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PICTORIAL ESSAY

Evaluation of Intraventricular Lesions of the Central Nervous System by Magnetic Resonance Imaging: A Pictorial Review

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Abstract

While magnetic resonance imaging (MRI) findings on T1 weighted (T1W), T2 weighted (T2W), T2 fluid attenuated inversion recovery (FLAIR), diffusion-weighted imaging (DWI), gradient echo (GRE), and contrast enhancement play an important role in the diagnosis and characterization of intraventricular lesions, conventional MRI imaging still plays an important role in diagnosis with the advantage of reduced scan times and scope for increased daily cases. Advanced techniques, such as perfusion imaging, magnetic resonance spectroscopy (MRS), diffusion tensor imaging (DTI), and functional MRI (fMRI) have been added for further characterization on a routine basis in some centers. The objective of our pictorial review is to present typical conventional MRI findings for diagnosis and characterization of intraventricular lesions.

Introduction

Intraventricular lesions can be well-characterized on magnetic resonance imaging (MRI) due to their typical imaging findings. Advanced imaging techniques such as diffusion weighted imaging (DWI) and magnetic resonance spectroscopy (MRS) may be necessary for the specific diagnosis of a brain tumor (1), but some of the unique conventional MRI features can help to diagnose intraventricular lesions (2). DWI and T2*-WI, such as susceptibility-weighted imaging (SWI), are usually added routinely to conventional MRI brain imaging (3). While advanced MRI techniques such as perfusion weighted imaging (PWI), MRS, diffusion tensor imaging (DTI), and functional MRI (fMRI) are used to guide tissue sampling or resection for achieving best post-surgical results (3), the unique advantage of conventional over advanced MRI techniques is the reduced scan time. Also, advanced MRI technical experts and imaging software may not be available, particularly in remote locations. We present here a pictorial essay of conventional MRI imaging of intraventricular lesions.

Intraventricular lesion is defined as a lesion whose epicenter is inside the ventricular system with or without extraventricular extension. A 1.5 Tesla MR Scanner (Avanto, Siemens AG, Germany) was used. The exams were analyzed according to the location,

signal intensity for solid (hypo/iso/hyperintense relative to normal cortex) or cystic components (relative to CSF signal), diffusion restriction, T1 weighted imaging (T1WI), T2 weighted imaging (T2WI), fluid attenuated inversion recovery (FLAIR), DWI, apparent diffusion coefficient (ADC), gradient echo (GRE), and post-contrast study.

Intraventricular lesions can originate from any of the ventricular components: for example, ependymoma from ependymal origin, subependymoma from subependymal layer, choroid plexus neoplasms from choroid plexus, neurocytoma from neuronal origin, and meningioma from arachnoid cap cells trapped in the choroid plexus (4). In terms of location, neurocytomas are classically described related to the septum pellucidum. Subependymal giant cell astrocytomas are commonly seen near the foramen of Monro, and intraventricular meningiomas are most commonly seen in the atrium of the lateral ventricular and infratentorial ependymomas in the fourth ventricle.

