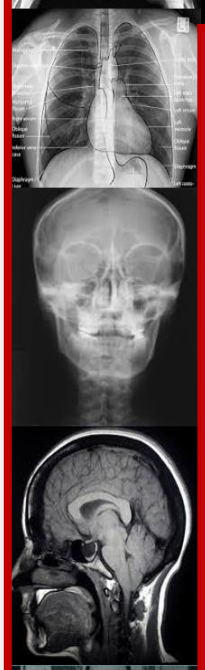
جامعة الملك سعود
King Saud University

RADIOLOGY TEAM 434





Radiology Team

Lecture 9

Radiology of Common Brain diseases

Tumor, Inflammation, Infection

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

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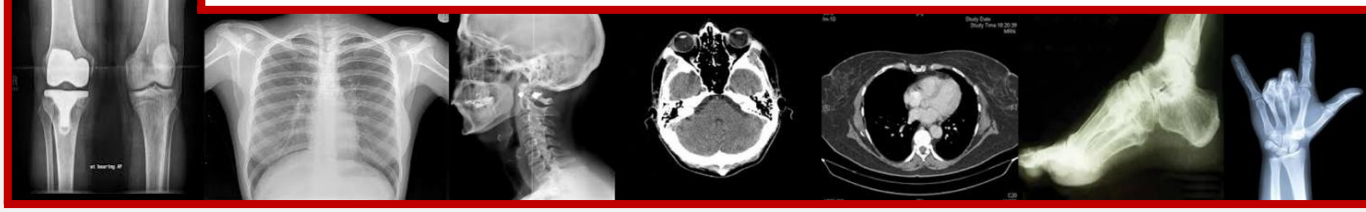
Sorry,there was NO time for decoration :()

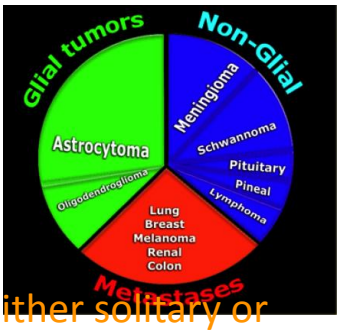


Color Index:

• Important • notes • Explanations

Brain Tumors

Pathological classification



Radiological approach of brain tumors:

A) Multiple masses > narrow DDx

- Metastases
- Lymphoma or Leukemia
- Multicentric GBM "Glioblastoma multiforme" can be either solitary or multiple.
- Gliomatosis cerebri
- Tumor with seeding "primary brain tumor that seeds to other parts of the brain"
- Multiple tumors in phacomatoses as neurofibromatosis type2 > as meningioma and schwannom

B) Solitary tumor > wide DDx >>Localize the site first!

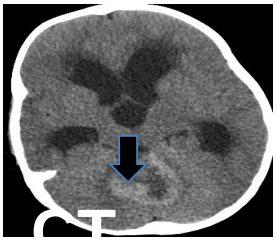
- Supratentorial "Cerebrum"/infratentorial "Brainstem & cerebellum"> in relation to Tentorium cerebelli.
- Intra axial "Brain Parenchyma"/ extra axial"Meninges or other coverings"
- Specific anatomic area "sellar and parasellar, perneal gland , cerebellopontine angle" since they have certain types of tumors
- CT/MRI texture, pattern of enhancement
- Age!!!

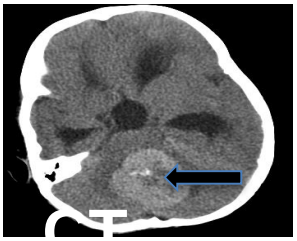
Common Intra-Axial Tumors in Pediatric:-	
Supratentorial "AP2GD"	Infratentorial "BEJAM"
• Astrocytoma • Pleomorphic xanthoastro (PXA) • Ganglioglioma • PNET Primitive neuroectodermal tumor • DNET Dysembryoplastic neuroepithelial tumour	• Brainstem astrocytoma • Ependymoma • Juvenile pilocytic astrocytoma • Atypical teratoid/rhabdoid tumor • Medulloblastoma

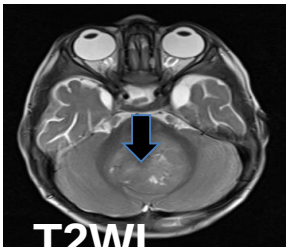
Medulloblastoma:

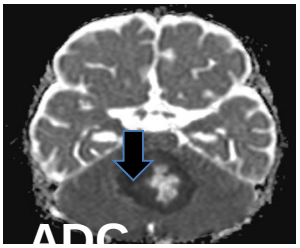
- PNET
- In the posterior fossa
- WHO IV
- Midline >85% 4th Ventricle
- Age incidence < 10 y, second peak 20- 40y

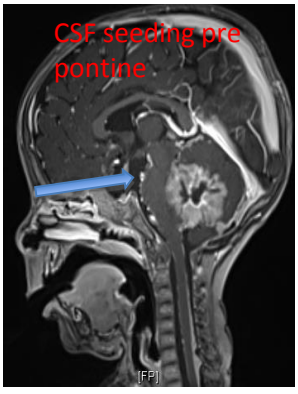
- Hyperdense on CT "White"
- Cysts 40% Dark area within the mass
- Ca++ 20-25% more Hypredense
- Low / intermediate signal on T2WI
- Diffusion restriction "bright on DWI and dark in ADC"
- Enhances post contrast injection >solid part "main bulk" is white
- CSF seeding >some cells metastasize through the CSF to some area as prepontine area, auditory canal
- Drop metastases in the spine

