The unknown world of the prepontine cistern

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Learning objectives

1. To review the prepontine cistern anatomy and its relationship to other brain cisterns.

2. To review the most frequent pathologies in this location, including those less frequent.

3. To enhance the main radiological findings, in MDCT and MRI, to elaborate an easy differential diagnosis.

Background

The brain cisterns are extensive CSF spaces between the pia and the arachnoid, which contain vessels and some nervous structures.

They communicate with each other and with the cerebral ventricles through Luschka and Magendie foramens.

The prepontine cistern is located between the ventral pons, and the clivus. It is bounded superiorly by the interpeduncular cistern, inferiorly by the subarachnoid space of the spinal cord, continuous about medulla with cerebellomedullary cistern; and laterally by the cerebellopontine cisterns.

The basilar artery, when in midline, cross the prepontine cistern. The prepontine cistern also contains part of the V and VI cranial nerves.

Each structure located in the prepontine cistern, may give rise pathology. Also lesions originated in other places may invade the prepontine cistern.

Among the lesions founded in the prepontine cistern are:

1. Common:

   - CSF Flow artifact.
   - Dolichoectasia (Vertebrobasilar).
   - Meningioma.
   - Metastases.
2. Less common:

- Epidermoid cyst.
- Chiari 2.
- Brainstem glioma.
- Pituitary macroadenoma.
- Neurocysticercosis.
- Intracranial hypotension.

3. Rare:

- Inflammatory mass (tuberculosis, fungal diseases).
- Clival neoplasms (chordoma, chondrosarcoma, plasmocytoma, nasopharyngeal tumor).
- Schwanonoma.
- Arachnoid cyst.
- Craniopharyngioma.
- Neurenteric cyst.
- Ecchordosis Physaliphora.
- Paragangioma.
- Juvenile xanthogranuloma.

**Findings and procedure details**

We show a pictorial review of the different prepontine cistern lesions found in our hospital in the last 5 years, analyzing its main image features, including CT, MRI and angiography.

In this period of time we found the following pathologies:
- Fusiform aneurysm of basilar artery.
- Meningioma.
- Epidermoid cyst.
- Chordoma of the clivus.
- Brainstem glioma.
- Glomus jugulare paraganglioma.
- Teratoma.
- Ecchordosis Physaliphora.
- Xathogranuloma juvenile.

1. Fusiform aneurysm of basilar artery.

Intracranial aneurysms are classified according to their shape into saccular and nonsaccular types. Fusiform aneurysms are nonsaccular dilatations involving the entire vessel wall for a short distance. This type of aneurysm may be caused by dissection or atherosclerosis, by disorders of collagen and elastin metabolism, by infections and—very rarely—by neoplastic invasion of the arterial wall.

The clinical features of fusiform aneurysms are categorized morphologically. They can be incidental or asymptomatic, discovered during workup for unrelated symptoms. They can present as a nonspecific headache without hemorrhage or other neurological signs or symptoms, as ischemia, transient ischemic attack, or complete stroke, as mass effect with or without seizure, or as hemorrhage, subarachnoid or intraparenchymal lesions.

Intracranial fusiform aneurysms are rare and are usually located in the vertebrobasilar system.

The fusiform aneurysm of the basilar artery may present on CT as hyperdense mass, due to thrombus. Fig. 1 on page 9. The residual lumen appears isodense and enhances after CIV. Fig. 2 on page 11. We see exaggerated arterial ectasia and focal fusiform enlargement on CTA (computed tomography angiography). Fig. 3 on page 11.

On T1 weighted images the signal varies with degree of flow and the presence/age of hematoma. On T2 weighted images the intramural clot is often hypointense but heterogeneous. After Gadolinium (Gd) administration, residual lumen enhances intensely (prominent phase artifact is common).
2. Meningioma

Meningiomas are the most common extra-axial tumours of the central nervous system. They are a non-glial neoplasm that originates from the arachnoid cap cells of the meninges, so they are located anywhere that meninges are found.

Many small meningiomas are found incidentally and are entirely asymptomatic. Often they cause concern as they are mistakenly deemed to be the cause of vague symptoms, most frequently headaches. Larger tumours, or those with adjacent edema or abutting particularly sensitive structures can present with a variety of symptoms.

