Brain Tumor Syllabus

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ASTROCYTOMA

Terminology
- Primary brain tumor of astrocytic origin with intrinsic tendency for malignant progression, degeneration into anaplastic astrocytoma (AA).

Imaging Findings
- Best diagnostic clue: Focal or diffuse nonenhancing white matter (WM) mass
- Cerebral hemispheres, supratentorial 2/3
- May appear circumscribed on imaging but isn’t; tumor cells typically found beyond imaged signal abnormality!

Top Differential Diagnoses
- Anaplastic astrocytoma (AA)
- Ischemia
- Cerebritis
• Oligodendroglioma
• Herpes encephalitis
• Status epilepticus

**Pathology**
- Represents 25-30% of gliomas in adults
- 10-15% of all astrocytomas
- Diffusely infiltrating mass with blurring of GM/WM interface
- WHO grade II

**Clinical Issues**
- Majority occur between ages of 20-45 years
- Inherent tendency for malignant progression of AA = major cause of mortality
- Median survival 6-10 years.

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**PEDIATRIC BRAINSTEM GLIOMA**

**Terminology**
- Tectal glioma (tectal)
- Focal tegmental mesencephalic (FTM)
- Diffuse (intrinsic) pontine glioma (DPG)
- Heterogeneous group of focal or diffuse gliomas involving mesencephalon, pons, or medulla

**Imaging Findings**
- Classic imaging appearance varies with tumor type and location
- Tectal: Pilocytic, focal, variable enhancement/Ca ++
- FTM: Pilocytic, cyst plus nodule
- DPG: Fibrillary, diffuse, nonenhancing
- All BSG are not equal! Geography predict prognosis
- Borders/margins predictive of prognosis

**Top Differential Diagnoses**
- Congenital aqueductal stenosis vs tectal glioma
- Alexander disease vs tectal glioma
- Neurofibromatosis type 1 vs DPG
- Other brainstem gliomas

**Pathology**
- General path comments: No metastases outside CNS
- Epidemiology: 10-20% pediatric brain tumors

**Diagnostic Checklist**
- Not all expansile brainstem lesions are neoplasms
- Geography predicts prognosis

**PEARLS IN THE DIAGNOSIS OF BRAIN STEM GLIOMAS**
- Peak age: 6-8 years
- Signal: Hyperintense on T2 (95%), exophytic tumor produces brighter signal
- Growth patterns
  - a. Cystic tectum (20%)
b. Infiltrative, pons (70%)
- Dedifferentiation of glioblastoma multiforme 5-7% of pediatric cases

Location
- Pontomedullary (80%)
- Midbrain (60%)
- Cerebellum (40%)
- Cervical cord (35%)
- Posterior thalamus (30%)

- Enhancement: Variable and may not be present
- Calcification: Less than 4%

Differential diagnosis
- Vascular malformation (flow void or hemorrhage signal, non-expansile)
- Metastases (adults with history of primary neoplasm, contrast enhancement)

RANGE OF NORMAL ANTEROPOSTERIOR BRAIN STEM DIAMETERS

- Midbrain tegmentum: 11-15 mm
- Pons: 24-29 mm
- Pontomedullary junction: 14-17 mm
- Cervicomedullary junction: 8-11 mm
ANAPLASTIC ASTROCYTOMA

Terminology
- Diffusely infiltrating astrocytoma with focal or diffuse anaplasia and a marked proliferative potential

Imaging Findings
- Infiltrating mass that predominately involves white matter (WM)
- Variable enhancement, typically none; may be focal or patchy
- Hemispheric WM, frontal & temporal lobes common
- Neoplastic cells almost always found beyond areas of abnormal signal intensity

Top Differential Diagnoses
- Low grade glioma
- Glioblastoma multiforme (GBM)
- Cerebritis
- Ischemia
- Oligodendroglioma
- Status epilepticus
- Herpes encephalitis

Pathology
- AA have histologic and imaging characteristics among spectrum between low grade astrocytoma and GMB
- 1/3 of astrocytomas
- May appear discrete but tumor always infiltrates adjacent brain
- WHO grade III

Clinical Issues
- Median survival 2-3 years
- Commonly arise as recurrence after resection of a grade II tumor
GLIOBLASTOMA MULTIFORME

Terminology
- Rapidly enlarging malignant astrocytic tumor characterized by necrosis and neovascularity
- Most common of all primary intracranial neoplasms

Imaging Findings
- Best diagnostic clue: Thick, irregular-enhancing rind of neoplastic tissue surrounding necrotic core

Top Differential Diagnoses
- Abscess
- Metastasis
- Primary CNS lymphoma
- Anaplastic astrocytoma (AA)
- “Tumefactive” demyelination
- Subacute ischemia
- Status epilepticus

Pathology
- Two types, primary (de novo) and secondary (degeneration from lower grade astrocytoma)
- 50-60% of astrocytomas
- WHO grade IV

Clinical Issues (Filippi et al., 1996)
- Age: Peak 45-70 years but may occur at any age
- Relentless progression
- Prognosis is dismal (death in 9-12 months)

Diagnostic Checklist
- Viable tumor extends far beyond signal abnormalities!
GLIOSARCOMA

Terminology
- Rare malignant neoplasm with both glial, mesenchymal elements

Imaging Findings
- Heterogeneously enhancing mass with dural invasion, +/- skull involvement

Figure 1A (Left): MRI Scan (Coronal View-Gadolinium enhanced). 45 year old male with a deep seated Right Thalamic region Glioblastoma with direct infiltration of the Brainstem (Arrow).

Figure 1B (Right): MRI Scan (Transaxial View-Gadolinium enhanced) in the same patient as Figures 1A & 2.) Partially Cystic Right Thalamic Region Glioblastoma infiltrates the Brainstem along fibre tracts (Arrow).
May be indistinguishable from GBM

Top Differential Diagnoses
- Glioblastoma multiforme (GBM)
- Metastasis
- Abscess
- Hemangiopericytoma
- Malignant meningioma

Clinical Issues
- Poor prognosis, median survival of 6-12 months

GLIOMATOSIS CEREBRI

Terminology
- Diffusely infiltrating glial tumor involving two or more lobes, frequently bilateral
- Infiltrative extent of tumor is out of proportion to histologic and clinical features

Imaging Findings
- Best diagnostic clue: T2 hyperintense infiltrating mass with enlargement of involved structures
- Typically hemispheric white matter involvement, may also involve cortex (19%)
- May cross corpus callosum or massa intermedia
- Morphology: Infiltrates, enlarges yet preserves underlying brain architecture
- Typically no or minimal enhancement
- Marked elevation of myo-inositol (mI)

Top Differential Diagnoses
- Arteriolosclerosis
- Anaplastic astrocytoma (AA)
- Viral encephalitis
• Lymphoma

Pathology
• Underlying brain architecture preserved
• Usually WHO grade III

Clinical Issues
• Peak incidence between 40-50 years
• Poor prognosis

Diagnostic Checklist
• Rare diffusely infiltrating glial tumor that can be mistaken for nonneoplastic WM disease

PILOCYTIC ASTROCYTOMA

Terminology
• Pilocytic astrocytoma (PA), juvenile pilocytic astrocytoma (JPA)

Imaging Findings
• Cystic cerebella mass with enhancing mural nodule
• Enlarged optic nerve/chiasm/tract with variable enhancement
• Paradoxical findings: MRS does not accurately reflect historical behavior of tumor
• Multiplanar or 3D volume post contrast imaging key to showing point to origin and degree of extension
Top differential Diagnoses
• Medulloblastoma (PNET-MB)
• Pilomyxoid astrocytoma