Ependymoma

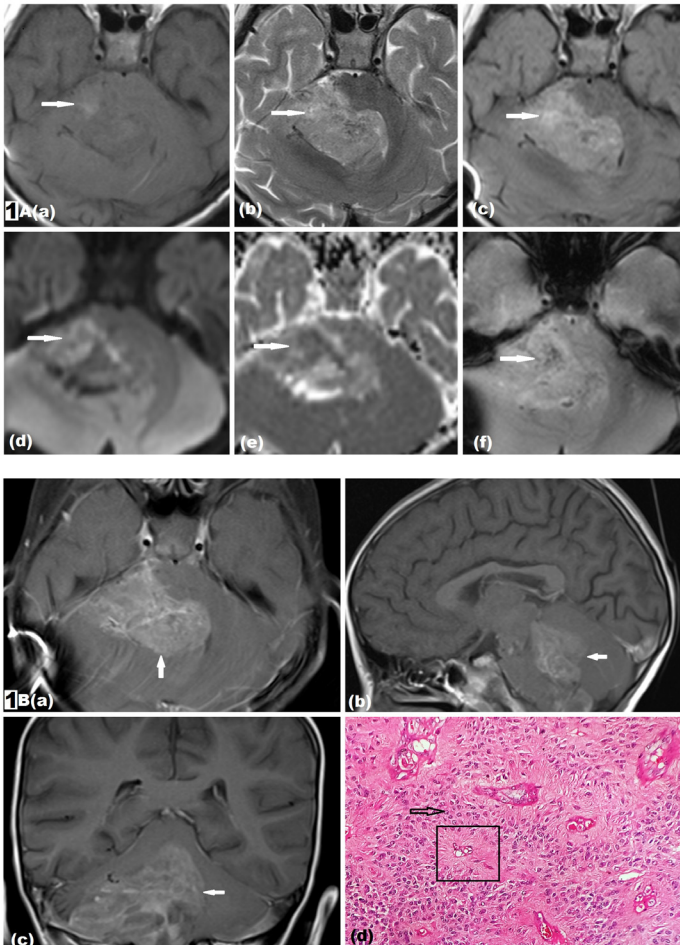
Ependymomas are the most common intraventricular lesions, accounting for 3-5% of all brain tumors. They are most commonly infratentorial in younger age groups (5). Approximately 60% of ependymomas are located in the posterior fossa (6), most commonly in the fourth ventricle. They are also seen in off-midline locations, especially in the lateral recesses of the fourth ventricle, the foramina of Luschka, and the cerebellopontine angle cisterns. The off-midline ependymoma has a worse prognosis because of surgical difficulty for total resection of the tumor (7). Therefore, the appropriate location and extension of the lesion is the single most important factor in prognostication. Restricted diffusion may be seen in these lesions and reflect high cellularity in some neoplasms (8).

On MRI, ependymomas are iso/hypointense on T1WI and iso/hyperintense on T2WI (4). The infratentorial ependymomas occur mainly located in the fourth ventricle and extending through the foramen of Luschka, foramen of Magendie, or foramen magnum (Figure 1).

On histology grossly, ependymomas are soft plastic neoplasm (4) which explains the high possibility of these lesions to extend throughout the foramina of Luschka and Magendie. Ependymomas classified as CNS WHO grade 2 have perivascular pseudo-rosettes and true ependymal rosettes with moderate cellularity and occasional mitotic figures (4).

Intraventricular meningioma (transitional type)

Intraventricular meningiomas are thought to arise from the trapped arachnoid cap cells in the choroid plexuses. On MRI intraventricular meningiomas are iso/hypointense on T1WI and iso- to hyperintense on T2WI and show avid post-contrast enhancement (4) (Figure 2). The most common location for intraventricular meningiomas is in the atrium of the lateral ventricles (5). Histologically, they resemble their counterpart of dural origin (Figure 2d).



