Review of intracranial non-neoplastic cystic lesions

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Learning objectives

The purpose of this review is to present main characteristics of various non-neoplastic intracranial cysts and their differential diagnoses. Firstly, imaging findings of different lesions will be discussed and the major differential diagnoses for each cyst will be presented. At the end, a diagnostic algorithm based on the location will be offered.
Background

Cysts and cystic-appearing lesions are common findings on magnetic resonance (MR) and computed tomography (CT) brain imaging. Etiologies of these lesions vary from congenital, infectious or associated with primary brain tumors. This review emphasizes the characteristics of non-neoplastic, non-infectious intracranial cysts which can be normal or anatomic variant, arise from inclusions of embryonic endodermal or ectodermal elements, or can be acquired insults to the central nervous system.

1. Normal or anatomic variant: choroid plexus cyst (xanthogranuloma), enlarged perivascular spaces (PVS), ependymal, neuroglial, pineal cyst.
3. Traumatic or vascular: porencephalic cyst.
Findings and procedure details

ARACHNOID CYST

Arachnoid cysts are sharply marginated, round or ovoid, extra-axial collections of cerebrospinal fluid (CSF) located within the subarachnoid space that doesn't communicate with the ventricular system. The size varies from few millimeters to enormous. They can occur in all age groups, mostly in children. 50-60% of arachnoid cysts are located in the middle intracranial fossa, typically along the temporal lobe. The most common infratentorial location is the cerebellopontine angle (CPA). 10% occur in the suprasellar cisterns, while other locations such as the ventricles or cisterna magna are rare.

On CT scans, arachnoid cysts are CSF density. When bigger, they can have expansile effect and cause bone remodeling. On all MR sequences follow intensity of CSF and don't show restricted diffusion on DWI. There is no postcontrast enhancement on CT or MR images. (Fig. 1, Fig. 2).

Main differential diagnoses are epidermoid cyst, chronic subdural hematoma and porencephalic cyst. Epidermoid cyst doesn't completely suppress on FLAIR and shows restricted diffusion. Chronic subdural hematoma has a lentiform shape, does not typically have signal intensity of CSF and often has an enhancing membrane. Porencephalic cyst communicates with the ventricular system.

COLLOID CYST

A colloid cyst is a unilocular mucin-containing third ventricle cyst. More than 99% of colloid cysts are located within the third ventricle, wedged into the foramen of Monro. Other sites are the fourth or lateral ventricles, cerebellar parenchyma and prepontine cistern. The size is from few millimeters to 3 cm, average 15 mm.

On CT most of them are hyperdense, but they can also have isodense and hypodense appearance. Usually they don't enhance, although rarely can have rim enhancement. If a high cholesterol content is present, T1WI will show high intensity; and a low content will cause hypointensity. T2WI is variable and mostly will be isointense to the brain. On FLAIR they do not suppress and on DWI don't show restriction. (Fig. 3).
Differentiation because of the typical location is quite easy. Sometimes neurocystercerosis can be present in the third ventricle. Neoplasms like subependymoma and choroid plexus papilloma are differentiated because they normally enhance.

DERMOID CYST

Dermoid cysts are congenital ectodermal inclusion cysts. They are well circumscribed, lobular, lipid containing masses. Normally located in the midline, in the sellar, parasellar or frontonasal region; and if infratentorial, in the midline vermis or fourth ventricle. The size is variable.

On CT they show fat density and 20% present with capsular calcification. On T1WI are high intensity and do not enhance. When ruptured, droplets of fat are visible in the subarachnoid space, which can cause chemical meningitis that shows intense enhancement. On T2WI appearance varies from hypointense to hyperintense. (Fig. 4, Fig. 5).

The main differential diagnoses are epidermoid, craniopharyngioma, teratoma or lipoma. Epidermoid is normally CSF intensity and it's not located in the midline. Craniopharyngioma is especially hyperintense on T2WI and avidly enhances. Teratoma may have similar location, but usually occurs in the pineal region. Lipoma demonstrates fat intensity on all sequences and shows chemical shift imaging artifact.

EPIDERMOID CYST

Epidermoid cysts are lobulated, irregular congenital ectodermal inclusion cysts. Most of them, 90% are intradural and the most common location is the basal cisterns. 40-50 % of them occur in the CPA, 17% in the fourth ventricle and 10-15% in the parasellar region of the middle fossa. Extradural locations, like skull and spine, are rare. The size is variable.

On CT scanning, 95% of epidermoids are CSF like, 10-25% can have calcification. If hemorrhage is present, they can be hyperdense. On postcontrast scans, they don't normally enhance, but rarely, show some rim enhancement. On T1WI mostly, they are slightly hypertense to CSF, on T2WI are often isointense (65%) to CSF or slightly hypertense (35%) to CSF. On FLAIR imaging, the signal doesn't suppress completely.
One of the most characteristic imaging findings is diffusion restriction on DWI. (Fig. 6, Fig. 7).