Pathology
• 15% of NF1 patients develop PAs, most commonly in optic pathway
• Up to 1/3 of patients with optic pathway PAs have NF1
• WHO grade 1

Clinical Issues
• Peak incidence: 5-15 years of age
• Older than children with medulloblastoma

Diagnostic Checklist
• Generally not a reasonable diagnostic consideration in adults
• An enhancing intra-axial tumor with cystic change in a “middle-age” child is more likely to be PA than anything else
PLEOMORPHIC XANTHOASTROCYTOMA

Terminology
• Distinct type of (usually) benign supratentorial astrocytoma found almost exclusively in young adults

Imaging Findings
• Supratentorial cortical mass with adjacent enhancing dural “tail”
• Temporal lobe most common

Top Differential Diagnoses
• Ganglioglioma
• Pilocytic astrocytoma
• Dysembryoplastic neuroepithelial tumor (DNET)
- Oligodendroglioma
- Meningioma
- Low grade astrocytoma (Grade II)

**Pathology**
- Superficial, circumscribed astrocytic tumor noted for cellular pleomorphism and xanthomatous change
- < 1% of all astrocytomas
- Cystic mass with mural nodule abutting meninges
- Deep margin may show infiltration of parenchyma
- WHO grade II

**Clinical Issues**
- Majority with long-standing epilepsy, often partial complex seizures (temporal lobe)
- Tumor of children/young adults

**Diagnostic Checklist**
- Cortical mass & meningeal thickening in a young adult with long seizure history? Think PXA!

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** SUBEPENDYMAL GIANT CELL ASTROCYTOMA  **

**Imaging Findings**
- Enlarging, enhancing intraventricular mass in patient with tuberous sclerosis complex (TSC)
- Location: Almost always near foramen of Monro
- Well marginated, often lobulated
- Heterogeneous, strong enhancement
- Presence of interval growth suggests SGCT
- Enhancement alone does not allow discrimination from hamartoma
- FLAIR MR to detect subtle CNS features of TSC
- Recommend brain MR with contrast every 1-2 years for SGCT follow-up
**Top Differential Diagnoses**
- Choroid plexus tumors
- Astrocytoma
- Germinoma
- Subependymoma

**Pathology**
- Most common CNS neoplasm in TSC
- Does not seed CSF pathways
- WHO grade I

**Clinical Issues**
- Increased ICP secondary to tumor obstructing foramen of Monro

**Diagnostic Checklist**
- SGCA in tuberous sclerosis patient with worsening seizures and/or symptoms of ventricular obstruction
OLIGODENDROGLIOMA

Terminology
- Well-differentiated, slowly growing but diffusely infiltrating cortical/subcortical tumor

Imaging Findings
- Best diagnostic clue: Partially Ca++ subcortical/cortical mass in middle-aged adult
- Typically involves subcortical white matter (WM) and cortex
- Majority supratentorial (85%), hemispheric WM
- Most common site is frontal lobe
- May involve temporal, parietal or occipital lobes
- Morphology: Infiltrative mass that appears well demarcated
- Majority calcify, nodular or clumped Ca++ (70-90%)
Top Differential Diagnoses
- Anaplastic oligodendroglioma (AO)
- Astrocytoma
- Gangliogioma
- Dysembryoplastic neuroepithelial tumor (DNET)
- Pleomorphic xanthoastrocytoma (PXA)
- Cerebritis
- Ischemia

Pathology
- WHO grade II

Clinical Issues
- Seizures, headaches
- Peak incidence 4th and 5th decades
- Surgical resection in primary treatment

Pearls in the Diagnosis of Oligodendroglioma
- Peak age: 30-50 years
- Calcification: 80%
- Cyst formation: 10%
- Edema: 50%
- Location: frontotemporal centrum
- Hemorrhage: 80-90%
- Margins: poorly defined; therefore, all areas of T2 relaxation prolongation should be radiated
- Enhancement: moderate and inhomogeneous
- Differential Diagnosis:
  - Meningioma (pseudocapsule, extra-axial)
  - Gangliogioma (males, temporal love and anterior third ventricle predilection)
  - Calcified glioma (less infiltrative, more mass effect, less calcification)
  - Arteriovenous malformation (hypointense flow void signal, T2 dependent hemosiderin)
ANAPLASTIC OLIGODENDROGLIOMA

Terminology
- Oligodendroglioma with focal or diffuse histologic features of malignancy

Imaging Findings
- Best diagnostic clue: Calcified frontal lob mass involving cortex/subcortical white matter (WM)
- May appear discrete, but always infiltrative
- Neoplastic cells almost always found beyond areas of abnormal signal intensity

Top Differential Diagnoses
- Oligodendroglioma
- Anaplastic multiforme (GBM)
- Cerebritis
- Ischemia
Pathology
- Well-differentiated (grade II) and anaplastic (grade III) types of oligodendroglioma
- Oligoastrocytoma (mixed tumor with 2 distinct neoplastic cell types) are common (50%)
- Oligos have better prognosis that astrocytomas of same grade
- Average number of chromosomes involved is higher in grade III than grade II oligos
- 20-50% of oligodendrogliomas are anaplastic
- WHO grade III

Clinical Issues
- Peak incidence fourth through sixth decade
- Median survival 4 years
- Local tumor recurrence common

TERMINOLOGY
- Sloe-growing tumor of ependymal cells

Imaging Findings
- Soft or “plastic” tumor: Squeezes out through 4th ventricle foramina into cisterns
- 2/3rd infratentorial, 4th ventricle
- 1/3rd supratentorial, majority periventricular WM
- Ca++ common (50%); +/- cysts, hemorrhage
- MR spectoroscopy alone does not reliably differentiate ependymoma from astrocytoma or PNET-MB
- High-quality sagittal imaging can distinguish point of origin as floor vs roof of 4th ventricle

Top Differential Diagnoses
- Medulloblastoma (PNET-MB)
Pathology
• Arise from ependymal cells or ependymal rests
• Third most common posterior fossa tumor in children (after PA and PNET-MB)
• WHO grade II (low grade, well-differentiated)
• WHO grade III (high grade, anaplastic)

Clinical Issues
• Clinical profile: 1-5 yo with headache, vomiting
• Gross total resection + XRT correlates with improved survival

Diagnostic Checklist
• Indistinct interface with floor of 4th ventricle = ependymoma

Pearls in the Diagnosis of Ependymoma
• Tendency to involve the filum
• Hemorrhagic in a significant percentage of the cases, especially the myxopapillary form of the filum
• Tendency to form cysts
  a. Marginal cysts located at the tumor edge and easily amenable to syringotomy decompression
  b. Central cysts which are located within the lesion and must be excised if they are to be treated
• Ependymomas tend to have hypointense T1 and hyperintense T2 signal and either show cyst formation or signal inhomogeneity
• Filum location is a strong tip-off to the diagnosis (these lesions tend to seed the CSF and may be a result of drop metastases)
• Enhancement is moderate to marked

• Indistinct interface with roof of 4th ventricle = PNET-MB
SUBEPENDYMOMA

**Terminology**
- Rare, benign well-differentiated intraventricular ependymal tumor

**Imaging Findings**
- Best diagnostic clue: T2 hyperintense lobular, nonenhancing intraventricular mass
- Intraventricular, inferior 4th ventricle typical (60%)
- Other: Lateral > 3rd ventricle > spinal cord
- Well-defined solid lobular mass
- When large, may see cysts, hemorrhage, Ca++
Variable enhancement, typically none to mild.

