A Meningioma with Hyperintensity on T1-Weighted Images in a Dog

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ABSTRACT. A male six-year-old Pomeranian showed recurrent seizures and progressive left hemiparesis. MRI revealed a mass in the right paramedian frontal-temporal region with hyperintensity on T1-weighted (T1W) and mixed-intensity on T2-weighted (T2W) images. After gadolinium enhancement, the mass was enhanced homogenously and demonstrated the dural tail sign. Surgical resection of mass was performed and its histological diagnosis was meningioma. The meningioma of this case had a high cellular density with some lipid contents and intra- and extra-tumor hemorrhage, however, calcification was not found. These cellular characteristics may contribute to a higher signal intensity on T1W imaging.

KEY WORDS: Meningioma, MRI, T1-weighted hyperintensity.

A male 6-year-old Pomeranian was presented to the Animal Medical Center of Nippon Veterinary and Animal Science University with progressive left hemiparesis and recurrent seizures that lasted for 2 weeks. According to the owner, each seizure began with a systemic tremor as if the animal was scared, and developed to a generalized tonic-clonic seizure. Neurological examination revealed right circling and reduced postural reactions of the left front and hind limbs, which suggested the presence of a right prosencephalic lesion. General physical examinations, as well as blood, urine, and radiographic examinations revealed no remarkable abnormality. Therefore, magnetic resonance (MR) imaging was performed for further scrutiny.

MR imaging revealed an irregular mass in the right paramedian frontal-parietal region with hyperintensity on T1-weighted (T1W) images (Fig. 1A), and hyper- to hypo-intensity (mixed-intensity) on T2 weighted (T2W) images (Fig. 1B) and fluid-attenuated inversion recovery (FLAIR) images. The margin of the mass revealed hypointensity on both T1W and T2W images. The mass was relatively well-delineated, but seemed to infiltrate the sagittal sinus. The adjacent brain tissue was compressed by the mass and a cingulate herniation with a midline shift was observed (ie, mass effect). Brain edema was also observed, predominantly in the white matter around the mass. Contrast enhanced T1W images after an intravenous injection of gadodiamide (Gd-T1W) revealed a near homogeneous contrast enhancement of the mass, accompanied by the dural tail sign along the meninges from the falx cerebri to the frontal-parietal region (Fig. 1C). Computed tomography (CT) was also performed and demonstrated the mass as a slightly high-density region (contrast enhanced CT was not performed).

At the owner’s request, a craniotomy was performed and resection of the mass was carried out. The mass was dark reddish, markedly soft, and fragile with a bleeding tendency. Most of the dura mater was separated easily, but the pia mater and the cortex of the cerebrum were difficult to separate due to a partial infiltration of the mass into the cortex. Because of the infiltration into the sagittal sinus and for conservation of the sinus, resection of the midline area was incomplete. The resected mass was submitted for histological examination.

Histologically, the mass was identified as a meningotheelial meningioma (Fig. 2). Histological specimens revealed a solid growth pattern of round to spindle shaped tumor cells with relatively abundant cytoplasm, heterogeneous nuclei in size, and clear nucleoli. In addition, a number of small vacuoles, possibly lipid droplets, were observed in the cytoplasm of many tumor cells. Furthermore, a large number of thin-wall dilated vessels and severe congestion were observed in the stroma of the tumor. There were multifocal accumulations of hemosiderin-bearing macrophages representing the chronic lesions of hemorrhage, and infiltration of neutrophils with cholesterol crystal deposits in the interstitial area of the tumor.

The dog recovered steadily after the operation. After surgery, the dog became seizure free (with phenobarbital administration after the operation). Three weeks later, the dog showed no neurological abnormality except a mild proprioceptive disturbance of the left front and hind limbs. Follow-up MR imaging was performed one month after surgery. No mass was observed and recurrence was not detected. The compressed brain tissues and edema were almost recovered to normal. However, on the basis of intraoperative findings and histological results, radiation therapy was recommended, but the owner was satisfied with the outcome of the operation and did not wish any further therapy. At the present, 330 days after surgery, the dog has not shown either seizures or any neurological sign.