The major differential diagnosis is arachnoid cyst which follows intensity of CSF on all sequences and has no diffusion restriction on DWI. Other diagnostic considerations are: dermoid and inflammatory cyst, like neurocysticercosis cyst. Dermoid is normally located in the midline and doesn't restrict, and inflammatory cyst shows enhancement and edema.

NEUROGLIAL CYST

Neuroglial cysts are smooth, rounded, unilocular benign epithelial-lined CNS cysts located anywhere throughout the neuroaxis. The most common location is the frontal lobe. The size ranges from few millimeters to few centimeters.

On CT they are low density, well circumscribed lesions without enhancement. On T1WI resemble to CSF, and on T2WI usually are hyperintense. On FLAIR are normally suppressed and on DWI there is no restriction. (Fig. 8).

The diagnostic considerations are: enlarged PVS, infectious cyst, porencephalic cyst and arachnoid cyst. Enlarged PVS normally presents as a cluster of cystic appearing lesions in the basal ganglia. Infectious cysts are smaller and show enhancement. Porencephalic cyst is connected to the ventricle and has surrounding gliosis. Arachnoid cysts are typically extra-axial.

ENLARGED PVS

Enlarged PVSs or Robin-Virchow spaces are pial-lined interstitial fluid structures that accompany the penetrating arteries. The usual size is 5 mm or less, but sometimes can be huge and show expansile effect. The most common location is the basal ganglia. Others are: the midbrain, deep white matter, subinsular cortex, extreme capsule. The giant PVSs occur most often in the midbrain.

On CT they are presented like clusters of round, ovoid, linear or puctate cyst-like lesions, density of CSF, with no enhancement. On T1WI and T2WI intensity is equal to CSF. On FLAIR are suppressed and in up to 25% gliosis of surrounding parenchyma is present.
Occasionally, on T1WI postcontrast sequence, a penetrating vessel can opacify. (Fig. 9, Fig. 10).

The major differential is lacunar infarct, infectious cyst and cystic neoplasm. Lacunar infarct has surrounding gliosis and occurs in the upper two thirds of the basal ganglia, while PVS occurs in the lower third. Infectious cyst and cystic neoplasm would have some enhancement and perifocal edema.

**PINEAL CYST**

Pineal cysts are non-neoplastic intrapineal glial-lined lesions. They are located above the tectum, below the internal cerebral veins and present as homogeneous, fluid-filled mass clearly distinct from the tectum. The size is normally less than 1 cm, but it can be up to 2 cm or more that can cause flattening of the tectum or compression of the aqueduct.

On CT pineal cyst presents as a sharply-demarcated, smooth cyst behind the third ventricle, isodense to slightly hyperdense to CSF. 25% show calcifications in the cyst wall. If hemorrhage is present, appearance will be hyperdense. Sometimes rim or nodular postcontrast enhancement is present. On T1WI 55-60% are slightly hyperintense to CSF, 40% are isointense, and on T2WI are isointense or hyperintense to CSF. On FLAIR sequence, most of them don't suppress. (Fig. 11, Fig. 12).

The main diagnostic consideration is pineocytoma, which is a benign neoplasm and grows equally as a pineal cyst extremely slowly, and sometimes they can't be distinguished. Other potential mimics are arachnoid cyst, which follows intensity of CSF and doesn't contain calcification, and epidermoid cyst that shows diffusion restriction.

**CHOROID PLEXUS CYST**

Choroid plexus cysts or choroid plexus xanthogranulomas are non-neoplastic, non-inflammatory cysts of the choroid plexus lined by compressed connective tissue. Normally they are bilateral, located in the lateral ventricles, and occasionally in the third ventricle. The size is usually variable and ranges from 2 to 8 mm, rarely is larger than 2 cm.

On CT choroid plexus cyst is isodense to slightly hyperdense to CSF with irregular, peripheral calcification. On postcontrast scans, enhancement varies from none to rim
or even solid. On T1WI is isointense to slightly hyperintense to CSF, and on T2WI hyperintense to CSF. On FLAIR only a third of them is suppressed. 65% of choroid plexus xanthogranulomas show diffusion restriction on DWI. (Fig. 13, Fig. 14, Fig. 15).

The major differential diagnosis is ependymal cyst that doesn't enhance. Another consideration is villous hyperplasia of the choroid plexus that enhances avidly and uniformly.

EPENDYMAL CYST

Ependymal cysts are congenital, benign, smooth, thin-walled neuroepithelial cysts that can be located in the ventricle, supratentorial parenchyma or subarachnoid space. Typical localization is the lateral ventricle. The size varies from 2 to 3 mm up to 8-9 cm.