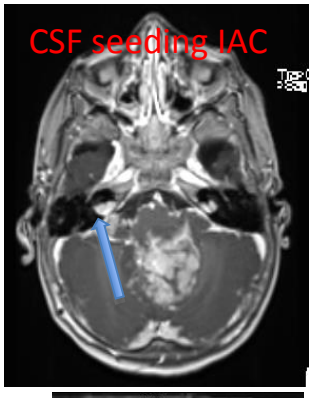


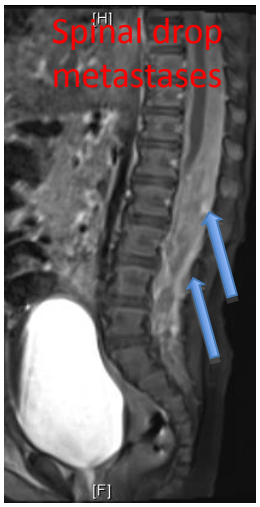






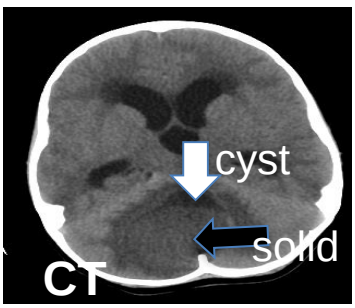


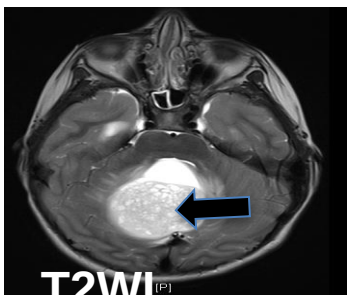


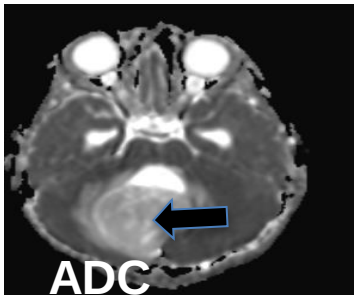


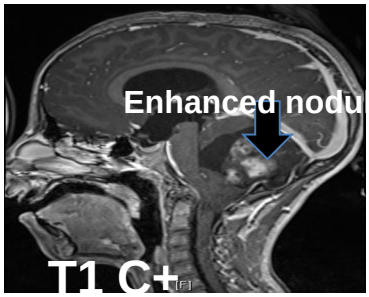
Pilocytic astrocytoma:

- Low grade I
- Age incidence 5-15 years
- Cyst with enhancing nodule Most are cyst with solid mural nodule
- Low density on CT cystic part contains CSF "dark" > the white arrow, while the solid "hypordense"
- High signal on T2WI
- No diffusion restriction "Bright"
- Enhanced solid mural nodule while the cyst is not





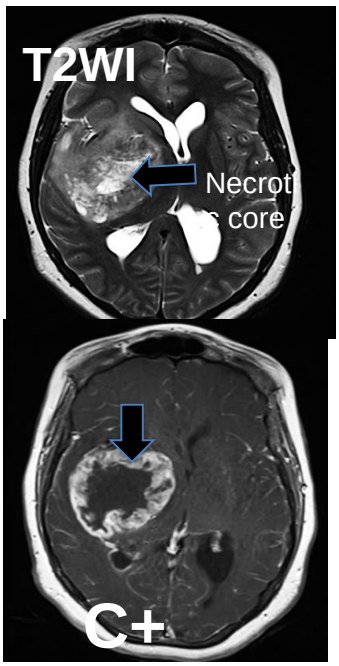


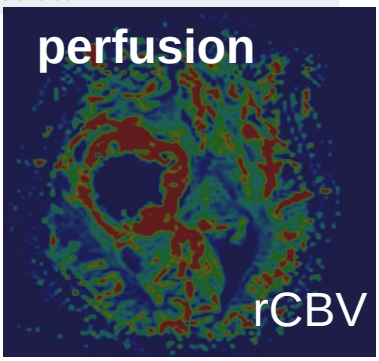


Common Intra-Axial Tumors in Adults:-	
Supratentorial	Metastases “NOT COMMON”
1. Metastases 2. Gliomas: • Diffuse astrocytoma > Low grade • Anaplastic • Glioblastoma Multiforme >grade IV • oligodendroglioma :can be Diffuse, Anaplastic or High grade	1. Metastases “50% of the brain tumors are metastases” 2. Hemangiblastoma

Common Intra-Axila Supra tentorial Tumor in Adult
Glioblastoma Multiforme (GBM)

- WHO grade IV.
- Most common primary brain tumor and most malignant.
- 60-75% of astrocytoma.
- Peak age 45-75 years
- Can occur at any age even neonates and infants
- Cerebral hemisphere (subcortical, periventricular and across compact tract). Basal ganglia and thalamus.
- It’s Intra axial means it is within the parenchyma surrounded always by white matter
- Heterogeneous complex mass (solid with necrotic core) sometimes hemorrhagic
- Thick irregular nodular peripheral enhancement. Necrotic parts won’t enhances post-contrast.
- High perfusion value > more red more perfusion more high grade.
- Mass effect > midline shift
- Usually High-signal T2. If higher grades it will be Low\intermediate.
- In the CT: complex, variable low density lesions “necrosis is dark”.



