MRI of the Posterior Cranial Fossa: Spectrum of Abnormalities in Adult Patients.

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Learning objectives

The posterior cranial fossa is part of the intracranial cavity, located between the foramen magnum and tentorium cerebelli. Anteriorly, it extends to the apex of the petrous temporal bone and posteriorly, it is enclosed by the occipital bone. It contains the brainstem and cerebellum.

The posterior fossa is affected by a multitude of conditions in adults; which includes normal variants, inflammatory, metabolic, infectious, vascular and neoplastic diseases. An understanding of these pathologies, common as well as uncommon one, will greatly facilitate to improve patient care.

MRI has high sensitivity for detection and determining the extent of disease process. Because of its better soft tissue resolution and multiplanar capability, MRI has most potential amongst all imaging modalities to allow complete diagnosis. MRI is the imaging modality of choice for the investigation of disorders of posterior cranial fossa. Accurate interpretation of MR examinations requires an understanding of the anatomy, histology and spectrum of pathology affecting the posterior cranial fossa.

The purpose of our essay is to

- Illustrate the spectrum of posterior cranial fossa lesions in adult patients.
- Describe the imaging and clinical features that will help to accurately characterize these lesions and improve diagnostic yield.
Background

The posterior fossa is affected by a multitude of conditions in adults. MRI can provide important information about the anatomic location, size, and shape of the lesions as well as their mass effect on adjacent structures. The pattern of signal intensity, morphology, and involvement of other areas on MR imaging along with appropriate clinical details can help accurately characterize the disease process. Understanding the spectrum of appearances of the various posterior fossa lesions improves the diagnostic yield, enables one to understand their pathogenesis, and facilitates patient care.

In this presentation, we will illustrate the MRI findings of various posterior fossa lesions according to the pathogenesis. We will describe the imaging features along with relevant clinical findings which will help discriminate different disease processes.

1. **Normal variants:**
   - **Mega Cisterna Magna:** Mega cisterna magna is a developmental variation of the posterior fossa characterized by expansion of retrocerebellar cistern (cisterna magna) with normal cerebellar morphology Fig. 1 on page 7.
   - **Dandy Walker variant:** A Dandy-Walker variant is a less severe posterior fossa anomaly than the classic Dandy-Walker malformation in which prominent retrocerebellar space of cerebrospinal fluid communicates freely with the fourth ventricle Fig. 2 on page 7. The vermis is usually hypoplastic and the posterior fossa is not as enlarged as in the classic Dandy-Walker malformation Fig. 3 on page 8 Fig. 4 on page 9.

2. **Developmental:**
   - **Arachnoid cyst:** Arachnoid cyst is a congenital lesion of the arachnoid membrane that expands with CSF secretion. They are filled with clear CSF and do not communicate with the ventricular system Fig. 5 on page 10.

3. **Inflammatory:**
   - **Multiple Sclerosis:** Multiple sclerosis (MS) is the most common inflammatory demyelinating disease of the central nervous system in young and middle-age adults. According to the McDonald criteria for MS, the diagnosis requires objective evidence of lesions disseminated in time and space. Typically there is involvement of corpus callosum, U-fibers, temporal lobes, brainstem, cerebellum and spinal cord Fig. 6 on page 11.
   - **Progressive Multifocal Leukoencephalopathy:** PML is strongly associated with immunosuppressed states, particularly AIDS. Typically
there is multifocal, asymmetric periventricular and subcortical involvement with little or no mass effect. Infratentorial white matter lesions are also seen which involves the brain stem (medulla, pons, midbrain), cerebellar peduncle, or cerebellar white matter Fig. 7 on page 12 Fig. 8 on page 13.

4. **Metabolic:**

- **Central Pontine Myelinolysis:** Central pontine myelinolysis is an osmolar disturbance resulting in demyelination which occurs in the setting of rapidly corrected hyponatremia. Acute demyelination of the white matter tracts traversing the pons is most commonly seen Fig. 9 on page 14. Despite the name extrapontine structures like basal ganglia, midbrain, cerebellum and subcortical white matter can also be affected Fig. 10 on page 15. The earliest changes are however seen on diffusion weighted images with restriction seen within 24 hours of the onset of insult Fig. 11 on page 16.

