High Yield MCQs Neurosurgery Part II

TOPICS

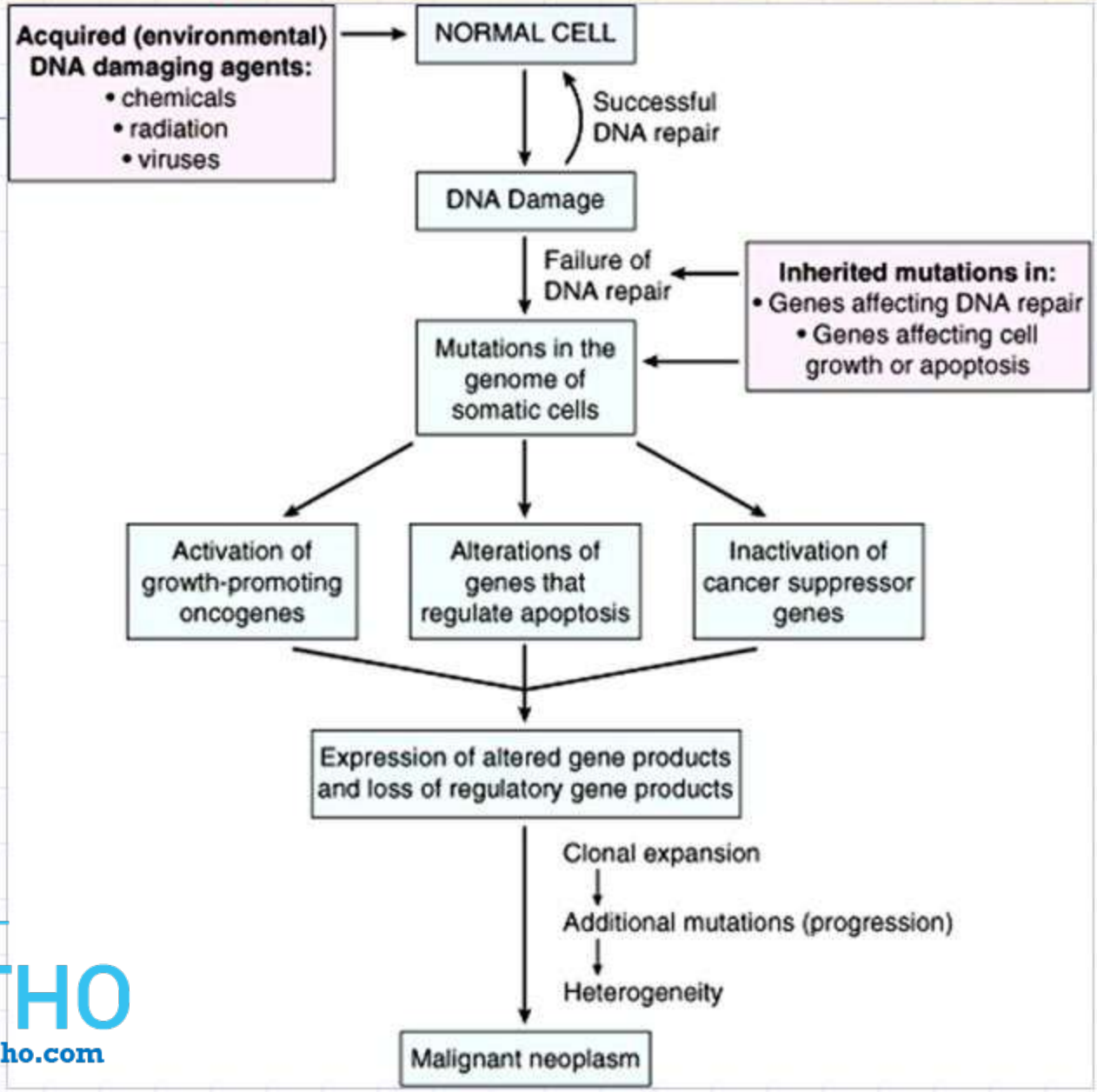
- Primary tumors of the nervous and related systems
- Tumors involving non neural origin : metastases, lymphomas, chordomas
- Head Trauma
- Differential diagnosis
- Important points in Neurosurgery

Evolution of Brain tumor classification by WHO

History

- 1979 WHO classification (1st edition) – Based on histological typing
- 1993 WHO classification (2nd edition) - reflected advances in Immunohistochemistry
- 2000 WHO classification (3rd edition) – started introducing pathology and genetics
- 2007 WHO classification (4th edition)
- 2016 WHO classification (Revised 4th edition)
- **2021** WHO classification (5th edition)

Cancer: General Etiology and Pathogenesis



Category	Gliomas, glioneuronal tumours and neuronal tumours						Choroid plexus tumours	Embryonal tumours		Pineal tumours	Mesenchymal/ Non-Meningothelial Tumours	Tumours of the sellar region
Family	Adult-type diffuse gliomas	Paediatric-type high-grade diffuse gliomas	Paediatric-type low-grade diffuse gliomas	Circumscribed astrocytic gliomas	Glioneuronal and neuronal tumours	Ependymal tumours		Medullo-blastoma	Other CNS Embryonal tumours		Uncertain differentiation	
Types	Astrocytoma, IDH-mutant	Diffuse midline glioma, H3 K27-altered	Diffuse astrocytoma, *MYB*- or *MYBL1*-altered	High-grade astrocytoma with piloid features	Diffuse glioneuronal tumor with oligodendroglioma-like features and nuclear clusters (DGONC)	Supratentorial ependymoma, *ZFTA* fusion–positive	Choroid plexus papilloma	MB, WNT-activated	CNS neuroblastoma, *FOXR2*–activated	Desmoplastic myxoid tumor of the pineal region, *SMARCB1*-mutant	Intracranial mesenchymal tumor, *FET-CREB* fusion positive (provisional type)	Pituitary blastoma
	Oligodendro-glioma, IDH-mutant and 1p/19q-codeleted	Diffuse hemispheric glioma, H3 G34-mutant	Polymorphous low-grade neuroepithelial tumour of the young (PLNTY)	Pilocytic astrocytoma	Myxoid glioneuronal tumor	Supratentorial ependymoma, *YAP1* fusion–positive	Atypical choroid plexus papilloma	MB, SHH-activated, *TP53* -wildtype	CNS tumour with *BCOR* internal tandem duplication and the provisional type (CNS tumour *BCOR* ITD)	Pineocytoma	CIC-rearranged sarcoma	Adaman-tinomatous cranio-pharyngioma
	Glioblastoma, IDH-wildtype	Diffuse paediatric-type high-grade glioma, H3-wildtype/ IDH-wildtype	Diffuse low-grade glioma, MAPK pathway-altered	Pleomorphic xanthoastro-cytoma	Multinodular and vacuolating neuronal tumor (MVNT)	Posterior fossa group A (PFA) ependymoma	Choroid plexus carcinoma	MB, SHH-activated, *TP53* -mutant	Cribriform neuroepithelial tumour (CRINET)	Pineal parenchymal tumour of intermediate differentiation	Primary intracranial sarcoma, *DICER1*-mutant	Papillary cranio-pharyngioma
		Infant-type hemispheric glioma	Angiocentric glioma	Subependymal giant cell astrocytoma	Diffuse leptomeningeal glioneuronal tumor	Posterior fossa group B (PFB) ependymoma		MB, non-WNT/non-SHH	Atypical teratoid/ rhabdoid tumour (ATRT)	Pineoblastoma	Solitary fibrous tumour	Pituicytoma, granular cell tumour of the sellar region, and spindle cell oncocytoma
				Chordoid glioma	Ganglioglioma	Spinal ependymoma, *MYCN*-amplified		MB, histo-logically defined	Embryonal tumour with multi-layered rosettes (ETMR)	Papillary tumor of the pineal region	Ewing sarcoma	Pituitary adenomas
				Astroblastoma, *MN1*-altered	Desmoplastic infantile ganglioglioma/desmoplastic infantile astrocytoma	Myxopapillary ependymoma			CNS embryonal tumor			Pituitary neuro-endocrine tumour (PitNET)
					Dysembryoplastic neuroepithelial tumor	Subependymoma						
					Papillary glioneuronal tumor							
					Rosette-forming glioneuronal tumor							
					Gangliocytoma							
					Dysplastic cerebellar gangliocytoma							
					Central neurocytoma							
					Extraventricular neurocytoma							
					Cerebellar liponeurocytoma							

Note: for Mesenchymal/Non-meningothelial tumours, only the group of "Uncertain differentiation" is shown.