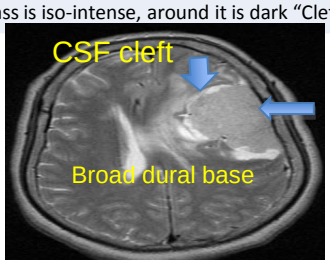


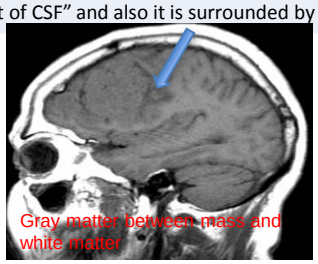
Extra Axial tumors:

- Meningioma < most common
- Metastases (calvarial, dural and leptomeningeal) Dural (breast, lung, prostate, melanoma, neuroblastoma, lymphoma and leukemia) leptomeningeal (CSF seeding from GBM, AA, medulloblastoma and ependymoma)
- Schwannoma
- Epidermoid
- Dermoid
- Arachnoid cyst

Signs of Extra-Axial Location:

- CSF cleft < CSF pushed by the tumor inside and surrounded it
- Broad dural base
- Cortical gray matter between mass and white matter
- Displaced subarachnoid vessels
- The mass is iso-intense, around it is dark “Cleft of CSF” and also it is surrounded by “Grey matter”.



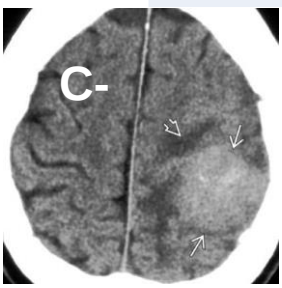


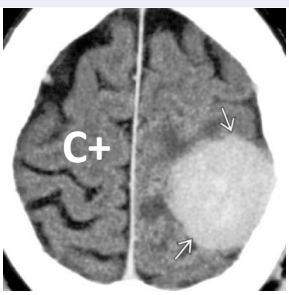
Extra Axial tumors:

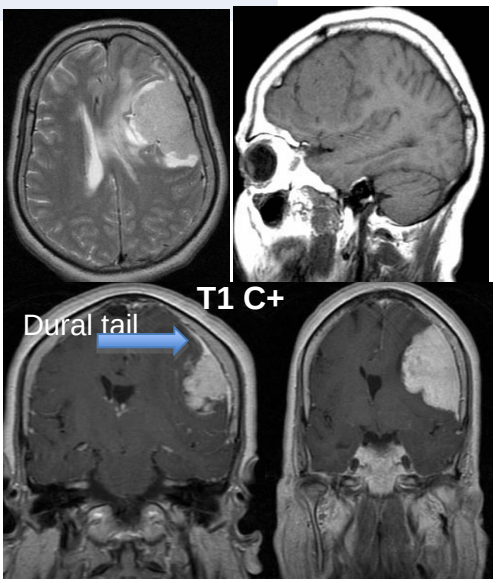
Meningioma:

Meningioma is the most common type of extra-axial neoplasm and accounts for 14 - 20% of intracranial neoplasms. It is a non-glial neoplasm that originates from the arachnoid cap cells of the meninges.
Location:
85 - 90% supratentorial, 45% parasagittal, convexities 15 - 20% sphenoid ridge,
10% olfactory groove / planum sphenoidale,5-10% juxtasellar

CT:	MRI:
• 60% mild-moderate hyperdense to normal brain “high cellular packed” 60% peri tumoral vasogenic edema • 20 - 30% have some calcification • Vast majority of meningioma post-contrast enhance strongly and uniformily	• T1 : Isointense: ~ 60 - 90% • T2: isointense : ~ 50% • T1 C+ (Gd) : usually intense and homogenous enhancement. • Dural tail seen in 60-70% “not specific”

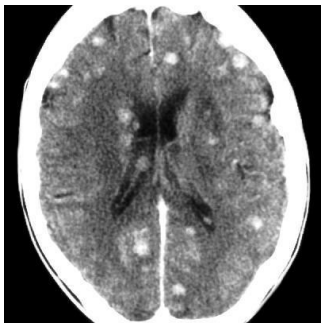




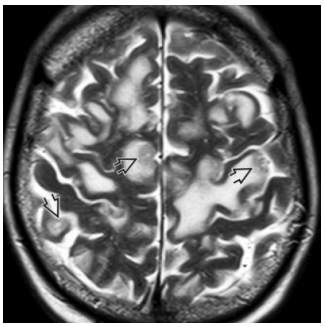


Secondary Brain Tumors (Brain Metastases):

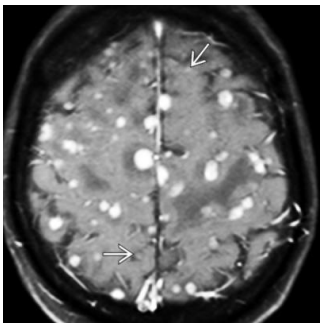
- Metastatic brain tumors are the most common brain tumors.
- The primary cancer is usually in the lung, breast, colon, kidney, or skin (melanoma), but can originate in any part of the body.
- Most are located in the cerebrum, but can also develop in the cerebellum or brain stem. The common thing is all secondary are enhancing post-contrast.
- More than half of people with metastatic tumors have multiple lesions (tumors)