**Top Differential Diagnoses**
- Ependymoma
- Central neurocytoma
- Subependymal giant cell astrocytoma
- Choroid plexus papilloma (CPP)
- Hemangioblastoma
- Metastases

**Pathology**
- WHO grade I

**Clinical Issues**
- Most asymptomatic
- Other signs/symptoms: Related to increased intracranial pressure, hydrocephalus
- Middle-aged/elderly adult, (typically 5th-6th decades)
- Surgical resection is curative in most cases
Diagnostic Checklist
- 4th or lateral ventricular hyperintense mass in an elderly male? Think sybependymoma!

GANGLIOGLIOMA

Terminology
- Well differentiated, slowly growing neuroepithelial tumor composed of neoplastic ganglion cells and neoplastic glial cells

Imaging Findings
- Best diagnostic clue: Partially cystic, enhancing, cortically-based mass in child/young adult with TLE
- Can occur anywhere but most commonly superficial hemispheres, temporal lobe

Top Differential Diagnoses
- Pleomorphic xanthoastrocytoma (PXA)
• Dysembryoplastic neuroepithelial tumor (DNET)
• Pilocytic astrocytoma
• Low grade astrocytome (grade II)
• Oligodendroglioma

Pathology
• Cortical dysplasia is commonly associated
• Most common mixed neuronal-glial tumor
• WHO grade I and II

Clinical Issues
• Clinical profile: Most common neoplasm causing chronic temporal lobe epilepsy
• Excellent prognosis if surgical resection complete
• Malignant degeneration is rare, approximately 5-10% (glial component)

Diagnostic Checklist
• In young patient with history of temporal lobe epilepsy, think ganglioglioma
• Cyst with an enhancing mural nodule is classic, but nonspecific for ganglioglioma

Pearls in the Diagnosis of Ganglioglioma
• Age: 15-30 years
• Gender: slight male predominance
• Location: temporal lobe or anterosuperior third ventricle
• Signal: nonspecific hypointense T1 and hyperintense T2
• Enhancement: variable and nominal to moderate
• Cyst formation: 10%
• Hemorrhage: rare
• Calcification: 10-20%
• Insidious seizure history and lesion in the correct location are tipoffs to diagnosis
• Differential diagnosis:
  • Oligodendroglioma: more edema
o Vascular malformation: less mass effect, no edema, flow void, hemosiderin
o Colloid cyst: smaller size, hyperintense T1

**DYSPLASTIC CEREBELLAR GANGLIOCYTOMA**

**Terminology**
- Best known as Lhermitte-Duclos disease (LDD)

**Imaging Findings**
- Best diagnostic clue: Widened cerebellar folia with striated appearance on MR
- Characteristics “layered” or striated” pattern of alternating isointense and hyperintense signal
- Also called “laminated”, “corduroy”, “lamellar”, “folial”
- No diffusion disturbance on ADC maps
- T1 C+: Rare lesions enhance
- PET: Elevated 18-FDG uptake
- Elevated 201-thallium uptake on delayed imaging

**Top Differential Diagnoses**
- Cerebellar infarction
- Acute cerebellitis
- Leptomeningeal

**Pathology**
- Associated with Cowden syndrome
- Characterized by development of multiple hamartomas
• Increased risk of thyroid and breast carcinoma
• Some evidence supports that all cases of LDD have Cowden syndrome
• Replacement and expansion of granular layer by large neurons

**Diagnostic Checklist**
• Striated cerebellar hemisphere is “Aunt Minnie” for LDD

**DESMOPLASTIC INFANTILE GANGLIOGLIOMA**

**Terminology**
• Desmoplastic infantile (DIG, DIGG) or desmoplastic infantile astrocytoma (DIA)

**Imaging Findings**
• Large cyst + cortical-based enhancing tumor nodule
• Location: frontal > parietal > temporal
• Solid tumor module(s) enhance markedly
• Enhancement of leptomeninges, dura adjacent to solid tumor is typical

**Top Differential Diagnosis**
• Primitive neuroectodermal tumor (PNET)
• Supratentorial ependymoma
• Pleomorphic xanthoastrocytoma (PXA)
• Hemangioblastoma
• Ganglioglioma
• Pilocytic astrocytoma

DNET
Terminology
- Dysembryoplastic neuroepithelial tumor (DNET)
- Benign, focal, intracortical mass superimposed on background of cortical dysplasia

Imaging Findings
- Best diagnostic clue: Well-demarcated, wedge-shaped “bubbly” intracortical mass in young patient with longstanding partial seizures
- Temporal lobe (often amygdala/hippocampus) most common site
- Intracortical mass scallops inner table of skull and “points” towards ventricle
- Minimal or no mass effect

Pathology
- Approximately 1-2% of primary brain tumors in patients < 20 years
- Reported in 5-80% of epilepsy specimens

Clinical Issues
- Clinical profile: Longstanding (difficult to control) partial complex seizures in child or young adult
- NO or very slow increase in size over time
- Rare recurrence
- Beware of atypical features (enhancement) on pre-op imaging
CENTRAL NEUROCYTOMA

Terminology
- Intraventricular neuroepithelial tumor with neuronal differentiation

Imaging Findings
- Best diagnostic clue: “Bubbly” mass in frontal horn or body of lateral ventricle
- Intraventricular mass attached to septum pellucidum
- Circumscribed, lobulated mass with intratumoral “cysts”
- Ca++ common, 50-70%

Top Differential Diagnosis
- Subependymoma
- Subependymal giant cell astrocytoma (SGCA)
- Metastasis
- Ependymoma
- Choroid plexus papilloma (CPP)
- Meningioma
- Cavernous malformation
Pathology
- < 1% of all primary intracranial neoplasms
- Represents 50% of intraventricular tumors on patients 20-40 years
- Resembles oligodendroglioma
- WHO grade II

Clinical Issues
- Most common signs/symptoms: Headaches, increased intracranial pressure, mental status changes, seizure
- Hydrocephalus secondary to forearm of Monro obstruction
- Complete surgical resection is treatment of choice

PINEOBLASTOMA

Terminology
- Highly malignant, primitive embryonal tumor of pineal gland

Imaging Findings
- Large, heterogeneous pineal mass with “exploded”, peripheral Ca++
- Nearly 100% with obstructive hydrocephalus
Top Differential Diagnoses
- Germ cell tumors (GCTs)
- Meningioma
- Pineocytoma (PC)
- Metastases

Pathology
- PBs exhibit little to no differentiation, similar to other PNETs

Clinical Issues
- Elevated ICP (hydrocephalus): Headache, nausea, vomiting, lethargy, papilledema, abducens nerve palsy

Diagnostic Checklist
- Both PBs and germinomas frequently hyperdense on CT (hypointense T2WI) and prone to CSF dissemination
- Peripheral “exploded” Ca++ in PB and central “engulfed” Ca++ in germinoma classic but not always identified

PINEOCYTOMAS

Terminology
- Slow-growing pineal parenchymal tumor of young adults composed of small, uniform mature cells resembling pineocytes

Imaging Findings
- Enhancing, circumscribed pineal mass which “explodes” pineal Ca++
- May mimic pineal cyst or pineoblastoma

Top Differential Diagnosis
- Pineoblastoma
- Nonneoplastic pineal cyst
- Astrocytoma
- Other germ cell tumors (GCT)
• Meningioma

Pathology
• Pineocytoma and pineoblastomas account for 15% of pineal region neoplasms
• Pineocytomas represent approximately 45% of pineal parenchymal tumors
• Pineal parenchymal tumors << germinoma
• Cysts and small areas of hemorrhage may be seen
• May compress but do not invade adjacent structures
• WHO grade II