World Health Organization (WHO) Brain Tumor Grades			
	Grade	**Characteristics**	**Tumor Types**
Low Grade	**WHO Grade I**	• Least malignant (benign) • Possibly curable via surgery alone • Non-infiltrative • Long-term survival • Slow growing	Pilocytic astrocytoma Craniopharyngioma Gangliocytoma Ganglioglioma
	WHO Grade II	• Relatively slow growing • Somewhat infiltrative • May recur as higher grade	"Diffuse" Astrocytoma Pineocytoma Pure oligodendroglioma
High Grade	**WHO Grade III**	• Malignant • Infiltrative • Tend to recur as higher grade	Anaplastic astrocytoma Anaplastic ependymoma Anaplastic oligodendroglioma
	WHO Grade IV	• Most malignant • Rapid growth, agressive • Widely infiltrative • Rapid recurrence • Necrosis prone	Gliobastoma Multiforme (GBM) Pineoblastoma Medulloblastoma Ependymoblastoma

Grade I		low proliferative potential	possibility of cure(surgical resection alone)	
Grade II	+ cytological atypia	•low-level proliferative activity •generally infiltrative in nature •often recur •tend to progress to higher grades of malignancy		Survive > 5 years
Grade III	• + nuclear atypia/ anaplasia • + brisk mitotic activity		Adjuvant radiation +/- chemotherapy	Survive 2-3 years
Grade IV	•+microvascular proliferation • cytologically malignant •mitotically active, •necrosis	rapid pre-and postoperative disease evolution •fatal outcome •In some-Widespread infiltration of surrounding tissue •craniospinal dissemination	Adjuvant radiation +/- chemotherapy	Depends upon therapy, survive < 1 year

Clinical Presentation

1. Due to direct tissue destruction
2. local brain infiltration or
3. 3.secondary effect of increased ICP (Cushing's triad)

- Depends upon location:

positive (headache/ seizure)

negative symptoms (loss of function)

Headache –

35% as first symptoms.

70% in growing tumor.

Associated with vomiting/ nausea, papilledema, focal cerebral signs

Facial pain - tumors at base of skull or nasopharynx

Seizure-

30% as first symptom.

98% in oligodendroglioma and 18% in metastasis

Parietal lobe

Co-ordinating sensory information
(taste, smell, touch, sight, hearing, temperature, pain)

Perception

Spatial relationships
(hand-eye co-ordination, recognising body position, judging distances, moving between objects)

Recognising faces or objects

Responding to internal sensations
(hunger, pain, temperature, illness)

Occipital lobe

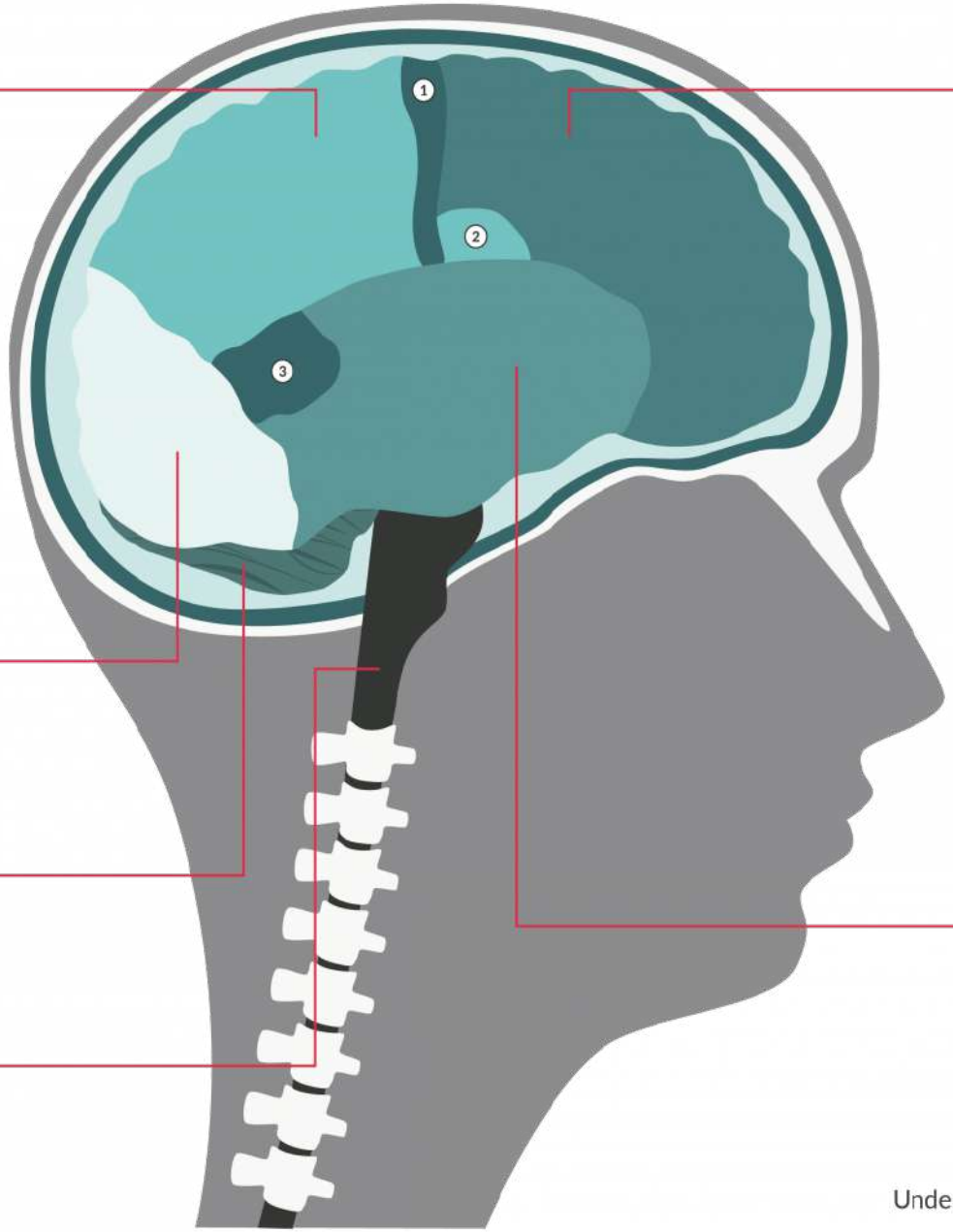
Sight
Understanding what you see

Cerebellum

Co-ordinating voluntary movement

Brain stem

Alertness
Breathing
Digestion
Heart rate
Blood pressure
Circulation
Swallowing



Frontal lobe

Executive functions
(planning, organising, problem solving, decision-making, reasoning)

Attention and concentration

Thinking speed

Personality

Memory and learning

Emotional and impulse control

Understanding social situations and behaving appropriately

① **Primary motor cortex**
Control and co-ordination of movement

② **Broca's area**
Speaking fluently and with meaning

Temporal lobe

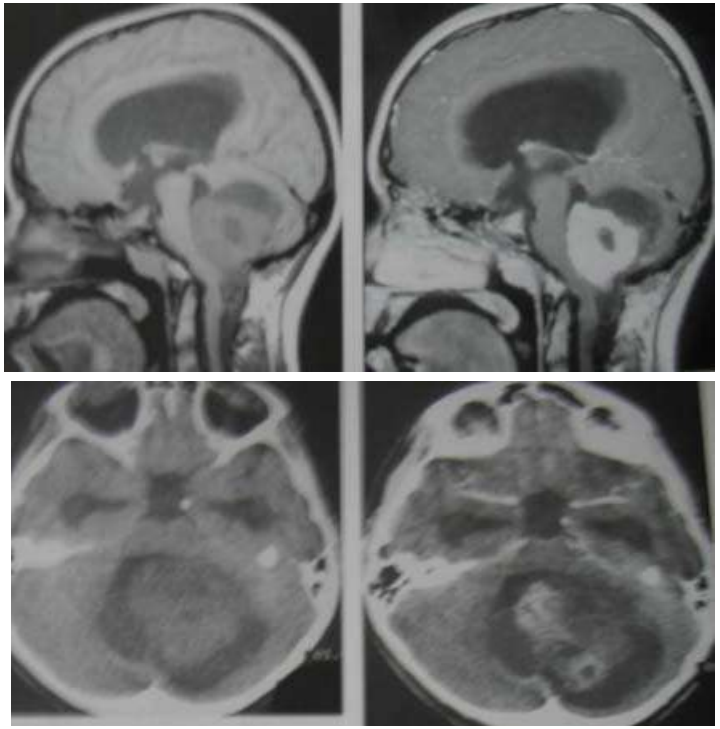
Hearing
Memory and learning new information
Recognising objects or faces
Identifying emotions in others

③ **Wernicke's area**
Understanding language and speech

Substrate	Tumor
Pineal glandular tissue	Pineocytomas, pineoblastomas
Glial Cells	Astrocytomas, oligodendroglioma, cyst
Arachnoid cells	Meningiomas, cysts
Ependymal lining	Ependymomas
Sympathetic nerves	Chemodectomas
Rests of germ cells	Choriocarcinoma, germinoma, embryonal ca, endodermal sinus tumor, teratoma
No BBB	Hematogenous Metastasis

