Received: 2 December 2021 | Revised: 9 March 2022 | Accepted: 21 March 2022

DOI: 10.1002/vrc2.365

Vet Record CaseReports

CASE REPORT

Companion or pet animals

Clinical, imaging and histopathological characteristics of a malignant intracranial meningioma with pulmonary metastasis in a dog

Sonia Ortiz-Nisa[1,2] | **Cristian de la Fuente**[2] | **Fabiano Sant´Ana**[3] | **Martí Pumarola**[1,4] | **Sonia Añor**[1,2]

[1]Departament de Medicina i Cirurgia Animal, Facultat de Veterinària, Universitat Autònoma de Barcelona, Bellaterra, Barcelona, Spain

[2]Fundació Hospital Clínic Veterinari, Universitat Autònoma de Barcelona, Barcelona, Spain

[3]Veterinary Pathology Department, Brasília University, Brasília, Brazil

[4]Unitat de Patologia Murina i Comparada (UPMiC), Universitat Autònoma de Barcelona, Bellaterra, Barcelona, Spain

Correspondence
Sonia Añor, Departament de Medicina i Cirurgia Animal, Facultat de Veterinària, Universitat Autònoma de Barcelona, Bellaterra, 08193 Barcelona, Spain.
Email: Sonia.Anor@uab.cat

Abstract

A 13-year-old Spanish Breton was presented for a hyperacute onset of dull mentation followed by a generalised tonic-clonic seizure and recumbency. An intracranial magnetic resonance imaging study identified a well-demarcated intraventricular mass, and cerebrospinal fluid analysis revealed moderate neutrophilic pleocytosis and proteinorrachia. A tentative diagnosis of meningioma was made and medical treatment was started. After a short initial improvement, the patient died 3 weeks later. Histopathology confirmed the presence of a malignant meningioma (World Health Organization grade III) and pulmonary metastasis. This is, to our knowledge, the first reported case of a canine intracranial meningioma with pulmonary metastasis showing magnetic resonance imaging and immunohistochemical characterisation of the tumour.

BACKGROUND

Meningiomas are common intracranial neoplasms derived from meningothelial cells, which have been well described in the veterinary literature. They are usually slow growing, benign tumours that account for 45% of all primary intracranial tumours in dogs.[1–4]

Based on the human World Health Organization (WHO) classification, most canine meningiomas are histologically classified as benign (56%) or grade I.[5] Grade II or atypical meningiomas are 43% of all of them, and grade III or anaplastic variants are the least common, accounting for 1%.[1,3]

Distant metastasis of intracranial meningiomas is extremely rare, with less than 1% reported in humans, and just one study in dogs describing three cases.[6,7]

This case is of interest because it describes an extremely rare presentation of a commonly diagnosed intracranial neoplasia such as meningioma. This is the first description of the immunohistochemical and MRI features of a canine malignant intracranial meningioma with metastasis to the lung.

CASE PRESENTATION

A 13-year-old, male, neutered Spanish Breton was presented to the veterinary hospital for a hyperacute onset of dull mentation followed by a generalised tonic-clonic seizure. The owner also described a dramatic change in the patient's mental status the same morning of the presentation. The dog was very quiet and less responsive than normal early in the morning, and progressed to show incoordination and hypersalivation during the next few hours. At night, the dog's mentation was severely depressed and a generalised tonic-clonic seizure developed. By then, the owner decided to take dog to the veterinary hospital. Before this event, no abnormalities had been observed. Abnormal findings on physical examination included tachypnoea, tachycardia and hyperthermia (39.7°C). Neurological examination showed dull mentation, ambulatory tetraparesis with generalised proprioceptive ataxia and absent proprioceptive positioning in all four limbs. Menace response was inconsistent in the left eye, and nasal mucosa sensation was decreased on the left side. Neuroanatomical localisation was right prosencephalon. Differential

diagnoses included vascular accident, intoxication, neoplasia, inflammatory/infectious or, less likely, metabolic disease.