- **Metronidazole-Induced Encephalopathy:** Metronidazole induced encephalopathy is a rare toxic encephalopathy caused by the antibiotic metronidazole. Brain lesions were typically located at the cerebellar dentate nucleus, midbrain, dorsal pons, medulla, and splenium of the corpus callosum Fig. 12 on page 17. The lesions show increased signal intensity on T2-weighted images and do not show contrast enhancement Fig. 13 on page 18. Some of the lesion especially those located in the corpus callosum show restricted diffusion corresponding to cytotoxic edema Fig. 14 on page 19. The signal changes are reversible after discontinuation of the drug Fig. 15 on page 20.

- **Posterior Reversible Encephalopathy Syndrome:** PRES describes a potentially reversible imaging appearance and symptomatology that is shared by a diverse array of causes, including hypertension, eclampsia, immunosuppressive medications, severe hypercalcemia, thrombocytopenic syndromes, systemic lupus erythematosus, and various causes of renal failure. It is a neurotoxic state that occurs secondary to the inability of posterior circulation to autoregulate in response to acute changes in blood pressure, leading to vasogenic oedema within the occipital and parietal region. Despite being termed posterior, PRES can be found in a non posterior distribution, mainly in watershed areas, including within the frontal, inferior temporal, cerebellar and brainstem regions Fig. 16 on page 21.

5. **Infectious:**

- **Tuberculosis:** Intracranial tuberculomas may occur either in isolation or combined with tuberculous meningitis. These tuberculomas are isointense to grey-matter on T1 weighted images and isointense on T2 images Fig. 17 on page 22 which may have central region of hypointensity representing abundant monocyte infiltration Fig. 18 on page 23.
• **Neurocysticercosis**: Neurocysticercosis is a neurologic parasitic disease caused by the encysted larva of the tapeworm *Taenia solium* and is the most important parasitic disease of the human central nervous system. Parenchymal neurocysticercosis is the second most common form of neurocysticercosis and is frequently found at the subarachnoid space near the gray matter-white matter junction or in the basal ganglia, cerebellum, brainstem Fig. 20 on page 25, Fig. 19 on page 24.

• **Japanese encephalitis**: Japanese encephalitis is a mosquito borne flaviviral encephalitis. Characteristic findings of Japanese encephalitis are bilateral thalamic Fig. 21 on page 26, substantia nigra Fig. 22 on page 27, basal ganglia, brain stem, cerebellum, cerebral cortical, and white matter lesions.

6. **Vascular**:

• **Wallenberg syndrome**: Wallenberg syndrome or Lateral medullary syndrome results from infarction of the dorsolateral medulla secondary to intracranial vertebral artery or posterior inferior cerebellar artery occlusion due to atherothrombosis or embolism Fig. 21 on page 26, Fig. 22 on page 27.

• **Cerebellar infarct**: Infarction of the cerebellum is a relatively uncommon subtype of ischaemic stroke, which may involve any of the three arteries supplying the cerebellum: superior cerebellar artery Fig. 25 on page 30, Fig. 26 on page 31, anterior inferior cerebellar artery and posterior inferior cerebellar artery.

• **Dural sinus thrombosis**: Cerebral venous thrombosis is a relatively uncommon but serious neurologic disorder that is potentially reversible with prompt diagnosis and appropriate medical care. Causal factors may be classified as local (related to intrinsic or mechanical conditions of the cerebral veins and dural sinuses) or systemic (related to clinical conditions that promote thrombosis) Fig. 27 on page 32.

7. **Neoplastic**:

• **Meningioma**: Meningiomas are the most common non glial primary brain tumor and most common extraaxial intracranial neoplasm. Around 10% of all arise in the posterior fossa Fig. 28 on page 33 Fig. 29 on page 34.

• **Epidermoid cyst**: An epidermoid tumor is a congenital lesion that arises from inclusion of ectodermal epithelial elements. They are slow growing show characteristic irregular, lobulated margins which insinuate along the cisterns Fig. 30 on page 35. Diffusion wighted images are the most
helpful imaging sequence in diagnosing an epidermoid cyst Fig. 31 on page 36.

- **Hemangioblastoma:** Hemangioblastomas are uncommon tumors, comprising 6-7% of posterior fossa tumors in adults. These are generally well circumscribed tumors. 60% are cystic masses with mural nodule while 40% are solid. Multiple hemangioblastomas are seen with VHL syndrome Fig. 32 on page 37.

- **Metastasis:** These are the most common intraxial tumor of posterior fossa in adults. Majority of the cases show multiple lesions. Grey-white matter junction is most common site for metastasis Fig. 33 on page 38, Fig. 34 on page 39. Lung, breast, melanoma and GI/GU tumors are the usual primary.