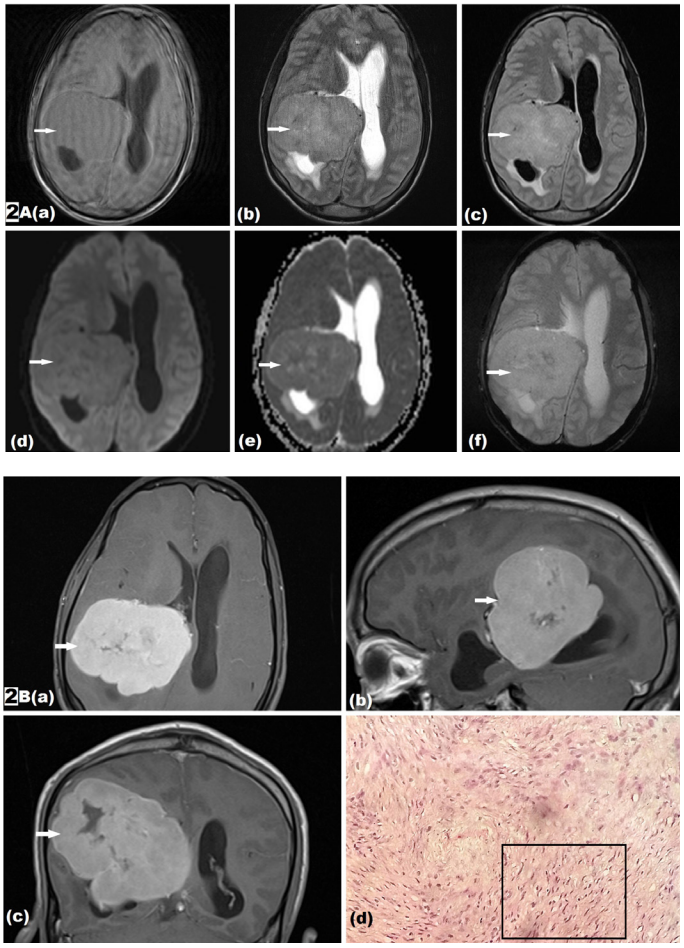
Figures 1A-B. Five-year-old female with intraventricular ependymoma (arrow) in the fourth ventricle.

1A. MRI without contrast. ***(a)*** T1WI the lesion is isointense. ***(b)*** T2WI showing the lesion is mildly hyperintense. ***(c)*** FLAIR image showing hyperintense signal. ***(d-e)*** Diffusion and ADC image showing foci of internal restriction. ***(f)*** Gradient echo image showing patchy areas of blooming.

1B. MRI after contrast study and histology. ***(a-c)*** T1W post contrast axial, sagittal and coronal showing heterogenous enhancement. ***(d)*** H&E 40X: Photomicrograph of ependymoma with good cellular areas, comprised of monomorphic cells with round nuclei with salt-and-pepper chromatin (black open arrow). Perivascular pseudorosettes and ependymal rosettes are also noted (black square box).

Subependymal giant cell astrocytoma

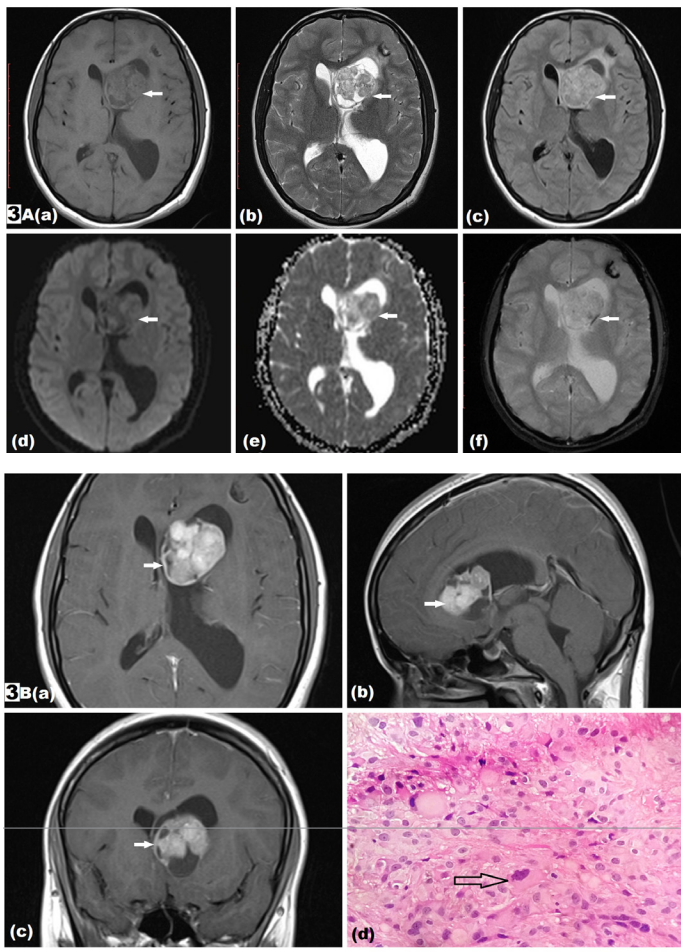
Subependymal giant cell astrocytoma (SEGA), also now called a subependymal giant cell tumor, is the most common cerebral neoplasm in patients with tuberous sclerosis (4). In the right clinical setting, a lesion involving the typical site of the foramina Monro is SEGA (Figure 3). SEGA is a CNS WHO grade 1 lesion whose large cells appear more or