CT+
Multiple enhanced lesions a
Grey-white matter interface



MRI T2WI
Multple slightly hyperintense
nodules with surrounding edema

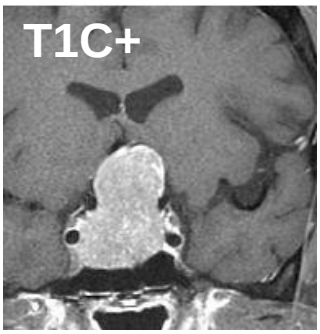


MRI T1WI C+
The nodules are strongly enhanced

Sellar and Parasellar masses:

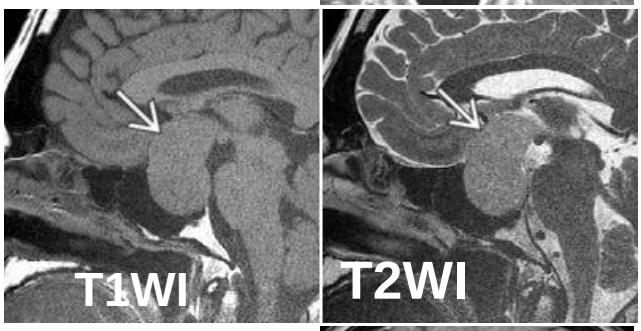
Adult	Children	Other less common
• Adenoma • Meningioma • Aneurysm "not tumor but mimics it"	• Craniopharyngioma "most common" • Hypothalamic/optic chiasm pilocytic astrocytoma	•Metastasis •Lymphoma •Hypothalamic hamartoma •Rathke cleft cyst •Arachnoid cyst •Epidermoid •Dermoid •Germinoma

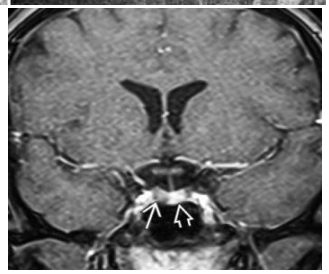
Sellar and Parasellar masses (continued):



A) Pituitary adenoma

- Pituitary adenomas are accounting for 10-15% of primary intracranial neoplasms.
- All are WHO grade I tumors.
- Macroadenomas are defined as tumors larger than 10 mm in diameter.
- Macroadenomas are usually isointense with cortex on T1WI and T2WI.
- Cysts and hemorrhage are common.
- Most macroadenomas enhance strongly but heterogeneously on T1 C+
- Relation to surrounding structures; Optic chiasm thinning (reversible post-surgery) , invasion of the cavernous sinuses or not.
- Microadenomas are defined as tumors ≤ 10 mm in diameter. Harder to diagnose!
- Dynamic contrast-enhanced study usually used for detection of small microadenomas "within certain time"
- Early coronal image from a dynamic contrast-enhanced sequence shows the intensely, rapidly enhancing normal gland (white open arrow). The mass enhances more slowly and so appears relatively hypointense (white arrow). Normally, enhances more after 20 seconds. If less enhancement > adenoma as filling defect.





B) CRANIOPHARYNGIOMA:

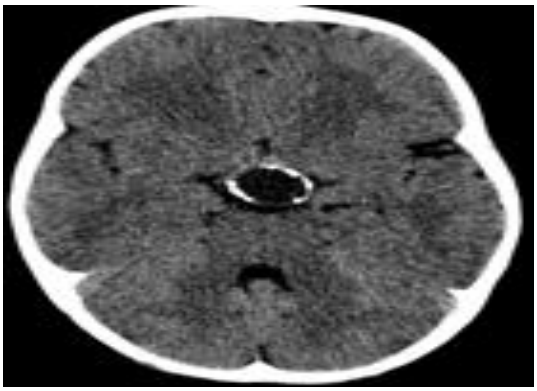
- Benign (WHO grade I) neoplasm.
- Arises in the sellar / suprasellar region.(Craniopharyngiomas are primarily suprasellar tumors (75%). A small intrasellar component is present in 20-25% of cases)
- They account for ~ 1 - 5 % primary brain tumours.
- They derive from remnants of the craniopharyngeal duct (narrowing which separates Rathke's pouch from the primitive oral cavity), and can occur anywhere along the infundibulum (from floor of the third ventricle, to the pituitary gland).
- Two types of craniopharyngiomas are recognized: Adamantinomatous 90% Papillary 10%.
- craniopharyngioma has two peaks in children and in adults. Adamantinomatous is more common in the children while papillary is more common in the adults)
- Cysts are seen in 70 - 75% of cases and are a more dominant feature of the adamantinomatous type.
- Adamantinomatous type has different components; cystic and solid components
- Papillary types has only solid components.
- Calcification: is very common, but this is only true of the adamantinomatous subtype (90% are calcified).
- Pattern of calcification : stippled and peripheral • In the cyst: usually calcification surrounds cyst • In solid component: calcification is heterogeneous.