Meningiomas usually are slightly hyperdense to normal brain. Fig. 4 on page 12, have some calcification and present brightly and homogenously contrast enhance. Fig. 5 on page 13. We can also find hiperostosis in meningiomas that abut the base of skull but it is important to distinguish reactive hyperostosis from skull vault invasion (eventually involves the outer table too).

Signal characteristics on MRI include:

T1WI: isointense or minimally hyperintense to gray matter. Fig. 6 on page 14 When tumor has calcifications or is highly fibrous, hypointense areas are visible.

T2WI: wide range of possible signals. Focal or diffuse parenchymal low signal is seen if calcified or highly fibrous are present. Fig. 7 on page 16

T1 C+ (Gd) : usually intense and homogenous enhancement. Fig. 8 on page 17

3. Epidermoid cyst

Intracerebral epidermoid cysts are rare tumours thought to arise from ectodermal inclusions during neural tube closure in the third to fifth weeks of embryogenesis. At this time of embryogenesis the optic and otic vesicles are being formed, and this could perhaps explain the frequent occurrence of epidermoid cysts in the cerebellopontine angle cistern and the parasellar region.

Typical imaging findings on CT include a round/lobulated mass with a density resembling cerebrospinal fluid. Calcification may be present in approximately 10% of all intracranial epidermoids.

On MR imaging epidermoid cysts appear hypointense on T1 Fig. 9 on page 19, and hyperintense on T2 weighted images Fig. 10 on page 19 with typical restricted
diffusion. There is usually some internal heterogeneities, which is best seen in the proton-density and FLAIR images Fig. 11 on page 20, and this could help distinguish these cysts from arachnoid cysts, which they closely mimic.

Lesions typically do not enhance.

4. Chordoma of the clivus.

Chordomas are relatively rare malignant tumors that arise from embryonic remnants of the primitive notochord, a primitive cell line around which the skull base and the vertebral column develop. They usually occur in the vicinity of the clivus.

Although intracranial chordomas are generally slow growing, their intimate relation to critical structures and extremely high local recurrence rate have often resulted in high mortality rates.

The classic appearance of intracranial chordoma at high-resolution CT is that of a centrally located, well-circumscribed, expansile soft-tissue mass that arises from the clivus with associated extensive lytic bone destruction. The bulk of the tumor is usually hyperattenuating relative to the adjacent neural axis and intratumoral calcifications may be seen Fig. 12 on page 21. There is moderate to marked enhancement following administration of iodinated contrast material.

On conventional spin-echo T1-weighted MR images, intracranial chordoma has intermediate to low signal intensity Fig. 13 on page 23. Classic intracranial chordoma has high signal intensity on T2-weighted images and intratumoral areas of calcification or hemorrhage, usually demonstrate heterogeneous hypointensity at T2-weighted imaging Fig. 14 on page 25.

The enhancement pattern of the tumor sometimes has a "honeycomb" appearance created by intratumoral areas of low signal intensity Fig. 15 on page 27.

5. Brainstem glioma.

In children, brainstem gliomas constitute ~10% of brain tumours and are usually classified in three main groups; the largest one is diffuse intrinsic pontine glioma (DPG). These tumours carry the worst prognosis of any brain tumour in childhood. The other subgroups comprise slow-growing low-grade gliomas with longer survival rates.

In contrast, brainstem gliomas in adults are poorly understood because they are quite unusual. Some data suggest that survival is much longer in adults than in children.
The classic DPG at T1-weighted MR images has low signal intensity and high signal on T2 and FLAIR, appearing infiltrative without circumscribed borders, expanding the pons Fig. 16 on page 29. Enhancement is uncommon but heterogeneous. If increased enhancement/necrosis appears over time suggests increasing grade.

6. Teratoma

Intracranial teratomas are uncommon intracranial germ cell tumour, comprised of cells originating from at least two and usually all three embryonic layers: ectoderm, mesoderm and endoderm.

They are often seen as large lesions at presentation. Given their extremely variable histological components, imaging also tends to be heterogenous, with tumours typically demonstrating a mixture of tissue densities and signal intensity. Most mature teratomas are predominantly cystic, lined by epithelium resembling epidermis. In addition, they can contain sebaceous fat. Toothlike calcifications are often seen within the tumor, and skull erosions may be seen in huge tumours Fig. 17 on page 29.