Clinical Issues
• Overall 5 year survival 86%

Diagnostic Checklist
• PCs “explode” gland Ca++ while germinomas “engulf” gland Ca++
• Imaging of pineocytoma may be nonspecific

MEDULLOBLASTOMA (PNET-MB)
**Terminology**
- Medulloblastoma (MB), posterior fossa PNET, PNET-MB
- Malignant, invasive, highly cellular embryonal tumor

**Imaging Findings**
- Solid mass in 4th ventricle
- Hydrocephalus common (95%)
- > 90% enhance
- Contrast essential to detect CSF dissemination
- Contrast-enhanced MR of spine (entire neuraxis)

**Top Differential Findings**
- Cerebellar pilocytic astrocytoma (PA)
- Ependymoma
- Choroid plexus papilloma (CPP)
- Atypical teratoid/rhabdoid tumor (AT/RhT)

**Pathology**
- 15-20% of all pediatric brain tumors
- WHO grade IV

**Clinical Issues**
- Ataxia, signs of increased intracranial pressure
- Relatively short (< 1 month) of symptoms
- Rapid growth with early subarachnoid spread
- “Standard risk” clinical profile
- “High risk” clinical profile

**Diagnostic Checklist**
- Remember AT/RhT in patients under 3 years
- 4\textsuperscript{th} V tumor arising from roof = PNET-MB
- 4\textsuperscript{th} V tumor arising from floor = ependymoma

Figure 1B (Center): MRI Scan (Coronal View-same patient). The tumor has considerable "enhancement" indicating a substantial blood supply.

Figure 1C (Right): MRI Scan (Transaxial View-same patient). The tumor (Arrow) fills the 4\textsuperscript{th} Ventricle demonstrates extensive "enhancement".

Distinctions among medulloblastoma, ependymoma, and astrocytoma in posterior fossa

<table>
<thead>
<tr>
<th>Feature</th>
<th>Medulloblastoma</th>
<th>Ependymoma</th>
<th>Astrocytoma</th>
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## SUPRATENTORIAL PNET

### Terminology
- Supratentorial primitive neuroectodermal tumor (S-PNET)
- Cerebral embryonal tumor composed of undifferentiated neuroepithelial cells

### Imaging Findings
- Best diagnostic clue: Large, complex hemispheric mass with minimal peritumoral edema
- Isoattenuating to hyperattenuating
- Calcification (50-70%)
- Hemorrhage and necrosis common
- Heterogeneous enhancement

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<td>Common (40%-50%)</td>
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<tr>
<td>Choline</td>
<td>High</td>
<td>Less elevated</td>
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**Metabolite**
- NAA: Low, Intermediate, Intermediate
- Lactate: Absent, Often present, Often present
- Choline: High, Less elevated, High
- DWI: Restricted diffusion common
- Best imaging tool: Enhanced MR of brain and spine
- Adding post-enhanced FLAIR aids in detecting leptomeningeal metastases

**Top Differential Diagnosis**
- Astrocytoma
- Ependymoma
- Oligodendroglioma
- Atypical teratoid/rhabdoid tumor

**Clinical Issues**
- Vary with site of origin and size of tumor
- Hemispheric – seizures, disturbed consciousness, motor deficit, elevated ICP
- Suprasellar – visual disturbance, endocrine problems
- Clinical profile: Infant presenting with microcephaly, seizures and large hemispheric mass
- S-PNET $\rightarrow$ 30-35% 5 year survival
MENINGIOMA

**Imaging Findings**
- Best diagnostic clue: Dural-based enhancing mass w/cortical buckling & trapped CSF clefts/cortical vessels
- Hyperostosis, irregular cortex, tumoral calcifications, increased vascular markings
- Brain cysts & trapped pools of CSF common
- Peritumoral hypodense vasogenic edema (60%)
- >95% enhance homogeneously & intensely
- Elevated levels of Alanine at short TE
- DSA: “Mother-in-law” sign → comes early, stays late
- Best imaging tool: MRI + contrast

**Top Differential Diagnoses**
- Dural metastasis
Granuloma (sarcoid, TB)
Idiopathic hypertrophic pachymeningitis
Extramedullary hematopoiesis

Pathology
- Loss of one copy of chromosome 22 is most prevalent chromosomal change in meningioma
- Arise from arachnoid meningeothelial (“cap”) cells
- Most common adult intracranial tumor (13-20%)

Clinical Issues
- < 10% of all meningiomas ever cause symptoms
- Age: Middle decade of life
- Gender: M:F ranges 1: 1.5 to 1:3
- Ethnicity: More common in African-Americans
- Generally grow slowly, compress adjacent structures
- Asymptomatic followed with serial imaging

Diagnostic Checklist
- Preoperatively define ENTIRE tumor extent

Signs of Meningioma
- Iso- or Hypointensity on T2 images
- Inward white matter buckling
- Speckled T2 signal hyperintensity (microcyst formation)
- Focal T2 hypointensity (macrocalcifications)
- Prominent circumferential flow void (hypervascularity)
- Cisternal widening
- Calvarial hypointense T1 and T2 (sclerosis) or hyperintense T2 (edema or hyperemia)
- Pseudocapsule formation due to desmoplasia or fibrosis, displaced dura, CSF, and vessels
- Variable edema (edema can be pronounced)
- En plaque variant, ridge
  b. Wraps around structures especially basilar skull vessels
c. Aggressive

d. Propensity for sphenoidal ridge

e. Fibrovascular histology more common

SCHWANOMA

Terminology
• Benign encapsulated nerve sheath tumor composed of differentiated neoplastic schwann cells

Imaging Findings
• Best diagnostic clue: VS looks like “ice cream on cone”; parenchymal looks like cyst with nodule
• All cranial nerves (exceptions: Olfactory, optic nerves) have myelinated schwann cell sheaths and are sites for intracranial schwannomas
• 1-2% intracerebral

Top Differential Prognosis
• Pleomorphic xanthoastrocytoma (PXA)
• Pilocytic astrocytoma
• Ganglioglioma
• Metastasis
• Hemangioblastoma
Pathology
- Schwannomas = 5-8% of all intracranial neoplasms
- Two types of tissue (Antoni A, B)

Clinical Issues
- Age: 70% of parenchymal schwannomas present before age of 30
- Slowly growing: recurrence after surgery < 10%
- Malignant degeneration exceptionally rare

Diagnostic Checklist
- Cystic, calcified, enhancing hemispheric parenchymal mass in a young patient isn’t necessarily a glioma!