Note:
Q-how to differentiate between pituitary adenoma and craniopharyngioma ? By presence of calcification which is very likely to be seen in craniopharyngioma. And CT scan is more sensitive in detecting calcification than MRI.

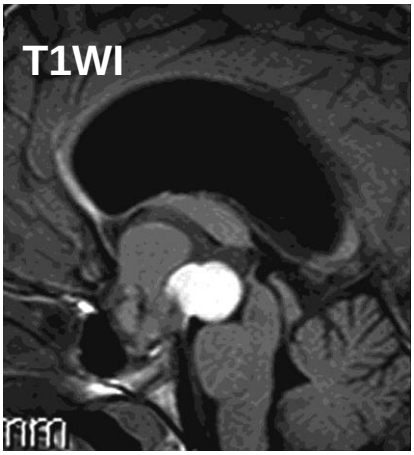
B) CRANIOPHARYNGIOMA (continued):

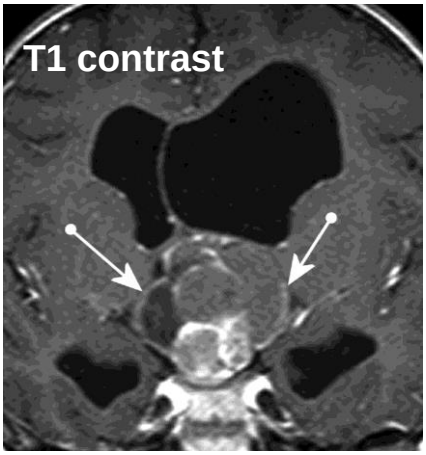
CT

Comment: Typically seen as a heterogeneous mass in the suprasellar region.
(cyst appears black in the CT)



MRI





Comment: MRI features can significantly vary depending on the histological subtype and on the size and content of the cysts.
T1WI : signal intensity varies depending on cyst contents, and can appear hyper intense due to protein, blood products, and cholesterol
T1 C+ (Gd): contrast enhancement is typical, with thin enhancement of the cyst wall, or diffuse heterogeneous enhancement of the solid components.
T2WI: signal is high in both solid and cyst but is variable depending on content of fluid

Note(s):

- Craniopharyngioma T1W1 sequent: here signal intensity is depending on the contents of the tumor, so if the cyst contains a dark fluid like CSF, it will appear hypo-intense. On the other hand, if it is consists of blood or protein, it will be very bright (hyper-intense)
- What are the roles of radiology in neuro-oncology ? 1-to diagnose the tumor itself 2-to differentiate it from other tumor mimics (such as aneurysm, infarction,,etc) 3-for treatment plan (surgery/radiotherapy). 4-for follow up (after surgery/radiotherapy)

Demyelinating and Inflammatory Diseases:

❖ What is the difference between infection and inflammation?

-Inflammation: is the response of tissues to a variety of pathogens (which may or may not be infectious microorganisms). The inflammatory "cascade" is complex and multifactorial. It involves the vascular system, immune system, and cellular responses such as microglial activation, the primary component of the brain's innate immune response.

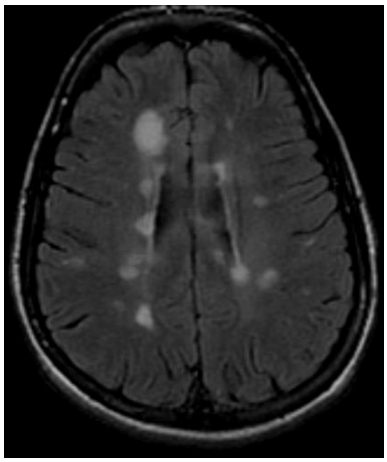
-Infection: **is the presence of the micro-organism**

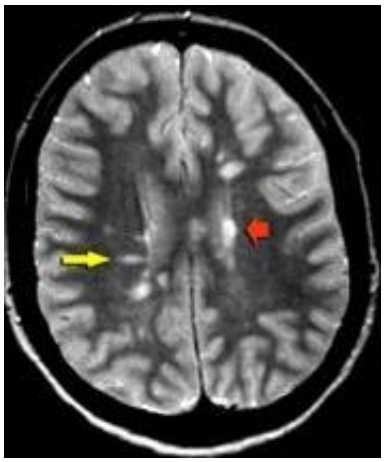
➢ Imaging plays a central role in the identification and follow-up of neuro-inflammatory disorders

A) Multiple Sclerosis :

Is a chronic, persistent inflammatory-demyelinating disease of the central nervous system, characterized pathologically by areas of inflammation, demyelination, axonal loss and gliosis scattered throughout the CNS.

- **Etiology:** unknown (autoimmune-mediated demyelination).
- **Age:** 20-40 years, female preponderance in young
- **McDonald criteria for diagnosing MS: requires an evidence of lesions disseminated in time and space**. As a consequence there is an important role for MRI in the diagnosis of MS, since MRI can show multiple lesions (dissemination in space), some of which can be clinically occult and MRI can show new lesions on follow up scans (dissemination in time).
- **We consider the 1st MRI as a baseline.**
- **MRI is the most important modality for diagnosing MS while CT-scan's role is limited here.**





The most common lesions are:

- Multiple
- Discrete ovoid/round (+/-) some confluence
- Bilateral asymmetrical
- Preferentially located along lateral ventricles

Very important:

Q1:How does the MS appear in different MRI sequences?