INVESTIGATIONS

Blood tests, urinalysis and abdominal ultrasound revealed no abnormalities, but thoracic radiographs showed a multiple nodular pattern scattered throughout both lungs (Figure 1a,b). MRI of the brain was performed using a 0.4 Tesla permanent magnet unit (Hitachi Aperto Lucent Hitachi Medical Systems, Madrid, Spain). Sequences performed included T2-weighted images (WI) in transverse, sagittal and dorsal planes; pre- and postcontrast T1-WI in transverse and sagittal planes; T2-weighted fluid attenuated inversion recovery images (T2-FLAIR), and T2*-WI in transverse plane. Gadolinium (Dotarem 0.5 mmol/ml, Dotarem-Guerbet Laboratories, Madrid, Spain) was the contrast agent used at a dose of 0.1 mmol/kg intravenously (IV).

Imaging identified a single, well-defined intraventricular mass located in the midline and dorsal to the thalamus. The mass was round to oval in shape, and measured 2.13 cm craniocaudally, 1.40 cm dorsoventrally and 2.40 cm transversely. It was heterogeneously hyperintense on T2-WI and T2-FLAIR, and iso- to hypointense on T1-WI compared to the normal gray matter. Contrast enhancement was marked and homogeneous (Figure 2a–f). Mass effect was identified causing collapse of the lateral ventricles in their central portion, and thalamic compression with caudoventral displacement of cerebral parenchyma. The cerebellum was flattened in its rostral aspect, and it was mildly compressed by the caudal colliculus, which was displaced caudally. Moderate generalised effacement of the cerebral sulci was also observed.

Cerebrospinal fluid (CSF) was collected from the cerebellomedullar cistern and analysis revealed a moderate neutrophilic pleocytosis (60 WBC/μl; reference range ≤5 WBC/μl), and proteinorrachia (864 mg/dl; reference range <30 mg/dl).[8] No microorganisms were identified on cytological examination.

LEARNING POINTS/TAKE-HOME MESSAGES

- Malignant meningiomas are very rare in both dogs and humans.
- Distant metastases of intracranial meningiomas are even more unusual in both dogs and humans.
- Primary and metastatic meningiomas are expected to inmunostain positively to S100 protein and vimentin, and they are expected to be negative to glial fibrillary acidic protein, epithelial membrane antigen and cytokeratins.
- To the authors' knowledge, this is the first report describing a canine intraventricular malignant meningioma with pulmonary metastasis and its magnetic resonance imaging and immunohistochemical features.
- Although rare, malignant meningiomas should be considered, and the presence of metastasis should be ruled out in patients with meningiomas.

DIFFERENTIAL DIAGNOSIS

Choroid plexus tumour, ependymal tumour or meningioma are the main differential diagnoses for ventricular tumours. Intraventricular neurocytoma and lymphoma have also been described.

TREATMENT

The patient was hospitalised and palliative medical treatment with anti-inflammatory doses of prednisone (0.5 mg/kg IV every 24 hours), phenobarbital (3 mg/kg IV every 12 hours) and diazepam in case of seizures (1 mg/kg IV) was started. Radiation therapy was rejected by the owner.