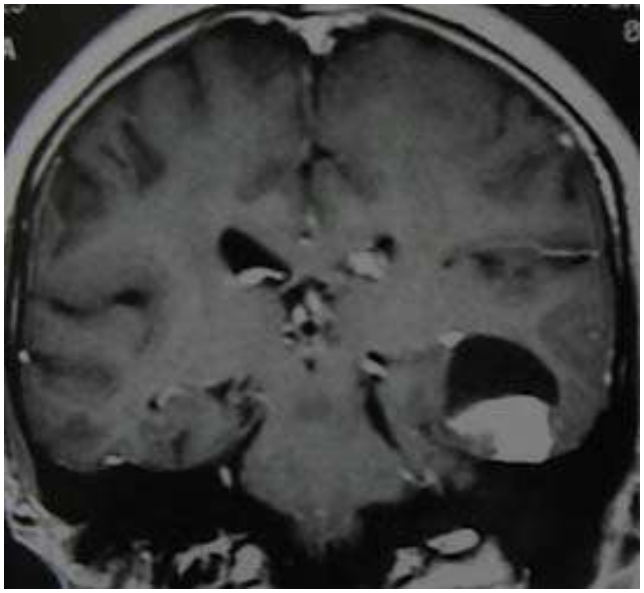
Pilocytic Astrocytoma

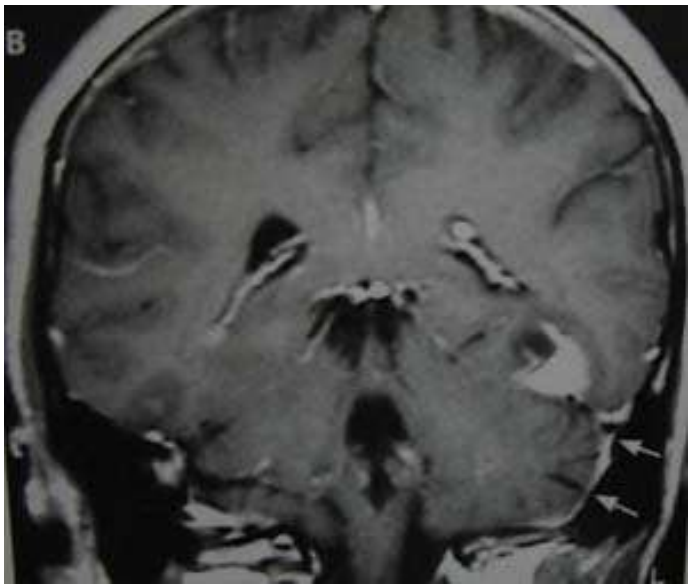
- Most common brain tumor in children
- Cerebellum> adj 3rdventricle> brainstem
- Circumscribed cystic mass with mural nodule
- Genetics: sporadic/ syndromic
- Slow growing
- Histology:
  - Classic biphasic pattern
  - Compacted bipolar cells with rosenthal fibres
  - Loose textured mulitpolar cells
  - Leptomeningeal seeding



Pleomorphic Xanthoastrocytoma

- Exclusive young adults.
- Rare but important cause: TLE
- Supratentorial intracortical cystic mass with mural nodule abutting meninges with dural tail





Diffuse astrocytoma

- 25% of all gliomas
- Supratentorial > brain stem (MC children)
- Mean age-34yrs , male >
- Gross: unencapsulated ill defined tumor with firm rubbery consistency, expanding involved cortex
- M/E:
  - Hypercellularity with indistinct tumor border
  - Cellular differentiation
- Tendency to differentiate into higher grade with age

Anaplastic Astrocytoma (WHO Grade II)

- Adults
- cerebral hemispheres.
- Grossly, it is somewhat better demarcated, soft, and grayish-pink.
- Histologically :

  - cellularity high, pleomorphism conspicuous

  - Hyperchromatic nuclei: small to large to multinucleated giant cells.

  - Mitoses frequent

  - Vascular proliferation not prominent, necrosis absent
- It may disseminate along the subarachnoid space

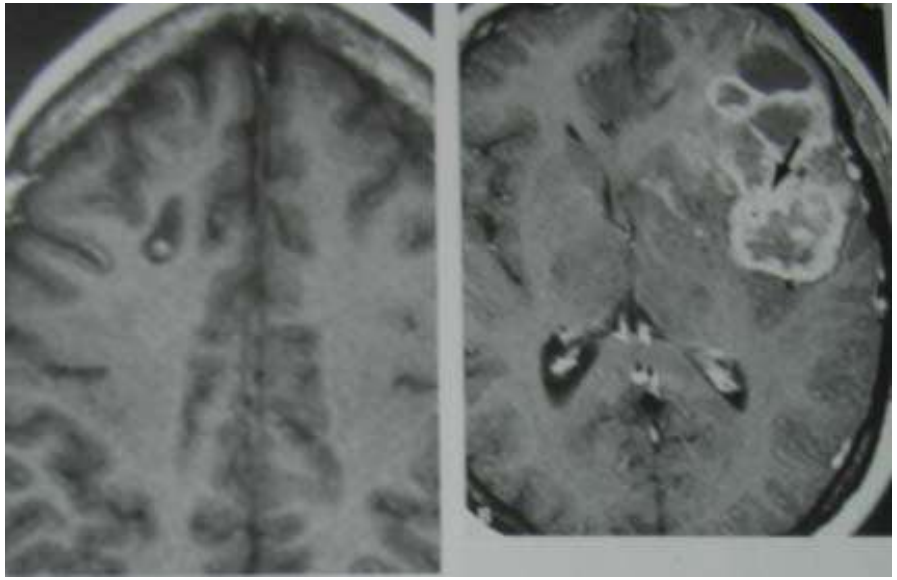
Glioblastoma (WHO Grade IV)

	most frequent and most malignant
Location	Hemispheric White matter, frontal & temporal lobes
Genetics	Primary GBM- •Older patients, biologically more aggressive •Develops de novo (without pre-existing lower grade tumor) •Amplification, over-expression of EGFR, MDM2 •PTEN mutation •Chromosome 10p LOH Secondary GBM- •Younger patients, less aggressive than primary •Develops from lower grade astrocytoma •TP53 mutations •PDGFR amplification, overexpression •Chromosomes 10q, 17p LOH •Increased telomerase activity and hTERT expression
Etiology **Pathogenesis** **pathophysiology**	Occurs sporadically or as part of heritable tumor syndrome, NF-1 Turcot, Li-Graumeni syndromes Spreads by creating permissive environment Produces proteases Deposits extracellular matrix (ECM) molecules Expresses integrins (neoangiogenesis)

Gross Pathology	•Reddish gray 'rind'of tumor surrounds necrotic core •Infiltrating mass with poorly delineated margins •Often expands invaded structures •May appear discrete but tumor always infiltrates
Microscopic features	•Increased cellularity •Marked mitotic activity •Distinct nuclear atypia •High nuclear cytoplasmic ratio •Coarse nuclear chromatin •necrosis or microvacular proliferation •Histologic variant-Gemistocytic
Presentation	•Bimodal –small peak around 5yrs, Peak: 40-50yrs •M:F= 1.8:1 •Seizures, focal neurological deficits •May have headache or raised ICP symptoms
Natural history	• Progession to secondary GBM common •Commonly arises as recurrence after resection of Grade II tumor •Spreads along White Matter tracts •Other sites-ependymoma, leptomeninges, CSF

Oligodendroglioma

- Partially calcified well differentiated slowly growing but infiltrating cortical mass in middle age adult
- Calcification: 90% CT
- Location : Frontal > TPO lobe
- Seizure: 50-80%
- 20-50% aggressive (anaplastic)
  - high cell density
  - **pleomorphism+ anaplastic nuclei**
  - Numerous **mitoses**
  - Microvascular proliferation
  - **Necrosis+/-**
- Gross-unencapsulated soft gelatinous gray to pink hue
- Histology : Moderately cellular with occasional mitoses, Monotonous round nuclei, eccentric rim of eosinophilic cytoplasm
- Classical but rare-(fried egg, chicken feet appearance)



Ependymal Tumors - Ependymoma

- Ependymal lining of ventricular wall, projects into the ventricular lumen or invades the parenchyma
- Predominant children and adolescents.
- Fourth ventricle
- Accounting for 6% to 12% of intracranial childhood
- Drop metastasis: 11%
- Variants –

❑ Non anaplastic (low grade)

- Clear cell
- Cellular
- tanycytic
- Papillary : classic lesion, 30% metastatise, dark small nuclei. 2 cytoplasmic patterns
  # Differentiation along glial lines forms perivascular pseudorosettes
  # Cuboidal cells form ependymal tubules around a central bv (true rosettes)
- Myxopapillary ependymoma - filum terminale. Papillary with microcystic vacuoles and mucosubstance
- Subependymoma

❑ Anaplastic : pleomorphism, multinucleation, giant cells, mitoticfigures, vascular changes, necrosis (ependymoblastoma)

	EPENDYMOMA	Medulloblastoma
Mass in 4th Ventricle	Floor	Roof (ffastigium), 4th ventricle drapes around tumor (banana sign)
Calcifications	Common	<10%
MRI T1WI	Inhomogenous	Homogenous
MRI T2WI	High intensity exophytic component	Mild hyperintense

Medulloblastoma

- Most common malignant paediatric Carcinoma
- 1st decade of life
- Male: Female= 2:1
- Cerebellar vermis, apex of 4thventricle roof (fastigium)
- C/F: early hydrocephalus, cerebellar signs
- Solid midline contrast enhancing
- Highly radiosensitive and moderately chemosensitive
- Recurrence: 10-35%, extraneural mets: 5%
- Poorly demarcated, pinkish-gray and soft.
- Histology-

  Densely cellular & small cells with round, oval, or carrot-shaped hyperchromatic nuclei surrounded by scanty cytoplasm (blue cell tumor).