- **T1WI** (no contrast)

lesions are typically iso to hypo intense (chronic)

- **T2WI** (no contrast +and all the lesions are enhanced here)

lesions are typically hyper intense

- **FLAIR**

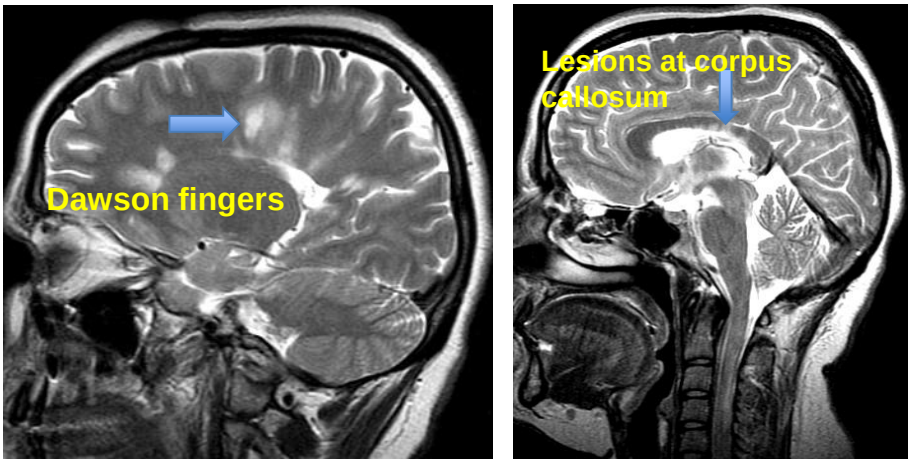
lesions are typically hyper intense when arranged perpendicular to long axis of lateral ventricles/corpus callosum, extending radially outward (best seen on parasagittal images) they are termed Dawson fingers

- T1 C+ (Gd) (with contrast)

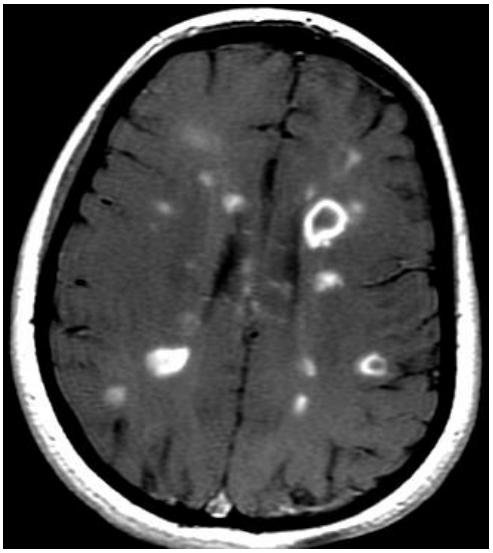
active lesions show enhancement. enhancement is often incomplete around the periphery (open ring sign)

Q2: what are the characteristic locations for the MS lesions?

- **Corpus callosum,**
- **U fibers (juxtacortical)**
- **Periventricular (Dawson's fingers)**(is the commonest site, the lesion here is next to the Lat.ventricle)
- Temporal lobes
- Brainstem
- Cerebellum
- Spinal cord.



Sagittal T2WI (all the lesions are enhanced)



- Pic (it is a nodular solid lesion MS)

Enhancement pattern:

- Nodular solid -70%
- Thick complete ring-20%
- C-shaped or incomplete ring-10% **(although it is rare, but it is very characteristic for MS and other demyelinating disease like ADEM)**
- Thin irregular marginal

CNS infections:

I. Classification

A-Viral Infection:

Herpes virus
Varicella
HIV
SSPE
Creutzfeldt-Jakob disease
ADEM(Acute Disseminated Encephalomyelitis)
Rasmussen Encephalitis

B-Bacterial Infection:

Pyogenic
Spirochetes
T.B

C-Fungal Infection

D-Parasitic Infection:

Toxoplasma
Cysticercosis
Amoeba
Hydatid

II. Classification

A- Congenital/Neonatal:

-TORCH
(**TO**xoplasmosis, **R**ubella,
Cytomegalovirus, **H**erpes)
-HIV

B- Acquired:

-Meningitis
-Pyogenic parenchymal infection:
encephalitis/cerebritis/abscess
-Encephalitis, TB, fungal, parasitic

A-Meningitis: Most common form of CNS infection.
Types:
1) Acute pyogenic (bacterial).(commonest)
2) Lymphocytic (viral).
3) Chronic: T.B and coccidiodomycosis.

1) ACUTE PYOGENIC MENINGITIS:

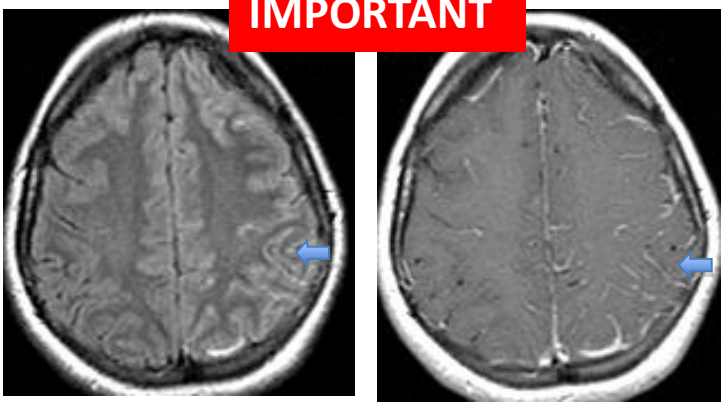
Pathology:
Purulent exudates in basal cisterns and subarachnoid spaces.