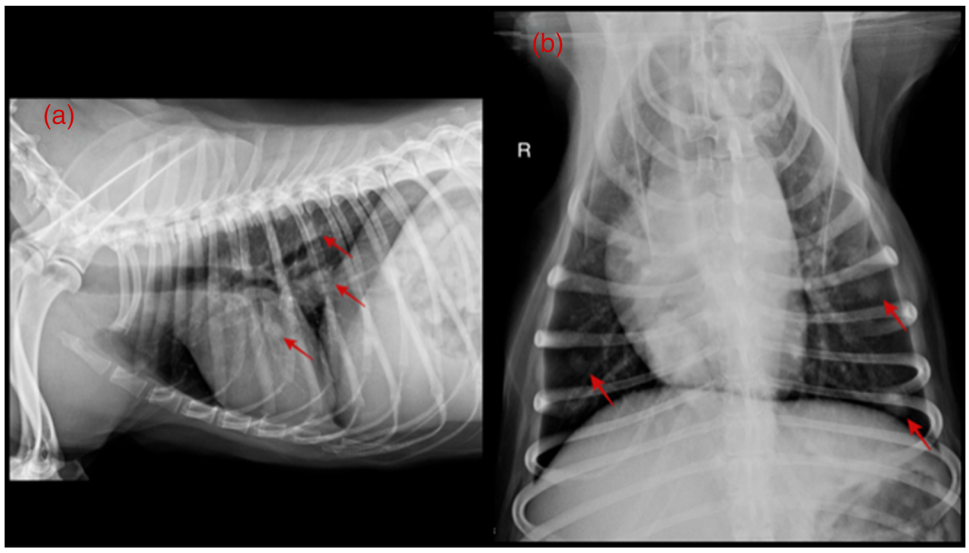

FIGURE 1 Thoracic radiographs. Right lateral (a) and ventrodorsal view (b). Multifocal nodular pattern affecting several lung lobes in both hemithoraxes (arrows)