- Medulloblasts may differentiate into neurons and glial cells.
- Neuronal differentiation –NSE+ & synaptophysin+
- Glial differentiation-GFAP-positive
- Disseminate via CSF pathway-small nodules & diffuse infiltrates in the ventricular wall and subarachnoid space

❑ Histological Variants :

➢ Nodular medulloblastoma – "pale islands"of tumor cells with small nuclei, abundant cytoplasm, and a tendency to differentiate along neuronal line.

Less aggressive, longer survival.

➢ Large cell/anaplastic medulloblastomas - cells with large vesicular nuclei and pleomorphic anaplastic cells. Mitoses and apoptotic bodies are numerous.

More aggressive, shorter survival.

➢ Desmoplastic medulloblastoma - Cerebellar hemispheres of children and young adults. Clusters of tumor cells are separated by a rich reticulin and collagenous network

➢ Medullomyoblastoma, lipomatous, and melanotic medulloblastomas - striated muscle fibers, lipid cells, and melanotic cells, respectively

Choroid plexus tumors

- 0.4-1% all intracranial tumors
- 70% patients are <2yrs
- Adults: infratentorial
- Children: lateral ventricle
- Clinical: raised ICP, Seizures, SAH

❖ **Choroid Plexus Papilloma** :

- Intraventricular papillary neoplasms
- derived from choroid plexus epithelium
- benign in nature, cured by surgery
- Gross: circumscribed moderately firm, cut surface: cauliflower-like appearance.
- Histology: tumor resembles a normal choroid plexus, but is more cellular,with cuboidal and columnar epithelial cells resting on a fine fibrovascular stroma.
- Hemorrhages and calcifications: common

Neuronal and mixed neuronal-glial tumors
Gangliocytoma & Ganglioglioma

- Temporal and frontal lobes.
- Gross: gray, firm, and often cystic.
- Gangliocytomas -atypical neoplastic neurons within fibrillary matrix
- Gangliogliomas-mixture of neoplastic neurons & glial cells, mostly astrocytes.
- Immunoreactive for synaptophysin and neurofilament proteins.
- Calcifications, eosinophilic globules, and perivascular lymphocytic infiltrations common.
- Mitoses are rare, necrosis is absent.

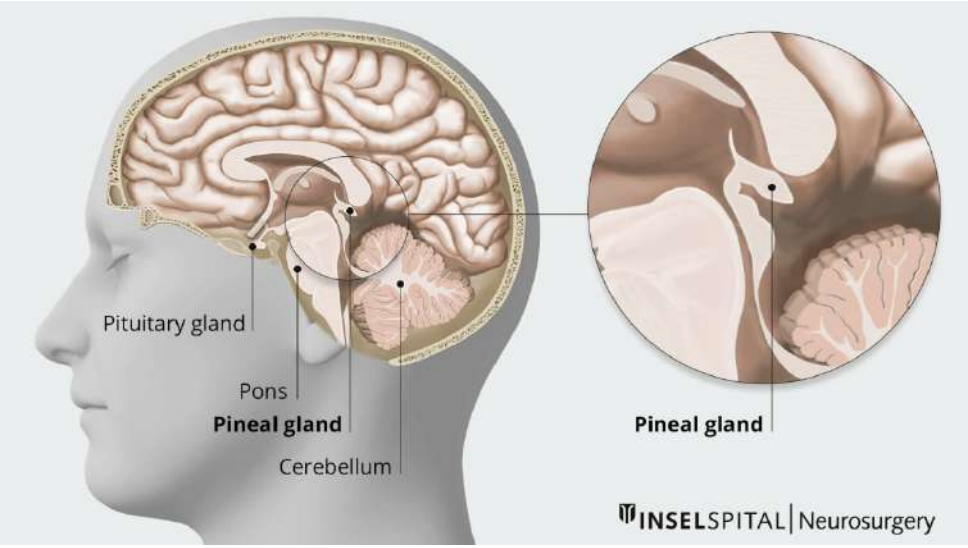
Central Neurocytoma

- Lateral or third ventricle at the Foramen Monro
- well-demarcated soft tumor
- Uniformly small neurocytes
- Several architectural patterns resembling oligodendroglial and ependymal tumors
- Calcifications-common, hemorrhages may occur.

Dysembryoplastic Neuroepithelial Tumor (DNET)

- Often temporal lobe, less cerebellum & pons.
- mucinous or gelatinous appearance.
- Neoplastic neurons, astrocytes, and oligodendrocytes in a nodular pattern.
- Pools of mucin, calcifications, abnormal blood vessels

Tumors of pineal region



- 3-8% of paediatric brain tumors, <1% adults

<u>PINEOCYTOMA</u>

Well differentiated
CSF metastasis
Radiosensitive

<u>PINEOBLASTOMA</u>

Malignant tumor – a PNET
Metastasize through CSF
Radiosensitive

<u>Pineal region</u>: bounded dorsally by splenium of corpus callosum and tela choroidea
ventrally by quadrigeminal plate and midbrain tectum,
rostrally by posterior aspect of 3rdventricle and caudally by cerebellar vermis

Tumors of Meningothelial Cells
Meningioma

- Slow growing extra-axial
- Arising from arachnoid not dura
- Falx> convexity> sphenoid bone
- Head injury and therapeutic radiation –predispose meningioma.
- Solitary or multiple -NF2
- Hyperostosis of adjacent bone
- Frequently calcified
- Grossly-extra-axial, encapsulated,round, oval, or lobulated; firm or moderately soft.
- Blood supply-meningeal branches of ECA
- Cut surfaces-pinkish-gray, granular, or gritty.
- Histology: Classical-psammoma bodies , EMA+, Vimetin+, inconsistently for S-100 protein

Grading	Definition
Grade I	- Mitotic count of less than 4 per 10 HPF - Absence of brain invasion - 9 histological subtypes: meningothelial, fibrous, transitional, psammomatous, microcystic, angiomatous, secretory, lymphoplasmacyte-rich, metaplastic
Grade II (atypical)	- Mitotic count of 4 to 19 per 10 HPF - Or presence of brain invasion - Or 3 of 5 specific histological features: spontaneous necrosis, sheeting, prominent nucleoli, high cellularity and small cells - 3 histological subtypes: atypical, clear cells, chordoid
Grade III (anaplastic)	- Mitotic count of 20 or more per 10 HPF - Or specific histologies: rhabdoid or papillary meningioma

Abbreviations: WHO: World Health Organization; HPF: high power field

Surgical Excision Grading of Meningiomas

Simpson Grade	Description
Grade 0	Complete tumor removal, plus removal of an additional 2–3 cm from the tumor insertion site
Grade I	Complete tumor removal, including any dural attachments or abnormal bone
Grade II	Complete tumor removal with coagulation of dural attachment
Grade III	Complete tumor removal without resection or coagulation of its dural attachment
Grade IV	Partial tumor removal
Grade V	Biopsy only

Pituitary Adenoma

- 10% of all intracranial tumors, common 3rd & 4th decades
- Arise from adenohypophysis;
- neurohypophysis –rare (glioma, granular cell tumor)
- Classification :

  Size-Microadenoma <1cm diameter and Macroadenoma > 1cm or > 10mm

  Endocrine function-2/3 secretory

  Anatomical-Modified Hardy system

  Histological-chromophobe/ acidophil/ basophil

  Electron microscopic appearance
- C/F : visual disturbance , Endocrine abnormalities , Pituitary apoplexy-1 to 2%
- Gross: discrete grayish yellow, soft mass <1 cm dia
- Histology: small round or oval nuclei with stippled chromatin

  Aggressive: mitoses, pleomorphism
- Hormone IHC identify specific hormone.
- Prolactinoma is the most common functional pituitary tumor.

Nonpituitary Tumors in the Sellar Region

- Meningioma
- Craniopharyngioma
- Germinoma
- Glioma
- Hamartoma
- Epidermoid, dermoid cysts
- Teratoma
- Lipoma
- Chordoma
- Metastasis

CRANIOPHARYNGIOMA

- More often children
- slowly growing
- originates from remnant epithelial cells of craniopharyngeal duct
- Mixed signal intensity with enhancing solid component; calcification
- Grossly: cystic with thick machine oil like contents
- Histology: multistratified squamous epithelial cells.
- Two types:

  Adamantinomatous type -cells form strands and cords , calcifications, amorphous masses of keratin (wet keratin) and cholesterol clefts are characteristic .