Figures 2A-B. 25-year-old male with intraventricular meningioma (arrow) in the right lateral ventricle.

2A. MRI without contrast. ***(a)*** T1WI showing isointensity in the lesion. ***(b)***. T2WI showing mild hyperintensity. ***(c)*** FLAIR image showing mild hyperintensity. ***(d-e)*** Diffusion and ADC image showing patchy restriction. ***(f)*** Gradient echo image showing small foci of blooming.

2B. MRI after contrast study and histology. ***(a-c)*** T1W post contrast axial, sagittal and coronal MRI showing intense homogenous enhancement. ***(d)*** H&E 40X- Photomicrograph of transitional meningioma showing meningothelial and fibrous patterns (black square box).



Figures 3A-B. 19-year-old female with subependymal giant cell astrocytoma (SEGA) (arrow) in the left foramen of Monro.

3A. MRI without contrast. ***(a)*** T1WI showing the lesion to be heterogenously hypointense. ***(b)*** T2WI showing heterogenous hyperintensity. ***(c)*** FLAIR image showing heterogenous hyperintensity. ***(d-e)*** Diffusion image and ADC map showing patchy areas of restriction. ***(f)*** Gradient echo image showing small foci of blooming.

3B. MRI after contrast study and histology. ***(a-c)*** T1W post-contrast axial, sagittal and coronal MRI showing heterogenous contrast enhancement. ***(d)*** H&E 40X -Photomicrograph of SEGA showing large cells with abundant eosinophilic cytoplasm and prominent nucleoli (black open arrow).

less like ganglion cells with abundant cytoplasm. Nuclear pleomorphism and increased mitosis may sometimes be noted.

Central neurocytomas

Central neurocytomas are thought to arise from the glial and residual precursor neuronal cells lining the septum pellucidum. On MRI, central neurocytomas are isointense to gray matter on T1WI and hyperintense on T2WI. They are well-circumscribed, lobulated masses that frequently have cyst-like areas (4). They are seen in the lateral ventricle arising from the septum pellucidum or ventricular wall, with or without extension into the third ventricle, with heterogenous post-contrast enhancement (9) (Figure 4). Neurocytomas are CNS WHO grade 2 lesions with solid sheaths of round to oval benign-looking cells, thin vascular network, and fine fibrillary neuropil (4).

Intraventricular cyst

Cystic lesions in the ventricles are common incidental findings. They are seen as well defined, intraventricular cystic lesions with thin walls and internal contents consistent with fluid signal on all sequences (Figure 5). Differential diagnoses for cystic lesions can be wide and can include ependymal