Imaging:

- Most common finding is normal scan.
- Mild ventriculomegaly (early).
- Effacement of basilar and convexity cisterns.(effacement of sulci)
- Enhancing meninges.
- Increased signal of subarachnoid space on FLAIR.

Role of imaging here isn't to diagnose but to monitor the complications or to support the diagnosis because:
1- It is usually diagnosed clinically (+ Lumbar puncture)
2- Most of the time, CT and MRI are normal here unless the patient has developed the complications.

IMPORTANT



- Left image(axial flair): **Increased signal at subarachnoid space**

Flair: fluid attenuation, here CSF appears black unlike in the T2 sequence. Also, sulci should appear black here.

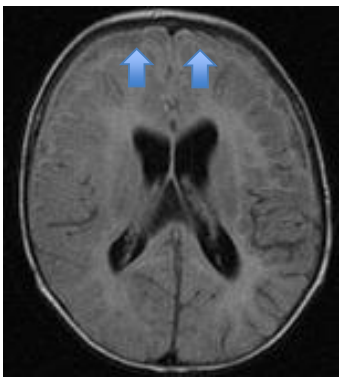
- Right image(Axial T1 C+): Enhancing meninges

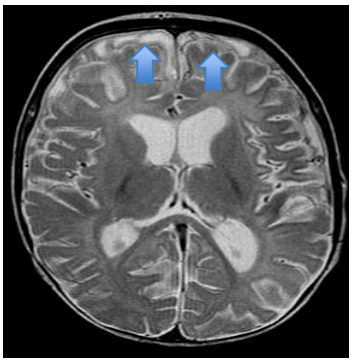
(high signals=white sulci = PYOGENIC MENINGITIS)

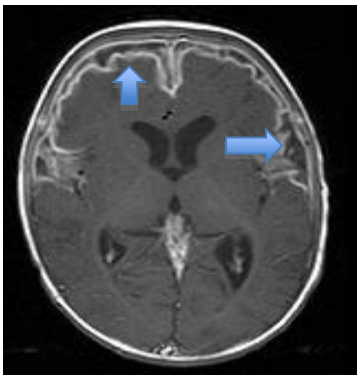
Complications of ACUTE PYOGENIC MENINGITIS:

- Hydrocephalus and ventriculitis
- Subdural effusion **(subdural fluid; clear="effusion" or pus="empyema")**
- Empyema
- Cerebritis and abscess
- Cerebrovascular complication

SUBDURAL EMPYEMA*







Axial T1WI Axial T2W1

Widening of bi-frontal subdural space

Axial T1 C+

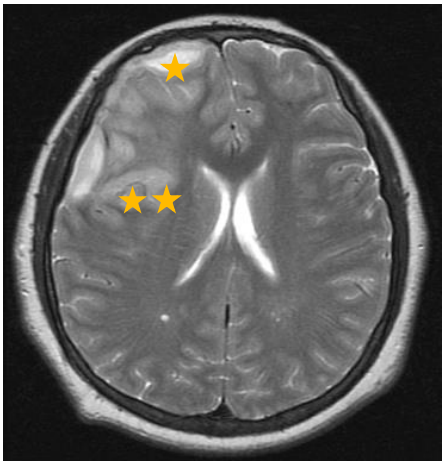
Thick enhanced

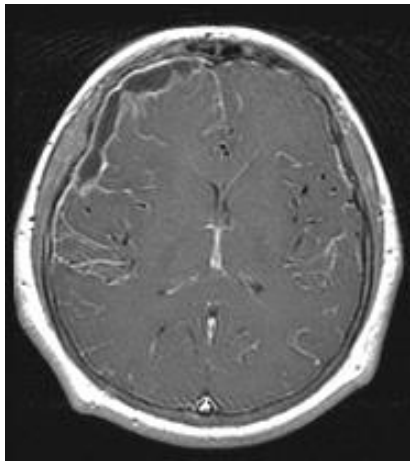
In the above 3 images:

•In T1W1: fluid is not clear (because it is not black)

•In T2W1: fluid will always appear hyper-intense here, so it is not helpful that much here except that it shows widening of subdural space.

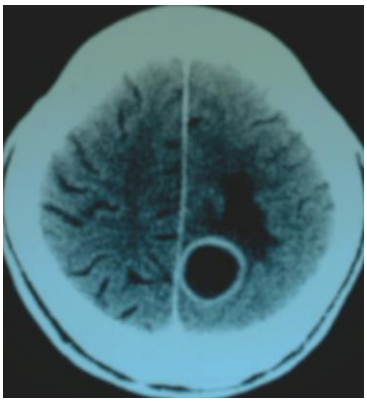
•In T1C+: it shows intense enhancement of the surrounding meninges