  Papillary type-cells rest on a fibrovascular stoma, lacks calcifications and cholesterol crystals. Glial reaction and Rosenthal fibers around the tumor

Metastatic tumor (secondary tumor)

- 3 times more common than primary brain tumor
- Often lodge-gray-white junction of cerebral, cerebellar hemisphere
- Commonly from lung, breast, kidney
- Two major forms:
  1. Single/ multiple well circumscribed deposits (commonest)
  2. Carcinomatous meningitis
- Leptomeningeal spread (breast, lung)
- Dural metastasis (non CNS lymphoma)
- Route-hematogenous/ direct/ CSF
- Abundant hemorrhage-melanoma, RCC, Chorio CA
- Multiplicity common
- Retain primary characteristics

NEUROFIBROMATOSIS

	NF 1	NF 2
Alternate term	von Recklinghausen's disease	bilateral acoustic NFT AKA MISME syndrome
Gene locus	17 (17q11.2)	22 (22q12.2)
Gene product	neurofibromin	schwannomin (merlin)
Vestibular schwannomas	uncommon, ≈ never bilateral	bilateral VSs are the hallmark
Cutaneous schwannomas	no	70%
Lisch nodules	Very common	Not associated
Cataracts	Not associated	60-80%
Intellectual impairment	in ≥ 50%	Not associated
Most commonly associated intramedullary spinal cord tumors	Astrocytoma	ependymoma
	More common than NF2, representing >90% cases	

Criteria for NF 1

- Suggestive findings of NF1 :

Two or more of the following:

- ≥ 6 café au lait spots, each ≥ 5mm in greatest diameter in prepubertal individuals, or ≥ 15mm in greatest diameter in postpubertal patients.
- ≥ 2 neurofibromas of any type, or one plexiform neurofibroma (neurofibromas are usually not evident until age 10–15 yrs). May be painful
- Freckling (hyperpigmentation) in the axillary or intertriginous (inguinal) areas
- optic glioma
- ≥ 2 Lisch nodules: pigmented iris hamartomas that appear as translucent yellow/brown elevations that tend to become more numerous with age
- Distinctive osseous abnormality, such as sphenoid dysplasia or thinning of long bone cortex with or without pseudarthrosis (e.g. of tibia or radius)
- A first degree relative (parent, sibling, or offspring) with NF1 by above criteria

{café au lait spots: hyperpigmented oval light brown skin macules (flat). May be present at birth, increase in number and size during 1st decade. Are present in > 99% of NF1 cases. Rare on face.}

Diagnostic criteria for NF 2

- Bilateral vestibular schwannomas (VS) on imaging (MRI or CT)
- OR a first degree relative (parent, sibling, or offspring) with NF2 AND

    1. unilateral VS

    2. OR any TWO of the following: meningioma, schwannoma (including spinal root), glioma (includes astrocytoma, ependymoma), posterior subcapsular lens opacity, or cortical wedge cataract
- OR Unilateral VS AND any TWO of the following: meningioma, schwannoma (including spinal root), glioma (includes astrocytoma, ependymoma), posterior subcapsular lens opacity, or cortical wedge cataract
- OR multiple meningiomas AND ONE of the following :

    1. unilateral VS

    2. OR any TWO of the following: meningioma, schwannoma (including spinal root), glioma (includes astrocytoma, ependymoma), posterior subcapsular lens opacity, or cortical wedge cataract

Diagnostic criteria for Tuberous Sclerosis Complex

- Definitive diagnosis : 2 major criteria, or 1 major AND≥ 2 minor
- Possible diagnosis 1 major or ≥ 2 minor

➢ **Major criteria** :

≥ 3 hypomelanotic macules ≥ 5mm diameter

≥ 3 angiofibromas or fibrous cephalic plaque

≥ 2 ungual fibroma

shagreen patch

multiple retinal hamartomas

cortical dysplasias (including tubers & cerebral white matter radial migration lines)

subependymal nodules

subependymal giant cell astrocytoma (SEGA)

cardiac rhabdomyoma

lymphangioleiomyomatosis

≥ 2 angiomyolipomas

➢ **Minor criteria** :

"confetti" skin lesions

≥ 4 pits in dental enamel

≥ 2 intraoral fibromas

achromic retinal patch

multiple renal cysts

nonrenal hamartomas

Trauma/Head Injury

- With significant head injury, delayed deterioration occurs in 15%. 75% of these will have an intracranial hematoma.
- There is a 4–5% incidence of associated spine fractures with significant head injury (mostly C1 to C3).
- Brain injury from trauma results from two distinct processes:

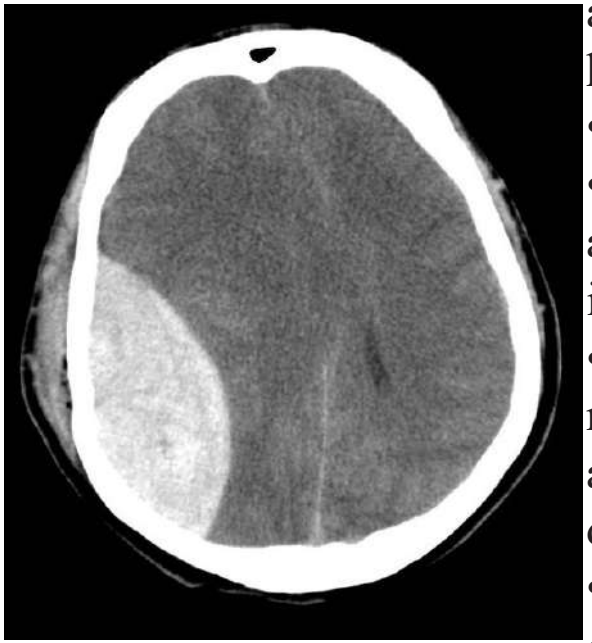
  1. primary brain injury: occurs at time of trauma (cortical contusions, lacerations, bone fragmentation, diffuse axonal injury, and brainstem contusion)

  2. secondary injury: develops subsequent to the initial injury. Includes injuries from intracranial hematomas, edema, hypoxemia, ischemia (primarily due to elevated intracranial pressure (ICP) and/or shock), vasospasm.
- ≈ 15% of patients who do not initially exhibit signs of significant brain injury may deteriorate in a delayed fashion, sometimes referred to as patients who “talk and deteriorate,” or when more lethal, patient who “talk and die.”

Q. A 65-year-old man is brought to the emergency department (ED) after sustaining a head injury secondary to involvement in a motor vehicle collision. In the ED, he is obtunded with a Glasgow coma scale (GCS) score of 9. He vomits during the primary survey evaluation. He has unequal pupils, and the right pupil is dilated and not reactive to light. The ED team using rapid sequence induction, immediately intubates him. A non-contrast CT scan of his brain shows a large right epidural hematoma with a midline shift. His pelvic x-ray shows a fracture of the right femur shaft with displacement. What should be the priority in his evaluation and further management?

1. Arrange emergency evacuation of the epidural hematoma
2. Arrange immediate reduction and internal fixation of the femur fracture
3. Arrange for transfusion of packed red blood cells
4. Arrange a transfer to a trauma centre

Ans : 1



• Incidence of epidural hematoma (EDH): 1% of head trauma admissions (which is ≈ 50% the incidence of acute subdural hematomas).

•Ratio of male:female =4:1.

•Usually occurs in young adults, and is rare before age 2 yrs or after age 60 (perhaps because the dura is more adherent to the inner table in these groups).

•Dogma was that a temporoparietal skull fracture disrupts the middle meningeal artery as it exits its bony groove to enter the skull at the pterion, causing arterial bleeding that gradually dissects the dura from the inner table resulting in a delayed deterioration.

•Alternate hypothesis: dissection of the dura from the inner table occurs first , followed by bleeding into the space thus created.

•Source of bleeding: 85% = arterial bleeding (the middle meningeal artery is the most common source of middle fossa EDHs).Many of the remainder of cases are due to bleeding from middle meningeal vein or dural sinus.

•70% occur laterally over the hemispheres with their epicenter at the pterion, the rest occur in the frontal, occipital, and posterior fossa (5–10% each).

- “Textbook” presentation (<10%-27% have this classic presentation): brief posttraumatic loss of consciousness (LOC): from initial impact followed by a “lucid interval” for several hours ,then, obtundation, contralateral hemiparesis, ipsilateral pupillary dilatation as a result of mass effect from hematoma.
- Deterioration usually occurs over a few hours, but may take days and rarely, weeks (longer intervals may be associated with venous bleeding).
- Other presenting findings: Headache,vomiting,seizure (may be unilateral), hemi-hyperreflexia + unilateral Babinski sign, and elevated CSF pressure (LP is seldom used any longer).
- Bradycardia is usually a late finding, and if present is s/o impending brain herniation due to cushing reflex.
- In peds, EDH should be suspected if there is a 10% drop in hematocrit after admission.
- Differential Diagnosis :

  - subdural hematoma

  - a posttraumatic disorder described by Denny-Brown consisting of a “lucid interval” followed by bradycardia, brief periods of restlessness and vomiting, without intracranial hypertension or mass. Children especially may have Headache, and may become drowsy and confused. Theory: a form of vagal syncope. CT must be done to rule-out EDH.