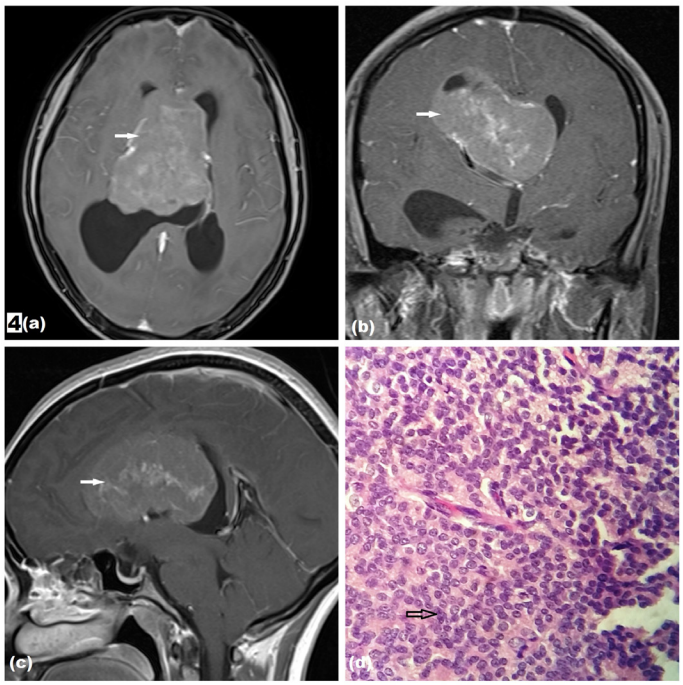


Figure 4. 22-year-old female with central neurocytoma. ***(a-c)*** T1W post contrast axial, sagittal and coronal MRI images showing heterogenous contrast enhancement. ***(d)*** H&E 40X-Photomicrograph of neurocytoma showing monotonous cells with moderate cytoplasm and salt-and-pepper chromatin, in a background of pink fibrillar matrix and Homer Wright rosettes (black open arrow).

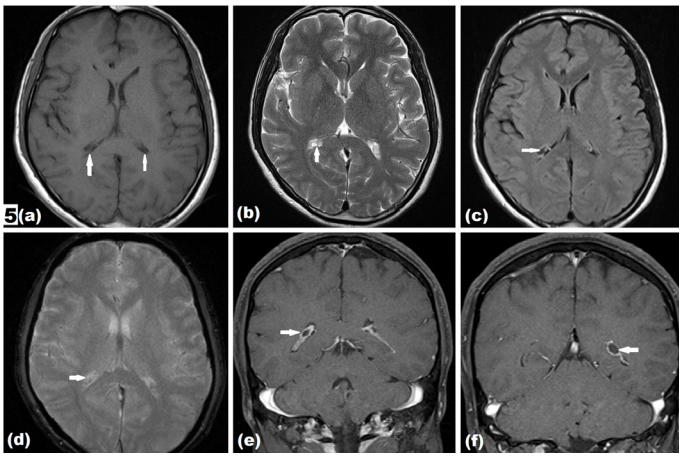


Figure 5. 32-year-old-male with bilateral choroid plexus cysts. ***(a)*** T1WI. ***(b)*** T2WI. ***(c)*** FLAIR images showing fluid signal intensity cyst (arrows). ***(d)*** GRE showing no blooming. ***(e-f)*** Coronal post-contrast showing no enhancement of the cyst.]

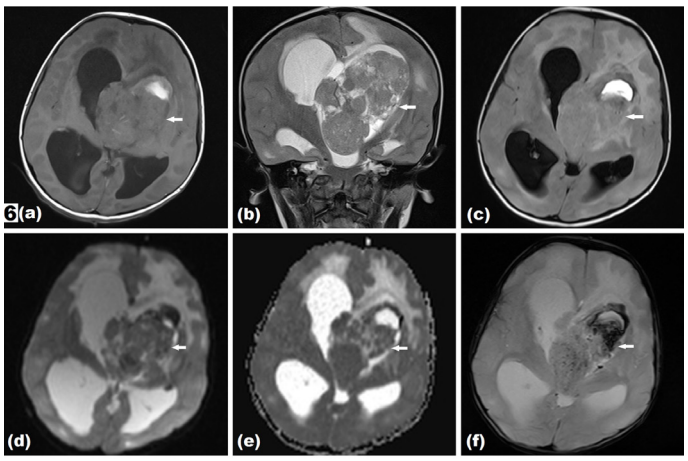


Figure 6. MRI of fatal case of choroid plexus tumor (arrow) in a 4-year-old patient. ***(a)*** axial T1WI showing isointense intraventricular lesion with focal hyperintense foci of bleed. ***(b-c)*** T2WI coronal and axial FLAIR images showing relatively isointense lesion with oedema in the adjacent brain parenchyma. ***(d-e)*** Diffusion and ADC map showing patchy areas of restriction. ***(f)*** GRE image showing blooming of the bleeding foci.