On CT they are isodense to CSF and don't show any enhancement. On T1WI are isointense to CSF with a possibly visible cyst wall. On T2WI they are isointense to CSF or due to a protein content hyperintense. Suppression is present on FLAIR and there is no diffusion restriction. (Fig. 16, Fig 17).

The differential diagnosis is: choroid plexus cyst, arachnoid cyst, neurocysticercosis cyst and asymmetric ventricles. Chorid plexus cyst normally enhances and doesn't follow CSF intensity on all sequences and is bilateral. Arachnoid cysts are normally located in the subarachnoid space, sometimes are indistinguishable. Neurocysticercosis typically has a visible scolex on FLAIR and shows enhancement. Asymmetrical ventricles are normal anatomic variant, but sometimes can be caused by neoplasm or infection.

PORENCEPHALIC CYST

Porencephalic cysts are unilateral or bilateral cavities, frequently communicating with the subarachnoid space or lateral ventricles, caused by brain destruction during the end of fetal or beginning of newborn period. They usually correspond to territories supplied by the cerebral arteries. The size is variable.

On CT they present as an intraparenchymal smooth-walled cavity, isodense to CSF and show no enhancement. On all MR sequences, they follow CSF intensity. On T2WI and FLAIR perifocal gliosis and brain atrophy is visible. (Fig. 18, Fig. 19).
The differential considerations are: arachnoid cyst, schizencephaly and ependymal cyst. Arachnoid cysts normally is extra-axial lesion that displaces the brain cortex. Schizencephaly is lined by heterotopic gray matter and not gliosis. Ependymal cysts are typically located intraventricularly with normal surrounding brain tissue.

NEUROENTERIC CYST

Neurenteric cysts are benign, round or oval, lobulated endodermal CNS cysts. More often they are found in the spinal region, and when they occur intracranially are normally situated in the midline in front of the brainstem. Other locations are the CPA, clivus, and rarely the suprasellar or quadrigeminal cisterns. The size is variable, normally less than 2 cm.

On CT are hypodense or isodense to the brain and show no enhancement. On T1WI are isointense or slightly hyperintense to CSF. On T2WI and FLAIR are hyperintense to CSF. DWI shows no diffusion restriction. (Fig. 20, Fig 21).

The major differential diagnosis is epidermoid and arachnoid cyst. Sometimes epidermoid that is hyperintense on T1WI is hard to distinguish from neurenteric cyst, however, epidermoid normally shows diffusion restriction. Arachnoid cyst follows CSF intensity on all sequences.

RATHKE CLEFT CYST

Rathke cleft cysts are non-neoplastic cysts arising from remnants of embryonic Rathke cleft. 40% are completely intrasellar, and 60% have suprasellar extension. The size is 5-15 mm.

On CT they present as well-delineated round, lobulated intra or suprasellar masses. 75% are hypodense and 25% have mixed (isodense to hypodense) density. Rarely, 10 to 15%, contain calcification within the cyst wall. On T1WI appearance varies from hypointense to hyperintense depending on the cyst content. 75% have a hyperintense intracystic nodule. On T2WI 70% are hyperintense and the rest hypointense. There is no internal enhancement on both CT and MR images. (Fig. 22).
The differential diagnoses include craniopharyngioma, cystic adenoma or other non-neoplastic cysts. Craniopharyngioma usually contains calcification and shows some enhancement.
Images for this section:

Fig. 1: Arachnoid cyst, T2W1

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Fig. 2: Arachnoid cyst, FLAIR

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Fig. 3: Colloid cyst, T2WI

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**Fig. 4:** Dermoid cyst, CT

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**Fig. 5:** Dermoid cyst, T2WI

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**Fig. 6:** Epidermoid cyst, T2WI

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Fig. 7: Epidermoid cyst, DWI

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Fig. 8: Neuroglial cyst, T1WI

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Fig. 9: Enlarged PVS, T1WI

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Fig. 10: Enlarged PVS, T2WI

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**Fig. 11:** Pineal cyst, T1WI

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Fig. 12: Pineal cyst, T2WI

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Fig. 13: Choroid plexus cyst, CT

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**Fig. 14:** Choroid plexus cyst, T2WI

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**Fig. 15:** Choroid plexus cyst, DWI

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Fig. 16: Ependymal cyst, T1WI

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Fig. 17: Ependymal cyst, T2WI

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**Fig. 18:** Porencephalic cyst, T1WI

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Fig. 19: Porencephalic cyst, T2WI

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**Fig. 20:** Neurenteric cyst, T1WI

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Fig. 21: Neurenteric cyst, T2WI

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Fig. 22: Rathke remnant cyst, T1WI

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Conclusion

Benign cystic lesions are common findings in every-day brain imaging and they have broad imaging appearance, therefore, knowledge of the main characteristics and location enables the narrowed differential diagnosis.

<table>
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<th>Most common locations of intracranial non-neoplastic lesions.</th>
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### Non-neoplastic intracranial cystic lesions

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References