### Differential diagnosis of meningioma versus schwannoma

<table>
<thead>
<tr>
<th>Feature</th>
<th>Meningioma</th>
<th>Schwannoma</th>
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<tr>
<td>Dural tail</td>
<td>Frequent</td>
<td>Extremely rare</td>
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<tr>
<td>Bone reaction</td>
<td>Osteolysis or hyperostosis</td>
<td>Rare</td>
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<tr>
<td>Angle made with dura</td>
<td>Obtuse</td>
<td>Acute</td>
</tr>
<tr>
<td>Calcification</td>
<td>20%</td>
<td>Extremely rare</td>
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<tr>
<td>Cyst/necrosis</td>
<td>Rare</td>
<td>Up to 10%</td>
</tr>
<tr>
<td>Enhancement</td>
<td>Uniform</td>
<td>Inhomogeneous in 32%</td>
</tr>
<tr>
<td>Extension into the internal auditory canal</td>
<td>Rare</td>
<td>80%</td>
</tr>
<tr>
<td>MRS</td>
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<td>Taurine, GABA</td>
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<td>Precontrast CT attenuation</td>
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<tr>
<td>Hemorrhage</td>
<td>Rare</td>
<td>Somewhat more common</td>
</tr>
</tbody>
</table>
NEUROFIBROMA

Terminology
• Plexiform NF (PNF) = infiltrative extrapeural tumor typically associated with neurofibromatosis 1 (NF1)

Imaging Findings
• Best diagnostic clue: “Worm-like” soft tissue mass infiltrative scalp, orbit or parotid in patient with NF1

Top Differential Diagnoses
• Schwannoma
• Malignant peripheral nerve sheath tumor (MPNST)
• Vascular malformation of scalp
• Sarcoma or lymphoma of skull/scalp
• Metastasis
• Chronic interstitial demyelinating polyneuropathy (CIDP)

Diagnostic Checklist
• Look for other stigmata of NF1 (café-au-lait spots, axillary freckling, Lisch nodules, etc)

PEARLS IN THE DIAGNOSIS OF GLOMUS TUMOR
• Age: 30-50 years
• Signal
  a. Intermediate T1, hyperintense T2
  b. Punctuate speckled salt and pepper areas pinpoint flow void due to hypervascularity
• Location
  a. Jugular foramen (50-60%)= glomus jugulare
  b. Tympanic branch or Jacobson’s nerve, glomus tympanicum (20-30%)
  c. Auricular branch or Arnold’s nerve, glomus vagale (10%)
  d. Periganglia cells of the carotid bifurcation= glomus caroticum (less than 10%)Female predilection
- Multiplicity (10%) particularly with multiple endocrine adenomatosis (3%)
- Eight percent harbor other neoplasms
- Most common primary middle ear neoplasm
- Second most common temporal bone neoplasm
- Enhancement: pronounced, early, mottled
- Associated thrombosis or flow phenomenon in the jugular vein
- Shape: Triangular shape in the coronal projection
- Differential diagnosis
  a. Neuroma: No punctate flow void, more rounded shape
  b. Meningioma: Flat dural margin, homogeneous enhancement, wraparound vessels with infiltrative growth pattern
  c. Normal slow flow in jugular vein

HEMANGIOBLASTOMA

Terminology
- HGBL currently classified as meningeal tumor of uncertain histogenesis (WHO, 2000)

Imaging Findings
- Best diagnostic clue: Adult with intra-axial posterior fossa mass with cyst, enhancing mural nodule abutting pia
- 90-95% posterior fossa
- Size: Size varies from tiny to several cms
- 60% cyst + “mural” nodule
- 40% solid
Top Differential Diagnoses
- von Hippel-Lindau syndrome (VHL)
- Metastasis
- Astrocytoma
- Vascular neurocutaneous syndrome
- Cavernous malformation (CM)
- Clear cell ependymoma

Pathology
- VHL phenotypes (based on presence, absence of pheochromocytoma and renal cell carcinoma)
- 1-2% of primary intracranial tumors
- 7-100% of posterior fossa tumors
- Secondary polycythemia (may elaborate erythropoietin)
- WHO grade I

Diagnostic Checklist
- Screen entire neuraxis for other HGBLs
- Most common posterior fossa intra-axial mass in middle-aged/older adult = metastasis, not HGBL!
Pearls in the Diagnosis of Hemangioblastoma

- Sixty percent are intramedullary; 40% are extramedullary but intradural
- Thirty percent have Hippel-Lindau disease
- Thoracic location in 50% and cervical location in 40%
- Lesions are single in 80% and multiple in 20%
- Cyst formation in 40%
- MR findings
  a. Intermediate signal intensity nodule which enhances
  b. Speckled foci or flow void signal in and about the nodule
  c. Areas of marginal cyst formation above and below the lesion
  d. Round or ovoid shape

MRI Scan (Gadolinium Enhanced Axial View) Left Cerebellar Hemisphere Cystic Tumor.

The "Mural Nodule" (Curved Arrow) "enhances" due to its considerable blood supply and is responsible for the formation of the fluid of the cyst. The "Nodule" must be entirely removed in order to "cure" this lesion, particularly in "Sporadically" occurring cases.
Cysts of this size cause considerable pressure on the Brain Stem which can threaten the patient's life if left untreated.

HEMANGIOPERICYTOMA

Terminology
• Sarcoma related to neoplastic transformation of pericytes, contractile cells about capillaries

Imaging Findings
• Lobular enhancing extra-axial mass with dural attachment, +/- skull erosion
• May mimic meningioma, but without Ca++ or hyperostosis
• Typically involve falx, tentorium, or dural sinuses
• Marked enhancement, often heterogeneous

Top Differential Diagnoses
• Meningioma
• Dural metastases
• Lymphoma
• Neurosarcoïdosis
• Gliosarcoma
• Solitary fibrous tumor
Pathology
- HPC is a distinctive mesenchymal neoplasm unrelated to meningioma
- Represents < 1% of primary CNS tumors
- Represents 2-4% of all meningeal tumors
- WHO grade II or III (anaplastic)

Clinical Issues
- Most common 4th-6th decade, mean age 43 years
- Extracranial metastases common, up to 30%

Diagnostic Checklist
- When a “meningioma” has atypical features (frank bone erosion, multiple flow voids) think HPC!

PEARLS IN THE DIAGNOSIS OF CRANIOPHARYNGIOMA

- Peak age: Biphasic, 3-5 years and 50-60 years
- Location
  a. Suprasellar (80%)
  b. Sellar/suprasellar (15%)
  c. Sellar (4%)
  d. Third ventricle (0.5%)
  e. Nasopharynx (0.5%)
- Signal
  a. Hyperintense T1 & T2: Hydrolyzed cholesterol and/or blood (65%)
  b. Intermediate T1, hyperintense T2: Keratin (20%)
  c. Hypointense T2: Calcification (75%)
  d. Hypointense T1, hyperintense T2: Cyst formation (40%)
  e. Intermediate T1 and T2: Solid tumor (15%)
- Calcification (75%): Twice as frequent in children as adults (Rathke’s cyst do not calcify)
• Origin: Rathke’s cells or pouch having multilayered complex epithelium (Rathke’s cysts have a simple single-layered epithelium)
• Enhancement: Variable, none to mild
• Hemorrhage: (10%)
• Differential diagnosis: Meningioma (homogenous, marked enhancement); aneurysm (flow void or clot); pituitary adenoma (more homogeneous signal, noncalcified, usually no hyperintense T1 signal)

**PRIMARY CNS LYMPHOMA**

**Terminology**
- Malignant primary CNS neoplasm composed of B lymphocytes

**Imaging Findings**
- Best diagnostic clue: Enhancing lesion(s) within basal ganglia, periventricular WM
- 90% supratentorial
- Deep gray nuclei commonly affected
- Often involve, cross corpus callosum
- Frequently abut, extend along ependymal surfaces

**Top Differential Diagnoses**
- Toxoplasmosis
- Glioblastoma multiforme (GBM)
- Abscess
- Progressive multifocal leukoencephalopathy (PML)

**Pathology**
- 98% B cell, non-Hodgkin lymphoma (NHL)
- Incidence increasing in immunocompetent, immunocompromised
- 1-7% of primary brain tumors, incidence rising
- Represents approximately 1% of lymphomas

**Clinical Issues**
- Median survival 17-45 months
• AIDS median survival 2-6 months
• Stereotactic biopsy, followed by radiation therapy and chemotherapy

**Diagnostic Checklist**
• Imaging and prognosis varies with immune status
• Periventricular location and Subependymal involvement is characteristic of PCNSL