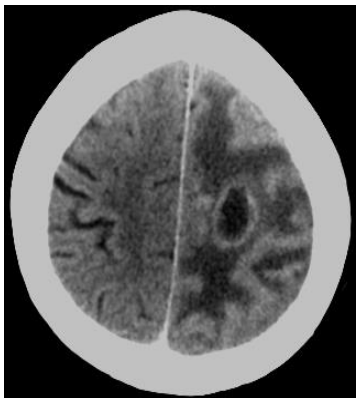




*Subdural collection
**Swollen cortex due to cerebritie
Left image: Axial T2WI
Right image: Axial T1C+
(meningeal enhancement)

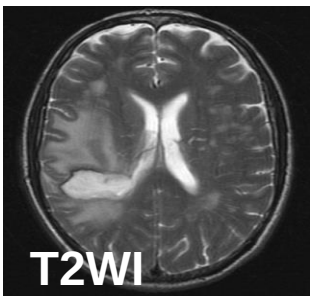
B) BRAIN ABSCESS

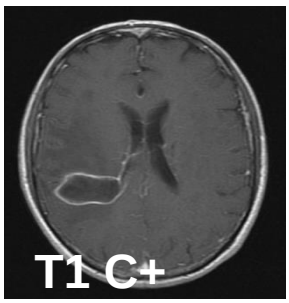


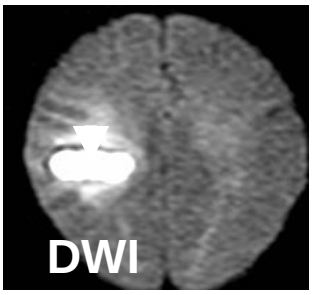


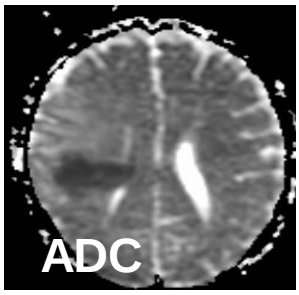
CT Brain
central low density
iso / hyper dense ring
peripheral low density
(vasogenic edema)

Peripheral thin smooth regular ring enhancement









IMPORTANT

MRI Brain:
T1WI: Low signal intensity.
T2WI: high signal intensity surrounded with vasogenic edema.
T1 C+: peripheral thin smooth regular ring enhancement.
DWI: diffusion restriction.
(to say that there is a diffusion restriction, it must be a high DW1 and a low ADC)
Mild mass effect on the right lateral ventricle

C) ENCEPHALITIS:

Diffuse non-focal parenchymal inflammatory disease that can be caused by broad spectrum of agents, the most common are viral.
(Herpes is the commonest)

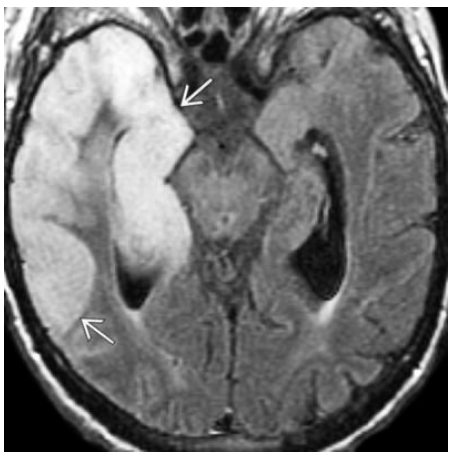
HERPES SIMPLEX ENCEPHALITIS:

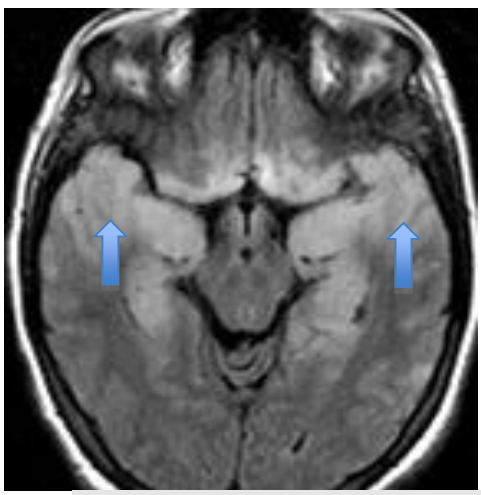
- Most common viral encephalitis.
- HSV2 in neonates, HSV1 in children& adults.
- Transported along sensory fibers to olfactory nerve or gasserian ganglion.

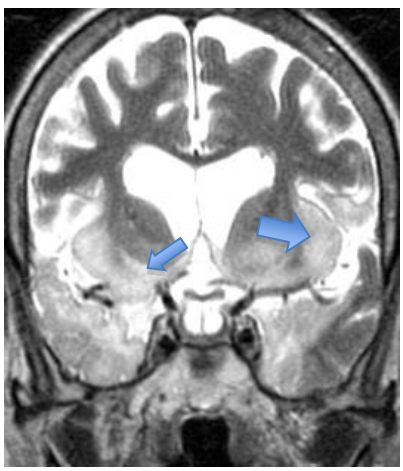
Location:

1) predilection for limbic system
2) Temporal lobe….insular cortex…. sub frontal area and cingulate gyrus.
3) Unilateral then bilateral.

Axial FLAIR shows striking hyper intensity, cortical swelling of the right temporal due to lobe (white arrow)Herpes simplex encephalitis







Axial flair Coronal T2WI
Bilateral temporal herpes encephalitis

You can notice that , it starts to involve cingulate gyrus then insular cortex

(this is the typical pattern of distribution of herpes simplex)