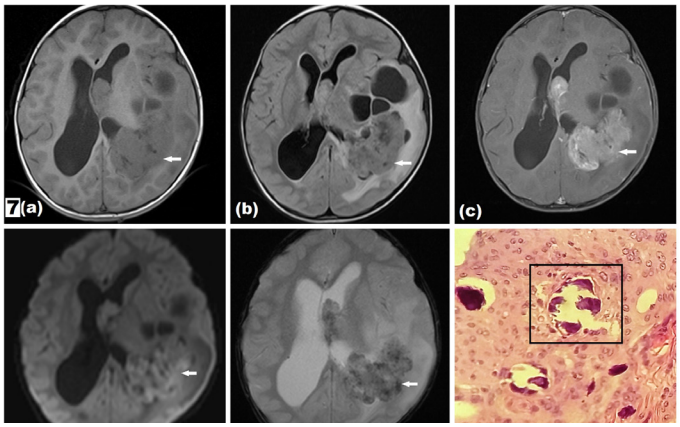


Figure 7. MRI of intraventricular meningioma (arrow) in a 6-year-old patient not differentiable from choroid plexus carcinoma on imaging. ***(a)*** Axial T1WI showing heterogenously isointense lesion in the left lateral ventricle. ***(b)*** T2 FLAIR showing isointense lesion with signal suppression of the cystic components and oedema in adjacent brain parenchyma. ***(c)*** T1 axial post-contrast showing heterogenous non-intense enhancement pattern. ***(d)*** DWI shows patchy areas of diffusion restriction. ***(e)*** GRE images showing areas of blooming inside the lesion. ***(f)*** 40X photomicrograph of meningioma showing meningothelial whorls and sammoma bodies (black open arrow).

cyst, choroid plexus cyst, parasitic and other congenital cysts.

Choroid plexus tumors

Choroid plexus may give origin to primary lesions like choroid plexus papilloma, atypical choroid plexus papilloma or choroid plexus carcinoma (4). Significant correlation between lesion size and perilesional edema is noted with grade of choroid plexus tumors (10). Choroid plexus tumors are more common in children compared to adults and constitute up to 20 % of pediatric neoplasms in the first year of life (4,11,12) (Figure 6). Choroid plexus neoplasm in favor of carcinomas is documented to be found entirely in the

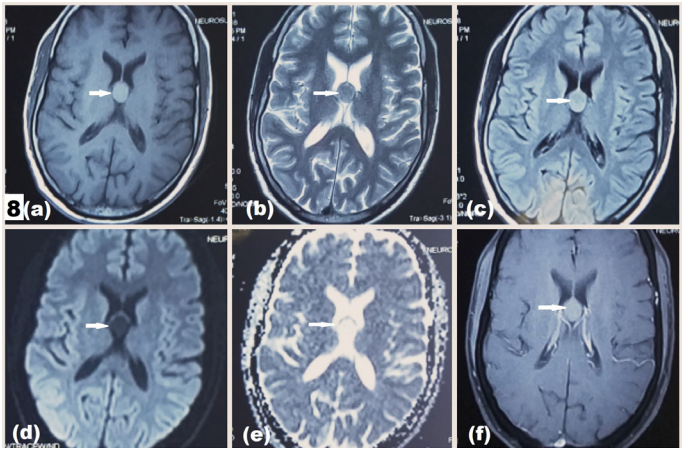


Figure 8. MRI of a 25-year-old male patient with colloid cyst (arrow) in the third ventricle. ***(a)*** T1WI axial shows a high-signal-intensity lesion in the third ventricle. ***(b)*** On T2WI the lesion appears iso- to hypointense. ***(c)*** Flair image of the lesion is isointense to cortex. ***(d-e)*** The lesions show no obvious restriction on diffusion and ADC map. ***(f)*** The lesion shows no enhancement post contrast.