**PEARLS IN THE DIAGNOSIS OF PRIMARY & SECONDARY BRAIN LYMPHOMA**

- **Location**
  - a. Deep white gray matter (70%)
  - b. Leptomeningeal signal: Intermediate T1 and isointense to hyperintense T2 (30%)
- **Enhancement**: Marked
- **Margin**: Sharply marginated intra-axial lesions which may be large, and round or oval in shape
- **Edema**: Mild to moderate
- **Cyst formation**: Extremely rare
- **Hemorrhage**
- **Calcification**: Rare
- **Multiplicity**: Extremely common
- **Tipoff**: Clinical history of immunosuppression or AIDS
CHORDOMA

Terminology
- Malignant tumor arising from notochord remnants

Imaging Findings
- Mass is hyperintense to discs on T2WI, with multiple septa
- Histologic identification of physaliphorous cell confirms diagnosis
- Location: Sacrococcygeal > sphenoo-occipital >> vertebral body
- Size: Several cm at presentation
- Morphology: Midline lobular soft tissue mass with osseous destruction
- May extend into disc, involve 2 or more adjacent vertebrae
- May extend into epidural/perivertebral space, compress cord
- May extend along nerve roots, enlarge neural foramina
- Amorphous intratumoral Ca++
Pathology
- 3 types described
- Typical: Lobules, sheets, and cords of clear cells with intracytoplasmic vacuoles (physaliphorous cells); abundant mucin
- Chondroid: Hyaline cartilage (usually sphenoid-occipital region)
- Dedifferentiated: Sarcomatous elements (rare, highly malignant)

Pearls in the Diagnosis of Chordoma
- Age: 30-40 years
- Location:
  - Sacrum 50%
  - Clivus 30%
  - Cervical (C2) 20%
- Intermediate T1 signal, mottles hyperintense T2 signal
- Calcification 30-50%
- Enhancement: none to mild
- Shape: cauliflower-like shape in the C2 and clival regions
- Tipoffs: cauliflower-shaped or exophytic mass involving intervertebral disc (sacrum) or straddling the clivus or C2 anteriorly and posteriorly in the sagittal projection

PARENCHYMAL METASTASES
Terminology
• Parenchymal tumors that originate from, but are discontinuous with, other CNS primary or extracranial systemic neoplasms

Imaging Findings
• Best diagnostic clue: Discrete parenchymal mass(es) at gray-white interface
• Best imaging tool: Contrast-enhanced MRI >> CECT
• Protocol advice: Double or triple-contrast dose increases sensitivity but questionable value on routine basis

Top Differential Diagnoses
• Abscess
• Malignant glioma
• Thromboembolic stroke(s)
• Demyelinating disease

Pathology
• Prevalence of metastases vs primary CNS neoplasms increasing
• Now account for up to 50% of all brain tumors
• Seen in 25% of cancer patients at autopsy
• Metastases usually displace rather than infiltrate tissue

Clinical Issues
• Median survival with whole brain XRT = 3-6 months

Diagnostic Checklist
• White matter disease (“UBOs”) in elderly patient can be caused by multifocal metastases
• Use contrast-enhanced scans

PEARLS IN THE DIAGNOSIS OF METASTATIC DISEASE

Hemorrhagic Metastases
• Choriocarcinoma: 90-95%
• Melanoma: 85%
- Hypernephroma: 65%
- Thyroid carcinoma: 55%
- Lung carcinoma: 15%
- Breast carcinoma: 10%
- Alimentary tract carcinoma: 5-10%
- Other: Less than 5%

**Subtypes with a Lower Propensity toward Brain Metastases**
- Squamous cell carcinoma
- Sarcoma

**Primary Brain Tumors Which May Metastasize Peripherally**
- Medulloblastoma
- Cerebellar sarcoma
- Glioblastoma multiforme

**Subependymal or Intraventricular Tumor Spread**
- Melanoma
- Lymphoma
- Breast carcinoma
- Lung carcinoma

**Leptomeningeal or Dural Carcinomatosis**
- Breast carcinoma
- Lung carcinoma (adenocarcinoma)
- Melanoma
- Lymphoma

**Brain Metastases without Edema**
- Squamous cell carcinoma
Cystic Metastases
- Lung carcinoma (oat cell)
- Radiated metastases

Isointense Metastases
- Metastatic colon carcinoma (70%)
- Prostate carcinoma (60%)
- Osteogenic sarcoma
- Melanoma (30%)

Pure Cortical Metastases
- Melanoma
- Choriocarcinoma
- Lung carcinoma

Intraventricular Choroidal Metastases
- Lung carcinoma
- Colon carcinoma
- Breast carcinoma

INTRACRANIAL CYSTS ON MR
- Arachnoid cyst: Extra-axial, no edema, non-enhancing
- Cystic neoplasm (low tumor density): Edema, enhances
- Chronic subdural hematoma or hygroma: Extra-axial
- Suprasellar cyst from dilated third ventricle
- Interhemispheric cyst from porencephaly
- Posterior fossa cyst form of Dandy-Walker malformation
- Enlarged cisterna magna
- Post-infarct cystic encephalomalacia
• Cysts associated with isodense tumors
  a. Ganglioma: May calcify
  b. Cerebellar hemangioblastoma
  c. Cystic astrocytoma: Enhancing nodule
• Cysticerosis: Calcification

ARACHNOID CYST

Terminology
• Arachnoid cyst (AC), subarachnoid cyst
• Intra-arachnoid CSF-filled sac that does not communicate with ventricular system

Imaging Findings
• Best diagnostic rule: Sharply demarcated round/ovoid extra-axial cyst that follows CSF attenuation/signal
• 50-60% middle cranial fossa (MCF)
• Sharply-marginated extra-axial fluid collection isointense with CSF
• FLAIR: Suppresses completely with FLAIR
• DWI: No restriction

Top Differential Diagnoses
• Epidermoid cyst
• Chronic subdural hematoma
• Subdural hygroma
• Other nonneoplastic cysts

Pathology
• 1% of all intracranial masses
• If in middle fossa, temporal lobe may appear (or be) hypoplastic
• Subdural hematoma (increased prevalence, especially MCF)
• Acs displace but don’t engulf vessels, cranial nerves
Clinical Issues
- Often asymptomatic, found incidentally

Diagnostic Checklist
**FLAIR, DWI best sequences for distinguishing etiology of cystic-appearing intracranial Pearls in the Diagnosis of Arachnoid Cyst**
- Location: extra-axial
  a. Middle cranial fossa, peritemporal
  b. Cerebral convexity
  c. Posterior fossa, retrocerebellar
  d. Suprasellar quadrigeminal plate cistern
- Homogeneous water-like signal, hypointense on T1 and very hyperintense on T2 (Remember that pulsation in the cyst may create the false impression of a nodule inside)
- There should be no evidence of intra-axial edema
- The margins of the lesion are smooth, sharp and straight, particularly in the middle fossa cysts along the posterior margin
- Suprasellar cysts are oval or square in shape, splay the cerebral peduncels and carotid termini, and push the mamillary body upward and posterior

Differential Diagnosis
- Epidermoid: Hypointense T1, mixed hyperintense T2, does not match CSF fluid
- Ependymal- or nonependymal-lined cyst: Intra-axial
- Craniopharyngioma: Mixed T1 and T2 signal, variable hyperintense fat
- Dermoid tumor: Hyperintense T1 & T2
- Cystic glioma: Hypointense T1, hyperintense T2, intra-axial with surrounding edema

- Masses
This is a series of MRI Scans of a 54 year old Male who complained about recent hearing impairment and ringing ("Tinnitus") in his Right ear. The scans show a large Arachnoid Cyst in the Right Cerebellar Pontine Angle of the Posterior Cranial Fossa.