➢ Indications for surgery :

- EDH volume >30 cm3 should be evacuated regardless of GCS
- EDH with the all of the following characteristics can be managed nonsurgically with serial CTscans and close neurological observation in a neurosurgical center:

    a) volume <30 cm3

    b) and thickness <15 mm

    c) and with midline shift (MLS) <5 mm

    d) and GCS>8

    e) and no focal neurologic deficit

- Timing of surgery : It is strongly recommended that patients with an acute EDH and GCS<9 and anisocoria undergo surgical evacuation ASAP.

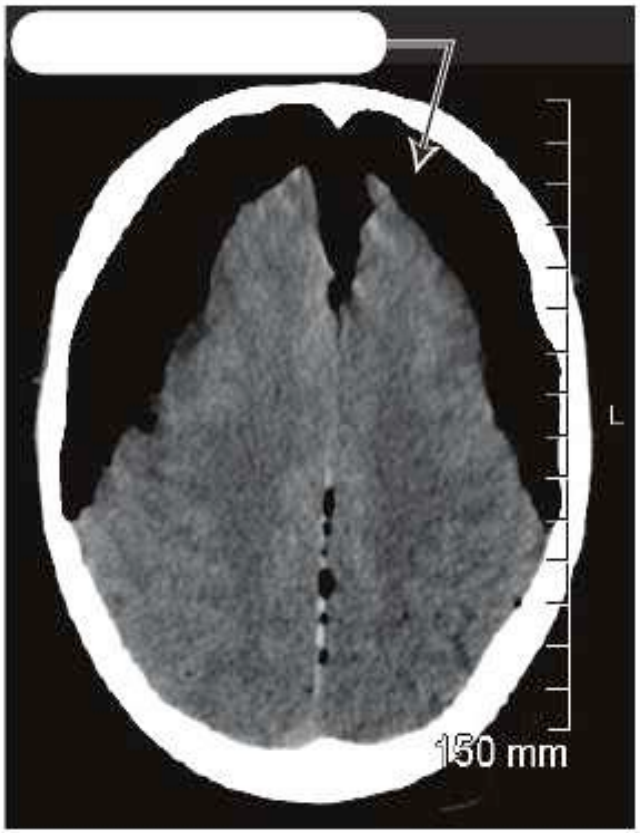
Q. Identify the Pathology :

A. Acute SDH

B. EDH

C. Subacute SDH

D. Tension pneumocephalus



Ans : D (Tension Pneumocephalus)

- Although intracranial low-density on CT may be associated with epidermoid, lipoma, or CSF, nothing is as intensely black as air. This can often be better appreciated on bone-windows than on soft-tissue windows.
- Above pathology is seen in Tension pneumocephalus and it is called as **Mt. Fuji sign** with bilateral pneumocephalus on Axial noncontrast CT scan.

Tension Pneumocephalus

- Intracranial gas can develop elevated pressure in the following settings:

  1. when nitrous oxide anesthesia is not discontinued prior to closure of the dura.

  2. when a “ball-valve” effect occurs due to an opening to the intracranial compartment with soft tissue (e.g. brain) that may permit air to enter but prevent exit of air or CSF

  3. when trapped room temperature air expands with warming to body temperature: a modest increase of only ≈ 4% results from this effect

  4. In the presence of continued production by gas-producing organisms.

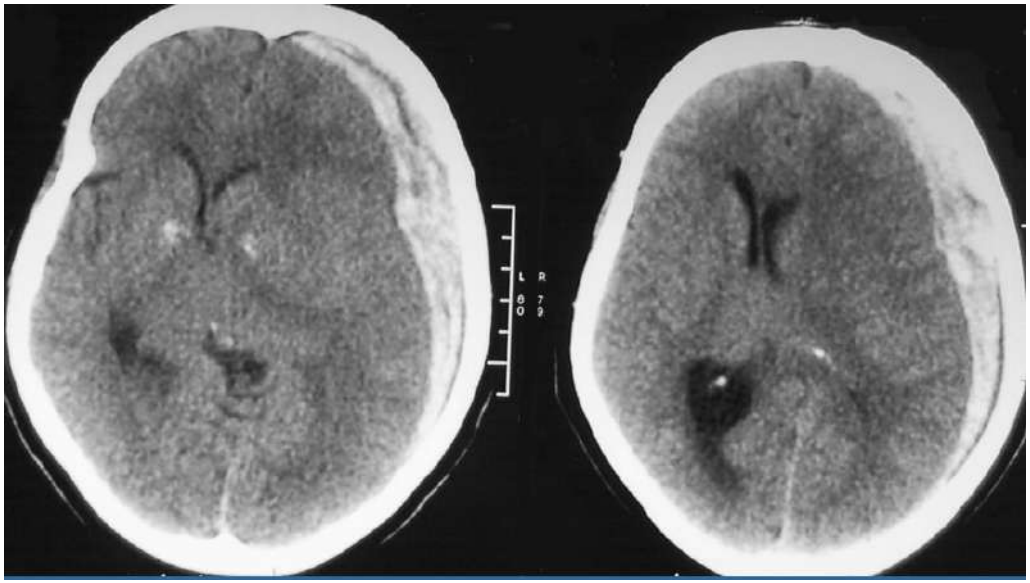
- Pneumocephalus is most easily diagnosed on CT which can detect quantities of air as low as 0.5 ml.
- Air appears dark black (darker than CSF) and has a Hounsfield coeffcient of –1000.
- One characteristic finding with bilateral pneumocephalus is the Mt. Fuji sign in which the two frontal poles appear peaked and are surrounded by and separated by air, resembling the silhouette of the twin peaks of Mt. Fuji.
- Intracranial gas may also be evident on plain skull x-rays.

- Since simple pneumocephalus usually does not require treatment, it is critical to differentiate it from tension pneumocephalus, which may need to be evacuated if symptomatic.
- Dramatic and rapid improvement may occur with the release of gas under pressure. Options include placement of new twist drill or burr holes, or insertion of a spinal needle through a pre-existing burr hole.

Q. Identify the Pathology :-

A. Acute SDH
B. Acute EDH
C. Chronic SDH
D. Subdural hygroma

Ans : A (Acute SDH)



- Two common causes of traumatic ASDH :

1. Accumulation around parenchymal laceration (usually frontal or temporal lobe). There is usually severe underlying primary brain injury. Often no “lucid interval.” Focal signs usually occur later and are less prominent than with EDH
2. Surface or bridging vessel torn from cerebral acceleration deceleration during violent head motion. With this etiology, primary brain damage may be less severe, a lucid interval may occur with later rapid deterioration

- ASDH may also occur in patients receiving anticoagulation therapy, usually with, but sometimes without, a history of trauma (the trauma may be minor).Receiving anticoagulation therapy increases the risk of ASDH 7-fold in males and 26-fold in females.
- CTscan in ASDH :

  Crescentic mass of increased density adjacent to inner table. Edema is often present.
- Locations:

  - Usually over convexity
  - Interhemispheric
  - Layering on tentorium
  - in posterior fossa

• Differences from EDH: SDH is more diffuse, less uniform, usually concave over brain surface, often less dense (from mixing with CSF), and bridging subdural veins (from brain surface to the skull) may be seen (**cortical vein sign**).

Acute SDH Density changes on CT with time

Category	Time frame	Density on CT Head
Acute	1-3 days	Hyperdense
Sub acute	4 days to 2-3 weeks	= Isodense
Chronic	Usually > 3 weeks and < 3-4 months After about 1-2 months	Hypodense(approaching CSF density) May become lenticular shaped with density > CSF, < fresh blood

- Treatment – Indications for surgery :

1. ASDH with thickness >10 mm or midline shift (MLS) >5 mm (on CT) should be evacuated regardless of GCS.
2. ASDH with thickness <10 mm and MLS<5 mm should undergo surgical evacuation if:

    a) GCS drops by≥ 2 points from injury to admission

    b) and/or the pupils are asymmetric or fixed and dilated

    c) and/or ICP is >20 mm Hg

    Monitor ICP in all patients with ASDH and GCS<9

- Timing of Surgery : Timing of surgery for ASDH is a matter of controversy. As a general principle, when surgery for ASDH is indicated it should be done as soon as possible (preferably < 4 hrs)

- Concussion is a complex pathophysiological process affecting the brain resulting in alteration of brain function, that is induced by nonpenetrating biomechanical forces, ***without identifiable abnormality in standard structural imaging*****.**
- The determination of concussion requires altered consciousness as a result of closed head injury.
- In concussion, Glutamate concentration changes. It goes up.
- Impaired metabolic state from a concussion can last 7-10 days after injury.
- Post concussive syndrome occurs in 10-15 % of cases, and often occurs within 4 weeks of injury, and remains >1 month after onset of symptoms.
- **Post Concussion syndrome** : Patients having ≥ 3 symptoms including headache, fatigue, dizziness, irritability, difficulty concentrating, memory difficulty, insomnia, and intolerance to stress, emotion, or alcohol, and symptoms must begin within 4 weeks of injury and remain for ≥ 1 month after onset of symptoms.
- When should a player return to the game after a mild concussion? -→ only after resolution of symptoms.
- **SIS (Second impact syndrome)** : A rare condition described primarily in athletes who sustain a second head injury while still symptomatic from an earlier one. Classically, the athlete walks off the field under their own power after the second injury, only to deteriorate to coma within 1–5 minutes and then, due to vascular engorgement, develops malignant cerebral edema that is refractory to all treatment and progresses to herniation. Mortality: 50–100%.