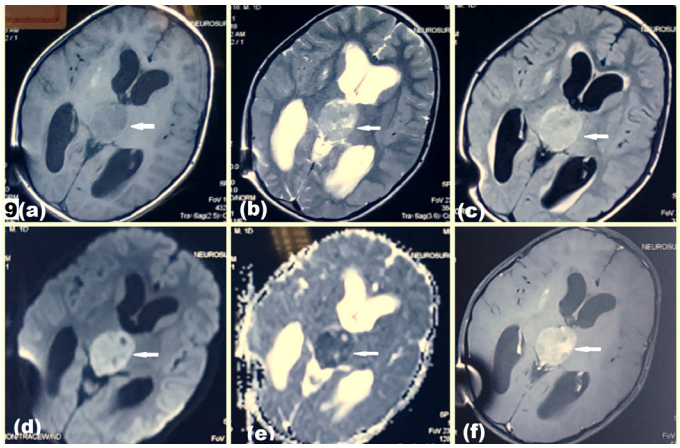


Figure 9. MRI of a 7-year-old boy with intraventricular germinoma (arrow) with evidence of mild hydrocephalus. ***(a)*** T1WI axial images showing a iso- to hypointense lesion in the posterior third ventricle. ***(b)*** On T2WI the lesion is heterogenously hyperintense. ***(c)*** On FLAIR images the lesion is mildly hyperintense. ***(d-e)*** The lesion is showing high signal on diffusion image and low signal on ADC map, suggestive of diffusion restriction. ***(f)*** Post-gadolinium contrast, nearly homogenous enhancement is noted.

pediatric population, with a mean age of 26-32 months (4,12). However, they can also occur in older children (13).

Intraventricular meningothelial meningioma with atypical imaging findings

Intraventricular meningiomas classically appear iso- to hypointense on T1WI and hyperintense on T2WI with avid post-contrast enhancement (4). Yet these lesions may show heterogenous contrast enhancement on imaging, resembling choroid plexus tumors in terms of age, lesion size and extensive nature (Figure 7). Meningothelial meningioma is characterized by neoplastic cells forming whorls or sheaths, whereas transitional meningiomas show both features of whorling and fibroblastic proliferation in the form of spindle cells (14).

Intraventricular colloid cyst

These lesions are located in the third ventricle along the anterior superior aspect, and classically appear hyperintense on T1WI and hypointense on T2WI (15). They may have variable appearance on MRI, usually representing the internal proteinaceous contents (Figure 8). Simple to pseudostratified epithelium with few mucus goblet and ciliated cells are characteristically described on histopathological examination (15).

Third ventricle germinoma

These are the commonest tumors in the posterior third ventricular region in adolescent boys and young men. On imaging they typically have relative homogenous enhancement (16) and may show internal diffusion restriction (Figure 9).

Subependymoma

These are CNS WHO grade 1 neoplasms usually seen as well-circumscribed lesions, typically attached to the ventricle wall by a narrow pedicle (4). On MRI, they are markedly T2 hyperintense with T1 iso/hypointensity and usually do not enhance (15).

Intraventricular metastases

History of other neoplasms should alert us to suspect intraventricular metastases commonly occurring in the lateral ventricles. When solitary, they may not be easily distinguishable from other intraventricular lesions like a meningioma or choroid plexus neoplasm (4).

Conclusions

Knowledge of the location, clinical findings, morphology, and contrast enhancement helped us to narrow the differential diagnoses in intraventricular lesions. Conventional MRI continues to play an important role in diagnoses and characterization of intraventricular lesions.

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Conflicts of interest

The authors report no conflicts of interest.

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