A number of published reports have described MR findings of meningioma in humans and animals [5, 9, 12, 16, 17, 19]. The common and typical MR findings of meningioma

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are a mass showing iso- to hypointensity on T1W, iso- to hyperintensity on T2W, and contrast enhancement with the dual tail sign on Gd-T1WI, which originated from the extra-axis region. MR findings in the present case were consistent with the typical findings of meningioma, except for the T1W hyperintensity. In veterinary medicine, only a few reports have demonstrated meningioma with hyperintensity on T1W (one tumor was meningioangiomatosis) [6, 11, 20]. Even in these studies, however, signal intensity on T1W was not discussed. It is important to clarify the lesion showing hyperintensity on T1W in imaging diagnosis and a differential diagnosis of meningioma.

Fig. 1. The mass showing hyperintensity on T1W (A: spin-echo; TR/TE=410/15), mixed-intensity on T2W (B: first spin-echo; TR/TE=4000/100) and contrast enhancement with dural tail sign on Gd-T1W (C: after an intravenous administration of gadodiamide) in the right paramedian frontal-parietal region. The margin of the mass showed hypointensity on both T1- and T2W images.

Fig. 2. Histology revealed that the mass was a meningiothelial meningioma. Solid growth of tumor cells abundant in cytoplasm containing lipid droplets was observed. Vascular distribution was developed in the tumor stroma and severe congestion was present. A large amount of hemosiderin was observed and hemorrhage was suggested (HE staining, ×100).
Some meningiomas in human, though rarely, may appear as hyperintense on T1W as a variation [1–5, 10, 12, 15, 21]. It was observed in 0 of 54 cases in one study [5], and in 3 of 35 cases in another study [12]. High signal intensity on T1W in human meningioma is thought to be related to either intra- and extra-tumor hemorrhage, a high lipid content in tumor cells, mild calcification, or a high cellular density [2, 3, 12].

In intra- and extra-tumor hemorrhage, signal intensity on T1W varies according to the time after bleeding (and/or status of hemoglobin), as in cases of other hemorrhagic lesions [2, 3, 7]. Unfortunately, the specific MR sequences for detecting hemorrhage such as T2*-weighted imaging [14] were not performed in the present case. However, the intra- and extra-tumor hemorrhage was confirmed histologically, and the hypointense margin of the mass on both T1W and T2W may be represented the presence of hemosiderin. Therefore, the diffuse and small intra-tumor hemorrhage may have influenced the T1W hyperintensity similar to the laminar necrosis that was observed in the case of cerebral infarction [3].

Meningioma with the most remarkable T1W hyperintensity is observed in lipomatous meningioma and xanthomatous meningioma, and the high signal intensity is due to the lipid content of the meningioma cells [2, 3, 10, 12, 21]. However, these meningiomas demonstrating T1W hyperintensity are visualized as low-density lesions by CT. Furthermore, these meningiomas, including those with high lipid content, would be suppressed in signal intensity by the fat suppression MR technique. In the present case, many tumor cells with abundant lipid droplets were observed histologically. Although these lipid contents may also be associated with higher signal intensity on T1W and fat suppression imaging was not performed, the mass was not shown as low-density in CT images.

Mild calcification is also detected as hyperintense on T1W (“surface effect”) and as iso- to hypo-intense on T2W, while it is visualized as a high-density lesion by CT [2, 3]. At the time of MRI, we could not discount mild calcification of the tumor, however, CT images and histology did not show any calcification in the present case.

The other histological findings in the present case, ie. cholesterin crystal deposition and highly solid cell growth, may demonstrate hyperintensity on T1W [3]. Although we cannot conclude the most direct cause of the T1W hyperintensity in this meningioma, we suggest that the various factors that can shorten T1, as mentioned above, may be relevant in this case.

Cerebral hemorrhage, dermoid, lipoma, solitary fibrous tumors, and hemangiopericytoma form intracranial mass lesions with hyperintensity on T1W. However, cerebral hemorrhage, dermoid and lipoma can be differentiated easily by combining some specific MR techniques (such as T2*-weighted imaging and/or fat suppression technique) and careful reading [2, 3, 7]. Solitary fibrous tumors and hemangiopericytoma are rare mesenchymal tumors in humans, and they may demonstrate hyperintensity on T1W. They often appear in the meninges and a differential diagnosis from meningioma is difficult because they also may have the dural tail sign [8, 13]. However, there has been no such report in veterinary medicine.

Although a meningioma showing T1W hyperintensity is very rare, further studies that accumulate such cases are expected and will determine the cause of spontaneous T1W hyperintensity in detail.

REFERENCES