DERMOID CYST

Imaging Findings
- Best diagnostic clue: Fat appearance + droplets in cisterns, sulci, ventricles if ruptured
- T1 C+: With rupture: Extensive MR enhancement possible from chemical meningitis
- Use fat-suppression sequence to confirm diagnosis

Top Differential Diagnoses
- Epidermoid cyst
- Craniopharyngioma
- Teratoma

Pathology
- Rare: < 0.5% of primary intracranial tumors
- Unilocular cyst with thick wall of connective tissue
Clinical Issues
- Uncomplicated dermoid: Headache (32%), seizure (30%) are most common symptoms
- 30-50 y
- Gender: Slight male predilection
- Larger lesions associated with higher rupture rate
- Rupture can cause significant morbidity/mortality
- Rare malignant transformation into SCCa
- Treatment: Complete microsurgical excision

Diagnostic Checklist
- Follows fat characteristics on NECT and T1WI fat-suppressed MRI

Terminology
- Intracranial epidermoids are congenital inclusion cysts

Imaging Findings
- Best diagnostic clue: CSF-like mass insinuates cisterns, encases nerves/vessels

EPIDERMOID CYST
• Morphology: Lobulated, irregular, “cauliflower-like” mass with “fronds”
• FLAIR: Usually doesn’t completely null
• Restricted diffusion yields high signal

Top Differential Diagnoses
• Arachnoid cyst
• Inflammatory cyst (i.e., neurocysticercosis)
• Cystic neoplasm
• Dermoid cyst

Pathology
• 0.2-1.8% of all primary intracranial tumors

Clinical Issues
• Most common symptom: Headache
• Cranial nerve 5,7,8 neuropathy common
• Age: Presents at 20-60 y with peak at 40
• Grows slowly: Epithelial component growth rate commensurate to that of normal epithelium
• Rare malignant degeneration into squamous cell carcinoma (SCCa) reported
• Treatment: Microsurgical resection

Diagnostic Checklist
• Resembles CSF on imaging studies, except usually incomplete nulling on FLAIR

COLLOID CYST
**Imaging Findings**

- Best diagnostic clue: Hyperdense foramen of Monro mass on NECT
- Most anterosuperior ventricle location
- Size < 1.5 centimeters
- No or nominal contrast enhancement
- Density correlates inversely with hydration state
- 2/3 hyperintense on T1WI
- Majority isointense to brain on T2WI (small cysts may be difficult to see!)
- 25% mixed hypo/hyper (“black hole” effect)
- Rare: May show peripheral (rim) enhancement

**Indirect Signs**

- Intermittent hydrocephalus
- Paramagnetic
Appearance of Colloid Cysts by Signal Intensity
- Paramagnetic type, most common (60%): Hyperintense T1, hypointense T2, peripheral hyperintense T2 rim*
- Cystic type, uncommon (20%): Hypointense T1, hyperintense T2
- Isointense type, rare (10%): Isointense T1 and isointense or minimally hyperintense T2
- Mixed type, rare (less than 105): Hyperintense T1, isointense T2

*Fluid levels with T2 hypointensity layering dependently are seen in 30-40% of cases.

Top Differential Diagnoses
- Neurocysticercosis
- CSF flow artifact (MR “pseudocyst”)
- Neoplasm
- Choroid plexus mass

Pathology
- From embryonic endoderm, not neuroectoderm!
- 0.5 – 1.0% primary brain tumors
- 15-20% intraventricular masses

Clinical Issues
- Headache (50-60%)
- 3rd-4th decade
- 90% stable or stop enlarging
- 10 % enlarge
- May enlarge rapidly, cause coma/death!

Diagnostic Checklist
- Notify referring MD immediately if CC identified (especially if hydrocephalus is present)

Pearls in the Diagnosis of Colloid Cysts
- Signal intensity similar to hemorrhagic cysts or cystic craniopharyngioma
- Paramagnetic type, most frequent
- Most anterosuperior third ventricle location
- Intermittent hydrocephalus
- Minimal enhancement on CEMR
- Internal constituents include calcium, magnesium, copper, iron, manganese, and sodium
- Rare in the pediatric population
- May simulate melanoma metastases
Radiation Necrosis
- Hypointense T1, iso- to hyperintense T2, variable central Hypointensity
- Enhancement is corrugated, wavy & irregular (wrinkled configuration)

Recurrent Neoplasm
- Variable T1 and T2
- Masslike & Nodular
- Edema has no respect for the forceps major or corpus callosum
- Metabolism on Pet usually equals or exceeds that of white matter
- May recur early or late

SIGNS OF INTRACRANIAL NEOPLASTIC HEMORRHAGE
- Intermediate signal intensity on T1 and T2
- Signal alteration which does not correspond to any known pattern of blood evolution over an appropriate period of time
- Delayed temporal resolution of hemorrhage
- Bizarre or complex signal intensities
- Irregular, absent or complex hemosiderin rings
- Persistent or exaggerated edema
- Lesion multiplicity
- Absence of hypointense calcification
- Disproportionate mass effect for lesion size
- Nodular enhancement

FREQUENCY OF HEMORRHAGE IN INTRACRANIAL NEOPLASMS
- Pineal choriocarcinoma or teratocarcinoma (90%)
- Primary intracranial neuroblastoma (85%)
- Oligodendroglioma (80%)
Melanoma (70%)
Ependymoma (55%)
Glioblastoma multiforme or high-grade astrocytic neoplasm (35%)
Metastasis (especially renal cell, thyroid, bronchogenic, melanoma and choriocarcinoma)
The frequency of intracranial neoplastic hemorrhage increases dramatically after cranial irradiation

**CYSTIC PITUITARY MASSES**

**Empty Sella**
- Homogeneous T1 hypointensity, T2 hyperintensity: Pure water signal
- Midline pituitary stalk
- Paucity of solid pituitary tissue
- No evidence of chiasmatic or suprasellar mass effect
- Enhancement of normal pituitary tissue only

**Arachnoid Cyst**
- Homogenous T1 hypointensity, T2 hyperintensity: Pure water signal
- Sellar, suprasellar, retrosellar, and perisellar mass effect are common
- Effaced and displaced pituitary stalk, multidirectional
- Enhancement of normal pituitary tissue

**Cystic Craniopharyngioma**
- May have foci of T1 hyperintensity
- May have hypointense T2 calcification
- Suprasellar +/- intrasellar extension
- Mixed enhancement

**Cystic Pituitary Adenoma or Neuroectodermal Tumor**
- Moderate T1 hypointensity, T2 hyperintensity: Proteinaceous water signal (therefore no exact CSF match)
- Displaced pituitary stalk
- Hormonal abnormalities frequently present
- Intra- and suprasellar mass effect and/or extension
• Foci of nodular enhancement from solid components

**Dermoid**
• Hyperintense T1, hyperintense T2
• Predominantly suprasellar
• Nonenhancing

**Epidermoid**
• Hypointense T1, hyperintense T2
• Inhomogeneous
• Minimal peripheral enhancement
• Irregular shape

**Cystic Optic Chiasmatic/Hypothalamic Glioma**
• Neurofibromatosis frequently associated
• Origin in, or involvement of, the optic chiasm or hypothalamus
• Mild enhancement

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**CRITERIA FOR SELlar MICROADENOMA**

**Direct Criteria**
- T1 hypointensity < 1 cm in size
- Hypointense on CEMR < 8 minutes, can be isointense 8-40 minutes and hyperintense on CEMR > 40 minutes