- **Acoustic Schwannoma:** Acoustic schwannoma are the most common cerebellopontine angle mass in adults. It usually arises from the opening of internal auditory canal, extends along the course of 8th cranial nerve and has a classic "icecream cone appearance" Fig. 35 on page 40. The shape & location of tumor are reliable features for diagnosis. 5-20% of cases are associated with neurofibromatosis-2.

- **Neurofibroma:** Soft tissue mass lesion of the scalp can present as an incidental finding on MR images through the posterior fossa. Some of the lesions are trivial like lipoma while few can point towards an underlying systemic disorder like subcutaneous neurofibroma Fig. 36 on page 41.

- **Clival masses:** Clival and temporal bone masses can project posteriorly and present as posterior fossa mass lesion Fig. 37 on page 42, Fig. 38 on page 43.

8. **Miscellaneous:**

- **Superficial Siderosis:** Superficial siderosis of the CNS is a rare clinical entity that results from chronic hemosiderin deposition in the subpial layers of the brain and spinal cord that leads to gradual progressive neurologic deterioration. Causes include spinal dural defects, intracranial neoplasms, vascular abnormalities, amyloid angiopathy and idiopathic. MRI evaluation for superficial siderosis is based on demonstration of magnetic susceptibility along the surface of the cerebellum, cord, brain, cisternal portions of cranial nerves, and intrathecal spinal nerve roots Fig. 39 on page 44.

- **Basilar invagination:** Mass at the foramen magnum, cranio-vertebral junction anomalies and basilar invagination can project superiorly and appear as unexpected posterior fossa mass on brain MR images Fig. 40 on page 45, Fig. 41 on page 46.
Images for this section:

**Fig. 1**: Mega cisterna magna: Transverse T2-weighted MR image shows retrocerebellar collection of CSF and normal cerebellum.

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Fig. 2: Dandy Walker Variant: Transverse T2 weighted MR image demonstrates prominent retrocerebellar space of cerebrospinal fluid that communicates freely with fourth ventricle.

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Fig. 3: Sagittal T1 weighted image in the same patient shows hypoplastic vermis but posterior fossa is not enlarged.

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Fig. 4: Coronal FLAIR image shows vermian hypoplasia and a wide communication with a "keyhole" appearance between cyst posteriorly and fourth ventricle.

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**Fig. 5:** Arachnoid cyst: Axial T2-weighted MR image shows a well defined extra-axial CSF collection anterior to cerebellum in right cerebellopontine angle region.

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**Fig. 6:** Multiple Sclerosis: Sagittal T2 weighted image shows T2 hyperintense lesions in middle cerebellar peduncle. This patient of multiple sclerosis also had similar lesions in periventricular white matter, thalamus and spinal cord.

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Fig. 7: Progressive multifocal leukoencephalopathy: Coronal FLAIR image in an HIV infected person shows multiple white matter lesions involving bilateral cerebellar white matter as well as subcortical cerebral white matter.

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**Fig. 8:** Transverse T2 weighted MR image of same patient reveals involvement of pons and cerebellar peduncles. The lesions did not show enhancement or restricted diffusion (images not shown).

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Fig. 9: Central Pontine Myelinolysis: Transverse T2 image at the level of pons depict increased signal intensity involving central pons and cerebellum.

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**Fig. 10:** Transverse T2 image of same patient with rapidly corrected hyponatremia showed involvement of basal ganglia, thalamus and insular cortex suggestive of changes of extra pontine myelinolysis.

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Fig. 11: Diffusion weighted image shows restricted diffusion in central pons as well as cerebellum.

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**Fig. 12:** Metronidazole induced encephalopathy: Transverse T2 image in a patient being treated with high doses of metronidazole depicts characteristic involvement of dentate nuclei of cerebellum.

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**Fig. 13:** Involvement of splenium of corpus callosum was also seen in the same patient.

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**Fig. 14:** Diffusion weighted image shows restricted diffusion in splenium of corpus callosum suggesting cytotoxic edema.

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Fig. 15: Metronidazole induced encephalopathy: Coronal FLAIR image shows near complete resolution of lesions after six weeks.
Fig. 16: PRES: Coronal FLAIR image of patient with long standing untreated hypertension and renal failure depicts involvement of bilateral parieto-occipital subcortical white matter and cerebellar white matter.

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Fig. 17: Tuberculosis: Axial T2 image shows multiple hypointense nodular lesions with hyperintense rim and adjacent edema.

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**Fig. 18:** Contrast enhanced T1 axial image shows thick peripheral rim of enhancement.