- Carotid artery dissection occurs in 1-2% of blunt trauma patients, and has a 13% mortality rate, and about 1/3 are untreatable.
- Carotid artery dissections occur most commonly in Motor vehicle accidents , and the mechanism involves both hyperextension and lateral rotation of the neck.
- **Diffuse Axonal Injury (DAI)** : A primary lesion of rotational acceleration/deceleration head injury.

Histologic grading of DAI

DAI Grade	Description
Grade I	Axonal injury in the white matter of the cerebral hemisphere, corpus callosum, brainstem and, less commonly, cerebellum
Grade II	focal lesion in the corpus callosum in addition to above
Grade III	focal lesion in the dorsolateral quadrant(s) of the rostral brainstem in addition to above

Surgical management of depressed skull fractures

- Indications for surgery :

1. open (compound) fractures

a) surgery for fractures depressed > thickness of calvaria and those not meeting criteria for nonsurgical management listed below

b) nonsurgical management may be considered if :

- There is no evidence (clinical or CT) of dural penetration (CSF leak, intradural pneumocephalus on CT…)
- and no significant intracranial hematoma
- and depression is < 1cm
- and no frontal sinus involvement
- and no wound infection or gross contamination
- and no gross cosmetic deformity

2. closed (simple) depressed fractures: may be managed surgically or nonsurgically

Temporal Bone fractures

- Although often mixed, there are two basic types of temporal bone fractures:

1. **Longitudinal fracture**: more common (70–90%).
   - Usually through petro-squamosal suture, parallel to and through EAC.
   - Can often be diagnosed on otoscopic inspection of the EAC.
   - Usually passes between cochlea and semicircular canals (SCC), sparing the VII and VIII nerves, but may disrupt the ossicular chain.

2. **Transverse fracture**: perpendicular to EAC.
   - Often passes through cochlea and may place stretch on geniculate ganglion, *resulting in VIII and VII nerve deficits*, respectively.

Contusion/TICH

- TICH Aka Traumatic intracerebral hemorrhage.
- Surgical management of TICH : Indications for surgical evacuation for TICH:
  - progressive neurological deterioration referable to the TICH, medically refractory Intracranial hypertension, or
  - signs of mass effect on CT
  - or TICH volume > 50cm3 cc or ml
  - or GCS = 6–8 with frontal or temporal TICH volume > 20cm3 with midline shift (MLS) ≥5mm
  - and/or compressed basal cisterns on CT
- non-operative management with intensive monitoring and serial imaging: may be used for TICH without neurologic compromise and no significant mass effect on CT and controlled ICP.

❑ **Delayed Traumatic Intracerebral Hemorrhage (DTICH):**

- Definition : TICH demonstrated in patients on imaging that was not evident on initial admitting CT scan.
- Incidence of DTICH in patients with GCS ≤ 8: ≈ 10%.
- Most DTICH occur within 72 hrs of the trauma.
- Factors that contribute to formation of DTICH include local or systemic coagulopathy, hemorrhage into an area of necrotic brain softening, and coalescence of extravasated microhematomas.
- Treatment is the same as for TICH.
- Outcome for patients with DTICH described in the literature is generally poor, with a mortality ranging from 50–75%.

Pediatric Head Injury

- As a group, children fare better than adults with head injury. However, very young children do not do as well as the school-age child.

❑ CEPHALHEMATOMA : Accumulation of blood under the scalp.Occurs almost exclusively in children.

Two types :

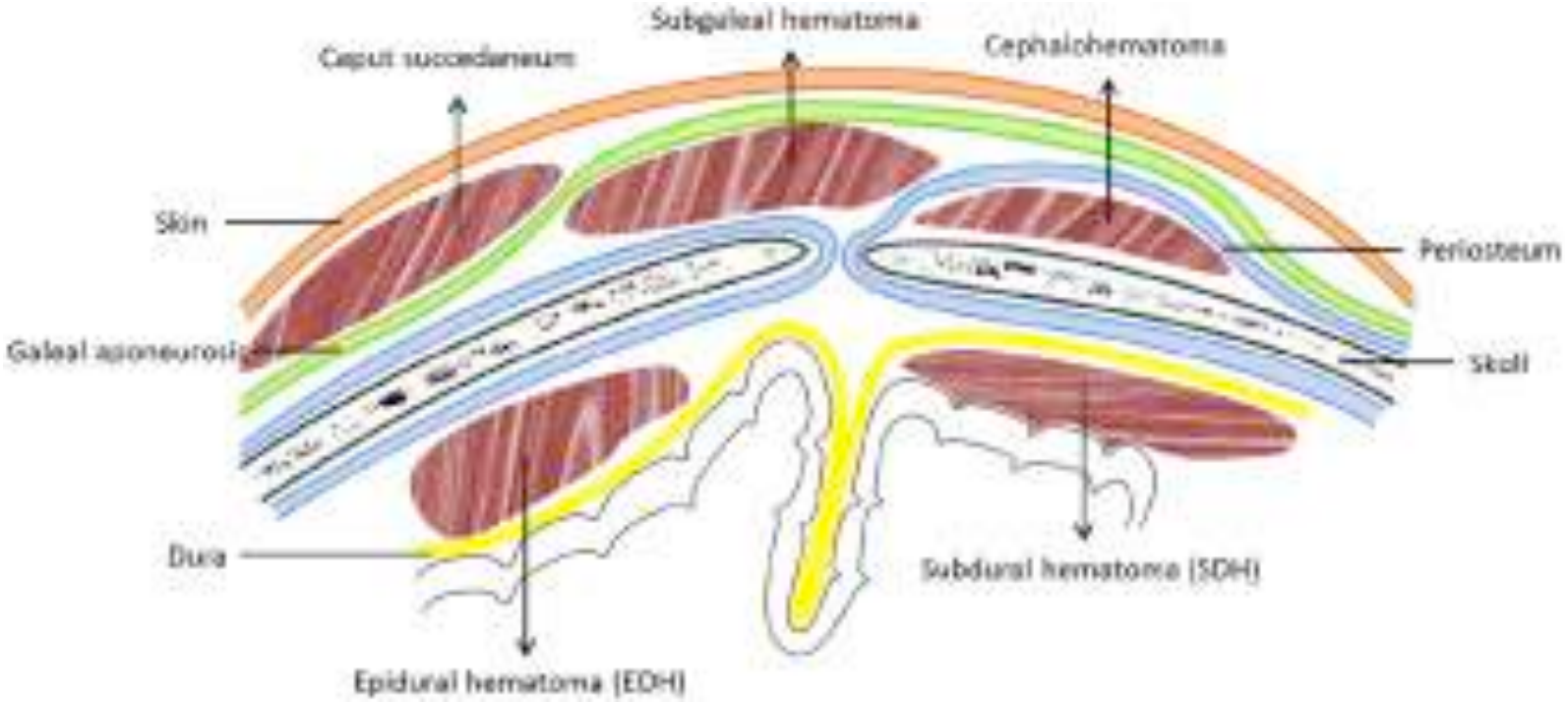
1. **Subgaleal Hematoma** : may occur without bony trauma, or may be associated with linear nondisplaced skull fracture (especially in age < 1 yr).

- Bleeding into loose connective tissue separates galea from periosteum.
- May cross sutures.
- Usually starts as a small localized hematoma, and may become huge (with significant loss of circulating blood volume in age < 1 year, transfusion may be necessary). Inexperienced clinicians may suspect CSF collection under the scalp which does not occur.
- Usually presents as a soft, fluctuant mass.
- These do not calcify.

2. **Subperiosteal Hematoma** : most commonly seen in the newborn (associated with parturition, may also be associated with neonatal scalp monitor).

- Bleeding elevates periosteum, extent is limited by sutures.
- Firmer and less ballotable than subgaleal hematoma.
- scalp moves freely over the mass.
- 80% reabsorb, usually within 2–3 weeks. Occasionally may calcify

- Infants may develop jaundice (hyperbilirubinemia) as blood is resorbed, occasionally as late as 10 days after onset.