At MR imaging, sebaceous fat within the tumor produces characteristically high signal intensity on T1-weighted images Fig. 18 on page 31. Solid parts show enhancement after Gadolinium administration Fig. 19 on page 33. On T2 weighted images, soft tissue components are iso to hyperintense Fig. 20 on page 35.

7. Ecchordosis Physaliphora

Ecchordosis physaliphora (EP) is a rare congenital, benign, hamartomatous, retroclival mass derived from notochordal tissue that is typically located intradurally in the prepontine cistern.

EP is usually asymptomatic and only a few studies have reported associated symptoms due to tumor expansion and compression of the surrounding structures and extratumoral hemorrhage.

CT is limited in the detection of EP due to the lesion's small size and beam-hardening artifacts in the posterior fossa. However, the osseous stalk at the dorsal wall of the clivus on thin-section CT images is defined as a morphologic hallmark of EP and does not occur in other retroclival lesions.

The typical site and its characteristic appearance on MR is that of a well circumscribed, round, extra-axial mass in the prepontine cistern with high signal intensity on T2-weighted images Fig. 21 on page 37 and low signal intensity on T1-weighted images Fig. 22
on page 38. Chordoma and EP have similar signal intensity on MR images but unlike intracranial extradural chordomas, the majority of EPs show no contrast enhancement or extensive bone destruction and are usually asymptomatic Fig. 23 on page 40.

8. Juvenile xanthogranuloma.

Juvenile xanthogranuloma (JXG) is an uncommon proliferative disorder of histiocytes which is typically a benign dermatosis that occurs predominantly in children.

Cutaneous JXG lesions are usually believed to be benign and will regress spontaneously leaving a flat, atrophic scar or an area of altered pigmentation.

Rarely, patients present with systemic disease, with or without cutaneous lesions. The organs most commonly involved include the liver, lungs, spleen and brain (occasional JXGs have been reported involving all levels of the neuroaxis, including the central and peripheral nervous system and their enveloping meninges).

While MRI is the best method for localizing the tumors, the imaging characteristics are nonspecific and variable Fig. 24 on page 42, Fig. 25 on page 44. Most cases show homogenous enhancement following administration of Gadolinium Fig. 26 on page 46. The intracranial lesions have a tendency to grow slowly and must be followed up.

Similarly, the intraoperative findings are nonspecific. Thus, histopathologic examination remains the gold standard for the diagnosis of JXG.


Glomus tumors, also termed paragangliomas, are typically benign, nonsecreting and highly vascular tumors that originate from paraganglionic tissue located at the carotid bifurcation, along the nodose ganglia of the vagus nerve, and in the jugular fossa and the tympanic cavity.

Although generally considered histologically benign, glomus jugulare tumors (GJTs) may present late with aggressive infiltrative disease resulting in considerable morbidity. Imaging hallmarks of paragangliomas of the head and neck include an enhancing soft-tissue mass in the carotid space, jugular foramen, or tympanic cavity, with "permeative-destructive" change of adjacent bone at CT Fig. 27 on page 47. The characteristic appearance on MR T1 weighted images are lesions > 2 cm demonstrate "salt and pepper" appearance ("salt" refers to hyperintense foci within tumor related to hemorrhage or slow flow, and "pepper" refers to numerous hypointense foci within tumor representing high-velocity arterial flow voids) Fig. 28 on page 47. On T2 weighted images it appears like
a mixed hyperintense mass with hypointense foci ("pepper") Fig. 29 on page 48, and it shows intense enhancement after Gadolinium administration, which better delineates tumor extent in skull base and middle ear Fig. 30 on page 49. The angiographic findings are hypervascular mass with enlarged feeding arteries, rapid, intense tumor blush and early draining veins.

Images for this section:
**Fig. 1:** Axial CT scan of the posterior fossa and base of the brain showing a fusiform and partly calcified aneurysmal dilatation of the basilar artery.