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**Fig. 19:** Neurocysticercosis: Transverse T2 MR image of the brain shows multiple cystic lesions with eccentric scolex suggesting vesicular neurocysticercosis in cerebellar and cerebral parenchyma.

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**Fig. 20:** Neurocysticercosis: Transverse T2 MR image of the brain shows vesicular neurocysticercosis in cerebellar and cerebral parenchyma. Further cysticerci are also seen in orbit and scalp.

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**Fig. 21:** Japanese encephalitis: Transverse T2 image in a patient with viral encephalitis demonstrate bilateral thalami involvement.

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**Fig. 22**: Axial T2 image shows signal changes in bilateral substantia nigra. These findings are characteristic of Japanese encephalitis in appropriate clinical settings.

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Fig. 23: Wallenberg syndrome: Coronal FLAIR image demonstrates increased signal intensity in dorsolateral medulla.

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**Fig. 24:** Axial Diffusion weighted image shows restriction of diffusion in involved dorsolateral medulla suggesting lateral medullary infarct characteristic for Wallenberg syndrome.

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Fig. 25: Cerebellar Infarct: Sagittal T2 weighted image in a patient presenting with acute onset ataxia shows wedge shaped infarct in superior cerebellum involving Superior Cerebellar Artery territory.

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Fig. 26: MRI TOF Angiogram image shows absent right superior cerebellar artery (open arrow). Left SCA is seen to be normal (arrow)

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Fig. 27: Dural sinus thrombosis: Axial T2 image in a patient with left sided mastoiditis shows hyperintense signal in left sigmoid sinus (arrow) replacing the normal flow void.

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Fig. 28: Meningioma: Transverse T2 image shows a isointense extra axial mass indenting right cerebellar parenchyma.

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**Fig. 29:** Contrast enhanced T1 image shows intense enhancement of the posterior fossa meningioma.

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**Fig. 30:** Epidermoid cyst: Axial T2 image demonstrates a hyperintense insinuating left cerebellopontine angle mass causing mass effect on pons and left cerebellum.

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**Fig. 31:** Diffusion weighted image shows characteristic restricted diffusion in CP angle epidermoid cyst.

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Fig. 32: Hemangioblastoma: Enhanced T1 image shows two intensely enhancing masses in cerebellum with cystic component. This patient also had a spinal hemangioblastoma. These findings are very specific for Von Hippel-Lindau disease.

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Fig. 33: Cerebellar metastasis: Axial T2 image in a patient of carcinoma lung depicts a complex cystic mass in vermis and right side of cerebellum. Fluid-fluid levels are seen due to blood products within the cyst.

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**Fig. 34:** Contrast enhanced T1 image of same patient shows thick peripheral enhancement in cystic mass.

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**Fig. 35:** Vestibular Schwannoma: Contrast enhanced axial T1 weighted image shows the classic "ice cream cone" appearance of acoustic schwannoma which arises in intracanalicular part and extends into right CP angle cistern.

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**Fig. 36:** Neurofibroma: Axial T2 image depicts subcutaneous neurofibroma (arrow) in occipital region. This patient of Neurofibromatosis-I also had optic nerve glioma (image not shown).

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Fig. 37: Clival round cell tumor: Axial T2 image of a patient with multiple cranial nerve involvement shows a large hypointense mass with its posterior extension in prepontine cistern and mass effect on pons.

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Fig. 38: Sagittal contrast enhanced T1 image shows intense enhancement of the mass which extends in posterior fossa.

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**Fig. 39:** Superficial siderosis: Axial gradient echo image at the level of pons in patient with unattended huge pituitary adenoma shows susceptibility artefact along surface of cerebellum and pons due to chronic hemosiderin deposition.

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Fig. 40: Basilar invagination: Axial T1 image at the level of foramen magnum shows a rounded mass displacing medulla.
Fig. 41: Basilar invagination: Sagittal T1 image of cervical spine reveals the mass to be cranially invaginated dens of atlas vertebra.

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Findings and procedure details

MR imaging of the brain was performed on a 1.5 T magnet system. Protocol included sagittal T1, axial T2, coronal FLAIR, diffusion weighted imaging. Contrast enhanced imaging, MR angiography, MR spectroscopy supplemented the study whenever relevant according to the results.
Conclusion

A multitude of pathologies affect the posterior cranial fossa in adults. Magnetic resonance imaging is an excellent noninvasive modality for evaluating posterior fossa. The pattern of signal intensity alteration, morphology, and location on MR imaging along with appropriate clinical details can help accurately characterize these lesions imperative for optimal management.
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