**Indirect Criteria**
- Stalk deviation
- Abnormal gland height (greater than)
  a. 6-7 mm male or prepubescent
  b. 7-11 mm gravid female postpuberty
  c. 10-13 mm female, peripartum
- Floor deviation
- Gland size asymmetry
PEARLS IN THE DIAGNOSIS OF PITUITARY MACROADENOMA

• Greater than 1 cm
• Isointense on T1
• Iso- or hyperintense on T2 with mild to moderate enhancement
• Diaphragma sellar notching helps differentiate extrasellar mass growing down from pituitary mass growing up

Complications of macroadenoma

a. Chiasmatic compression
b. Cavernous sinus invasion
c. Prolactin levels > 2,000 picograms/dl implies cavernous invasion

Cont. of Complications of macroadenoma

ii. Abuts the lateral dural sinus walls
iii. Loss of speckled signal in the cavernous sinus distribution
c. Pituitary hemorrhage or apoplexy
d. Pituitary adenoma recurrence
e. Differential diagnosis of macroadenoma

i. Craniopharyngioma
ii. Meningioma (dark-isointense)
iii. Aneurysm (lamellated)
iv. Metastases (isointense-bright)

INTRASELLAR PITUITARY SIGNAL VOIC OR HYPOINTENSITY

Common
• Volume averaging of the parasellar carotid artery dura and CSF
Uncommon
- Aneurysm of the paracavernous carotid artery

Rare
- Vascular malformation of the paracavernous carotid artery
- Primitive trigeminal artery aneurysm
- Pituitolith
- Intramesellar calcified meningioma
- Pituitary gas associated with abscess formation or prior surgery
- Intramesellar calcified craniopharyngioma
- Postsurgical intramesellar susceptibility effect (clip, metal, etc.)

**INTRACRANIAL SIGNAL: HYPERINTENSE T1, HYPOINTENSE T2**

Common
- Subacute hematoma or clot (mid or high field)
- Flow (first echo slice entry phenomenon)
- Melanoma metastases (choriocarcinoma, neuroblastoma, embryonal cell carcinoma, thyroid carcinoma, renal cell carcinoma, malignant melanoma)
- Lipoma
- Pantopaque

Uncommon
- Colloid cyst
- Calcified xanthogranuloma
- Aneurysm (with clot or slice entry)
• Craniopharyngioma

**INTRACRANIAL SIGNAL: HYPO-TO ISOINTENSE T1, HYPOINTENSE T2 (1.5T)**

**Common**
- Acute hematoma
- Flow (first echo flow void, second echo rephasing)
- Aneurysm with flow phenomenon or acute clot
- Calcification (nontraumatic, nonhemorrhagic)
- Brain iron
- Neoplasm with acute hemorrhage or extensive calcification
- Meningioma

**Uncommon**
- Colloid cyst
- Melanoma

**Rare**
- Chloroma

**INTRACRANIAL SIGNAL: ISOINTENSE-T1 & T2**

**Common**
- Hyperacute hematoma (transition to acute hematoma [1.5 T])
- Acute hematoma (mid field [0.5 T])
- Subacute hematoma (high field)
• Flow (combinations of flow void adding to flow-related hyperintensity)
• Aneurysm with flow phenomenon
• Meningioma
• Brain iron (low field)
• Isointense metastases (colon, prostate, osteogenic, sarcoma, breast)
• Hamartoma

**Uncommon**
• Colloid cyst

**Rare**
• Medulloblastoma or adult cerebellar sarcoma
• Lymphoma
• Tuberculoma
• Chloroma

**BLACK SIGNAL**

• Flow
• Air or gas
• Hemosiderin (T2 dependent)
• Iron, copper or metal
• Bone
• Calcium
• Superparamagnetic contrast agents
• Ligaments, tendons, fascia
• Magnetic susceptibility
HYPOINTENSE RINGS

- Hemosiderin ring: Chronic hematoma
- Susceptibility rim artifact: Glial or astrocytic neoplasm
- Pseudocapsule of dura, cerebrospinal fluid, cleft, desmoplasia, vessels: Meningioma
- Fibrous rim: Abscess, neurocysticercosis, meningioma

INTRAVENTRICULAR MASSES

Hypointense T1, Hyperintense T2, Nonenhancing

- Arachnoid cyst
- Cysticercosis
- Colloid cyst (3rd ventricle)
- Cystic craniopharyngioma
- Cystic meningioma
- Dandy-Walker cyst (4th ventricle)
- Epidermoid (4th ventricle)
- Neuroepithelial cyst, intraventricular type
- Neuroepithelial cyst (xanthogranuloma of the choroid plexus)

CSF Signal Mass

- Arachnoid cyst
- Cysticercosis
- Dandy-Walker cyst or variant (4th ventricle)
- Mega cisterna magna (pseudocyst)
- Trapped ventricle (pseudomass)
- Hypointense T1 & T2, Enhancing
- Acute hematoma
- Calcified giant cell astrocytoma
- Calcified flomus of choroid plexus
- Dense or calcified metastases (prostate, colon, osteogenic sarcoma)
- Heavily calcified meningioma
- Hemorrhagic ventricular metastases

**Hyperintense T1, Hypointense T2**
- Colloid cyst
- CSF flow
- Dermoid
- Early subacute hemorrhage
- Intraventricular craniopharyngioma (heavily calcified)
- Lipoma
- Pantopaque
- Xanthogranuloma of the choroid plexus

**Hyperintense T1 & T2**
- Dermoid
- Flow
- Intraventricular craniopharyngioma (3rd ventricle)
- Late subacute hemorrhage

### Intraventricular Masses by Site

<table>
<thead>
<tr>
<th>NEOPLASMS</th>
<th>Lateral</th>
<th>Third</th>
<th>Fourth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Choroid plexus pspilloma/ca</td>
<td>Common, pediatric</td>
<td>Common from</td>
<td>Common, adult</td>
</tr>
<tr>
<td>Tumor</td>
<td>Age</td>
<td>Demarcation</td>
<td>Edema?</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------</td>
<td>-------------</td>
<td>--------</td>
</tr>
<tr>
<td>Ganglioglioma</td>
<td>0-30</td>
<td>Well</td>
<td>Very little</td>
</tr>
<tr>
<td>Low grade astrocytoma</td>
<td>0-30</td>
<td>Well</td>
<td>Yes</td>
</tr>
<tr>
<td>DNET</td>
<td>10-20</td>
<td>Well</td>
<td>None</td>
</tr>
<tr>
<td>Oligodendroglioma</td>
<td>30-60</td>
<td>Less well</td>
<td>Yes</td>
</tr>
<tr>
<td>PXA</td>
<td>10-35</td>
<td>Well, but malignant change in 20%</td>
<td>Uncommon</td>
</tr>
<tr>
<td>Desmoplastic infantile ganglioglioma</td>
<td>0-1</td>
<td>Well</td>
<td>Occasionally</td>
</tr>
<tr>
<td>Feature</td>
<td>Scar</td>
<td>Tumor</td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------</td>
<td>------------------------------</td>
<td></td>
</tr>
<tr>
<td>Enhancement within 1-2 days</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Enhancement after 3-4 days</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Change in size with time</td>
<td>Decreases</td>
<td>Increases</td>
<td></td>
</tr>
<tr>
<td>Type of enhancement</td>
<td>Linear, outside preoperative tumor bed</td>
<td>Nodular, solid</td>
<td></td>
</tr>
<tr>
<td>Mass effect edema</td>
<td>Decreases</td>
<td>Increases</td>
<td></td>
</tr>
</tbody>
</table>