**Fig. 2:** Strong enhancement is seen on the axial post-contrast images in the same patient.
Fig. 3: A large fusiform aneurysm of the basilar artery was confirmed by CTA.
Fig. 4: Axial NECT (nonenhanced CT) scan shows a hyperdense mass occupying almost all the basal cisterns with potential compressive effect on the brainstem. Note presence of focal calcifications.
Fig. 5: Post-contrast scan shows the mass enhances strongly and uniformly.
Fig. 6: Sagittal T1WI shows a well-delineated, hypointense, broad-based mass that abuts the clivus.
**Fig. 7:** The mass is hyperintense on axial T2WI. Focal parenchymal low signal is seen due to calcifications.
**Fig. 8:** The mass shows marked enhancement on postcontrast T1WI.

**Fig. 9:** Sagittal T1WI MR demonstrates a CSF isointense multilobulated epidermoid within the right cerebellopontine angle and the prepontine cistern, with extensive mass effect upon the pons.
**Fig. 10:** Axial T2WI shows a very hyperintense, lobulated mass centered in the right cerebellopontine angle which extends into the prepontine cistern.
Fig. 11: Lesion heterogeneity is seen in fluidattenuated inversion-recovery (FLAIR) sequences.
**Fig. 12:** Axial NECT demonstrates a typical midline, hyperdense, clival chordoma with irregular intratumoral calcifications. These may represent associated matrix calcifications or bone fragments. This tumor compresses the pons posteriorly.
Fig. 13: Sagittal T1 MR image shows near complete involvement of the clivus with expansile low signal tumor and the classic “thumb” of chordoma focally compressing the pons.
**Fig. 14:** Axial T2WI demonstrates a hyperintense expansile mass arising from the clivus. Focal low signal within the mass represents osseous matrix or fragmented clival bone.
**Fig. 15:** Axial T1WI C+ MR reveals heterogeneously enhancing with the "honeycomb" pattern secondary to intratumoral areas of low signal intensity.

**Fig. 16:** This case has fairly typical imaging characteristics of pontine glioma. FLAIR image shows a hyperintense mass in an enlarged pons.
**Fig. 17:** Axial NECT shows dense structures in the upper portion of the prepontine cistern, which are confirmed to be toothlike calcifications on the bone CT.
**Fig. 18:** Sagital T1WI shows a well defined, predominantly cystic and hypointense mass, with hyperintense areas on the top, due to sebaceus fat within the tumour.
Fig. 19: The mass is lined by epithelium which moderately enhances after Gd.
Fig. 20: The cystic portion of the mass has high signal intensity on T2WI.
Fig. 21: Sagital T2 MR image demonstrates a hyperintense lesion within the clivus and with slight extension into the prepontine cistern adjacent to basilar artery
**Fig. 22:** Notice the typical low T1 signal.
Fig. 23: Lack of any enhancement supports the diagnosis of Ecchordosis Physaliphora.
**Fig. 24:** Sagittal T1WI image shows an expansile, destructive mass in the skull base, originating from the clivus and sella. The mass erode both petrous apex, occipital condyles and the anterior part of C1 vertebral body. It extends anteriorly into the nasopharyngeal space and posteriorly into the prepontine cistern. Note the characteristic hypointensity signal.
**Fig. 25:** Axial T2WI image demonstrates the mass focally compressing the pons. It is slightly hyperintense but heterogeneous.
Fig. 26: Sagittal T1WI C+ shows prominent enhancement. This mass was initially diagnosed as a chordoma/chondrosarcoma and only after the pathology analysis it was correctly diagnosed as Juvenile Xanthogranuloma.

Fig. 27: Axial bone NECT demonstrates a large mass centered on the left cerebellopontine angle. It invades the jugular foramen and there are permeative destructive changes of the adjacent temporal bone, typical of glomus jugulare paraganglioma.
**Fig. 28:** Axial T1WI MR demonstrates a jugular foramen mass with multiple high-velocity flow voids characteristic of glomus jugulare paraganglioma.
Fig. 29: T2WI shows mixed hyperintense mass with hypointense foci ("pepper").
**Fig. 30:** Coronal T1WI C+ MR shows the classic intense enhancement of this large vascular tumor. There is intracranial extension in this patient with mass effect upon the adjacent pons.
Conclusion

Is essential for the radiologist to know in detail the prepontine cistern and its anatomical relations in order to analyse and identify the most frequent lesions in this area and provide an accurate differential diagnosis.

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