Growing skull fractures or posttraumatic leptomeningeal cyst (PTLMC)

- Not to be confused with arachnoid cysts.
- PTLMC consists of a fracture line that widens with time. Although usually asymptomatic, the cyst may cause mass effect with neurologic deficit.
- Occurring in 0.05–0.6% of skull fractures in children.
- Usually requires both a widely separated fracture AND a dural tear.
- Mean age at injury: <1 year; over 90% occur before age 3 years (formation may require the presence of a rapidly growing brain).
- Treatment of true PTLMC is surgical, with dural closure mandatory. Since the dural defect is usually larger than the bony defect, it may be advantageous to perform a craniotomy around the fracture site, repair the dural defect, and replace the bone.

❑ **<u>"Ping-pong ball" fractures</u> :** A green-stick type of fracture → caving in of a focal area of the skull as in a crushed area of a pingpong ball.

- Usually seen only in the newborn due to the plasticity of the skull.
- No treatment is necessary when these occur in the temporo-parietal region in the absence of underlying brain injury as the deformity will usually correct as the skull grows

Skull fractures in child abuse

- The parietal bone was the most common site of fracture (≈ 90%).
- Depression of skull fractures is frequently missed clinically due to overlying hematoma
- Clinical features in patients with skull fractures did not reliably differentiate child abuse from
- Characteristics more frequently seen after child abuse than after other trauma:

  a) multiple fractures

  b) bilateral fractures

  c) fractures that cross sutures

Important Points in Neurosurgery

- Most common brain tumor Δ Metastases (>50%)
- Most common primary brain tumor Δ GBM
- Most common primary intracranial tumor Δ Meningioma (15-20%)
- Most common primary non-glial tumor ΔMeningioma.
- Most common primary CNS tumor in adults Δ GBM
- Most common primary CNS tumor in children Δ Gliomas (more specifically astrocytomas 50%), and the second most common is Δ Medulloblastoma
- Most common pediatric brain malignancy Δ Medulloblastoma
- Most common pediatric vermian tumor Δ Medulloblastoma
- Most common supra-tentorial tumor in pediatrics (as in adults) - Astrocytoma.
- Most common abnormality associated with the progression of malignant astrocytomas overall ΔLOH on chromosome 10.
- What is the most common chromosome involved with cytogenic aberration in GBM - ΔChromosome 7

- Meningiomas are the most common primary intracranial tumors, and the routine use of CT & MRI for numerous indications has led to an increased rate of discovery of incidental (asymptomatic) meningiomas.
- Most common distribution of intracranial meningiomas in adults: ◊ Convexity 35% , Parasagittal 20% , Sphenoid ridge 20% , Intra-ventricular 5% , CPA 5% , Tuberculum sellae 3% , Infratentorial 13% , Others 4%
- Most common site of meningioma in children Δ Intra-ventricular and spinal epidural
- Most common location of meningioma that's associated with extensive hyperostosis Δ Sphenoid wing meningioma.
- Most common site of ODG Δ Centrum semiovale (frontal lobes).
- Most common CPA tumor - Acoustic neuroma (70-80%) > Meningioma (5-10%) > Epidermoid tumors (5%)
- Most common solid tumours in childhood Δ Intracranial tumors
- Most common site for germinoma Δ Pineal region
- Most common pineal region tumor Δ Germinoma (It is similar in histological appearance to germinoma of the gonads and mediastinum; it occurs predominantly in males).
- Most common initial symptom in acoustic schwannoma Δ Tinnitus
- Most common initial symptom in acoustic schwannoma patient with nonauditory complaint - Headache
- Most common form of Langerhans Cell Histiocytosis Δ Eosinophilic granuloma

- Most common calcified tumor Δ Astrocytoma (because of its high incidence)
- Most common congenital intracranial tumor Δ Epidermoid
- Most common intracranial embryonal tumor Δ Medulloblastoma
- Most common intracranial embryonal lesion Δ Epidermoid (And it is the 3rd most common CPA / lAC mass, after vestibular schwannoma and meningioma)
- Most common tumor in the jugular fossa Δ Glomus jugulare tumor (3 times more common in females)
- Most common feeder to glomus jugulare tumor Δ Ascending pharyngeal A. (branch of ECA)
- Most common site of brain stem glioma Δ Pons
- Most common type of brain stem glioma Δ Infiltrating astrocytoma (almost all are fibrillary), arise most frequently in the pons.
- Most common non-glial tumor in children Δ Craniopharyngioma
- Most common site for craniopharyngioma - Pars tuberalis and ant. lobe of the pit., which are both formed by the ant. wall of Rathke's pouch.

- Most common astrocytoma in the ant. 3rd ventricle of young children Δ Juvenile pilocytic astrocytoma which arises from the ventricular wall.
- Most common primary bone tumor found in the craniofacial skeleton Δ Osteoma.
- Most common primary malignant bone tumor in adults Δ Multiple myeloma
- Most common site of chordoma Δ Sacrococcygeal region (skull base is the 2nd most common site).
- Most common site of PCNSL is Δ Cerebral hemispheres (especially the periventricular areas)
- Most common type of PCNSL Δ Diffuse large cell lymphoma (B-immunoblastic sarcoma)
- Most common intracranial sarcoma Δ Gliosarcoma
- Most common initial presentation in intrinsic brain stem gliomas ΔCranial neuropathy.
- Most common spinal tumor to bleed ΔEpendymoma of the filum terminale.
- Most common site of origin of neuroblastoma ΔMedulla of the adrenal gland (40% of
- neuroblastic tumors).
- Most common site of gangliogliomas ΔTemporal lobe.

- Cranial nerve VI (Abducens) has the longest intracranial course.
- Astrocytomas are the most common supratentorial tumor in pediatrics as a whole.
- Brain tumors are the second most common cancer in childhood. They are the most common solid tumors in childhood.
- In neonates, 90% of brain tumors are of neuroectodermal origin with teratomas being the most common.
- The beneficial effects of steroids are greater for metastatic (metastatic vs. primary) tumors.
- The proper time to obtain post-op imaging to check for bleeding is typically within 6 -12 hours.
- The proper time to obtain post-op imaging to check for residual tumor is either within 2-3 days or after about 30 days. An exception to this timing rule of thumb is for pituitary tumors.
- The tumor marker S-100 may rise after head trauma and may be elevated in Creutzfeldt-Jakob disease.

- Sir Victor Horsley— Founder of Modern Neurological Surgery.
- Charles Sherrington— Father of Modern Neurophysiology.
- Harvey Cushing was the first to map the Human Cerebral Cortex with faradic electrical stimulation in the conscious patient. Founded the first School of American Neurological Surgery.
- M. Gazi Yasargil of Zurich performed the first EC-IC procedure on a human being on October 30, 1967 (Microsurgical procedure). Recently credited as “Neurosurgeon of the Millennium”.
- The incidence of diabetes insipidus in patients with severe head injury is about 2%.
- Hyponatremia may be seen in 5-12% of head injured adults and in upto 25% of head injured children.
- Lundberg classification of ICP :

  Normal < 10 mmHg

  Slightly increased 11-20 mmHg

  Moderately increased 21-40 mmHg

  Severely increased > 40 mmHg

- The total cerebral blood volume is about 150 ml. About 25-50ml is found in the arterial system.
- Mean regional cerebral blood flow is 54 ml/100gm/ minutes.
- The major arteries are capable of dilating to 15 – 40% of their normal diameter.
- The cerebral arterioles are critical for CBF and are mainly responsible for autoregulation. They are approx. 50 microns in diameter and are capable of diameter change of up to 200-300 percent.
- Cerebral metabolic rate for oxygen (CMRO2) is 3.3 ml/100g/minute.
- Cerebral capillary pore size is about 1-2 microns which is one percent of that in the systemic capillaries.
- Grey matter cerebral blood flow – 70ml/100gm/minute, White matter CBF – 20 ml/100gm/minute. The critical blood flow below which infarction occurs is 18 ml/100gm/minute.
- CPP = [MAP-ICP] where CPP is cerebral perfusion pressure. MAP is mean arterial pressure. ICP is intra cranial pressure.

❑ Spinal and Cranial Dysraphism and Chiari Malformations

Embryological event related to postovulatory day :

Day 13 — Formation of the primitive streak

Day 17 — Notochord

Day 22 — Formation of neural tube

Day 24 — Closure of cranial neuropore (stage 11 of embryo formation)

Day 26 — Closure of caudal neuropore (stage 12 of embryo formation)

- Anencephaly is due to failure of closure of the anterior neuropore at about 24 days gestation [1-4 weeks].

- Myelomeningocele is due to failure of closure of the posterior neuropore at about 26 days gestation [1-4 weeks].

Radiosurgery

- Father of Radiosurgery - Lars Leksell
- The first Gamma knife was installed in Karolinska Institute, stockholm in 1968.
- The Leksell gamma knife delivers a single high dose of ionising radiation emanating from [201] collimators of cobalt 60.
- AVM constitute the single largest indicator (50%) for radiosurgical procedure.
- Radiosurgery is the treatment of choice for all AVM upto 3cm in diamater.

THANK YOU