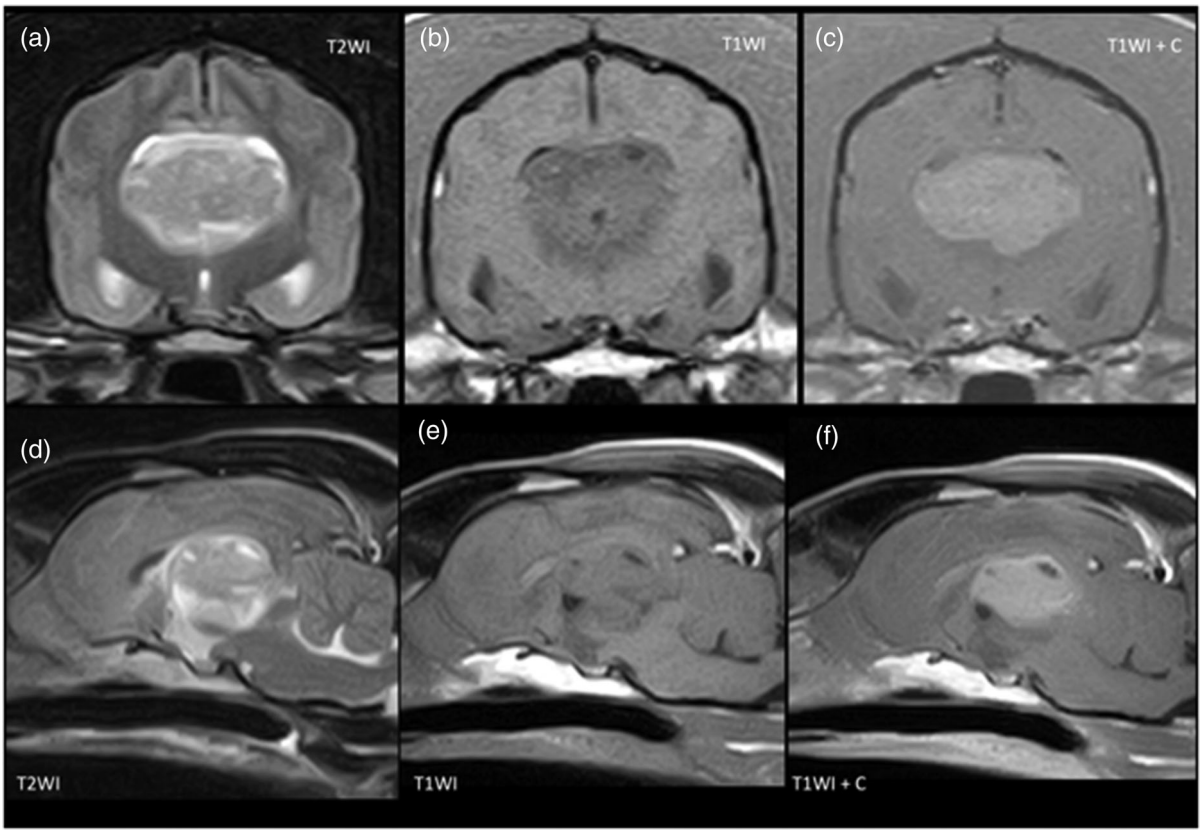

FIGURE 2 Magnetic resonance images (MRI) of the intraventricular meningioma. Transverse T2-weighted images (WI) (a), T1-WI (b) and T1-WI postcontrast (c) images; and sagittal T2-WI (d), T1-WI (e) and T1-WI postcontrast (f) sequences. A well-defined mass, round to oval shaped, is present within the lateral ventricles. It is heterogeneous and hyperintense on T2-WI (a and d), iso- to hypointense on T1-WI images (b and e), and strongly contrast enhancing (c and f). It measures 2.13 × 1.4 × 2.4 cm (craniocaudally × dorsoventrally × transversely) and causes a moderate mass effect displacing and compressing adjacent structures (0.4 T MRI system)

OUTCOME AND FOLLOW-UP

The dog's neurologic condition improved progressively, and no further seizures were observed for the rest of the days of hospitalisation. The patient was discharged 4 days after admission with mild generalised proprioceptive ataxia, but the rest of the neurological examination was unremarkable.

A week later, the neurological examination was normal on recheck appointment and the owner reported a positive progress. The third week after discharge, there was an acute worsening of clinical signs. The owner described a sudden onset of dull mentation, constant panting and recumbency, and sudden death 1 hour later on his way to the hospital.

A postmortem examination, authorised by the owner, was performed. On gross examination of the brain, a well-circumscribed and firm intraventricular mass was identified (Figure 3). Several firm nodules were also identified in the lungs, spreading over all lobules (Figure 4).

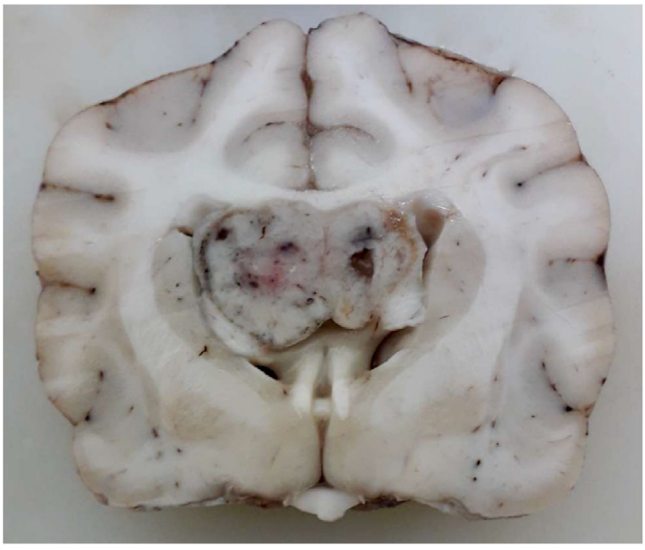

FIGURE 3 Macroscopic view of the fixed brain. Transverse section of the mass at the level of the lateral ventricles and caudate nucleus. A well-circumscribed and firm mass is exposed, and it is occupying both lateral ventricles

Microscopic examination of the brain mass evidenced a non-encapsulated but well-defined neoplastic cell proliferation of fusiform cells with a solid growth pattern (Figure 5a). Abundant and wide necrotic areas, with a large number of active macrophages and neutrophils and several blood vessels, were present (Figure 5b). The cells were medium to large, with a big round or irregular nucleus, lax chromatin and sometimes apparent nucleoli (Figure 5c). The cytoplasm was scarce, but eosinophilic when evident. Anisocytosis, anisokaryosis and numerous mitoses were found. The neoplastic population followed a perivascular and papillary pattern. The perilesional brain parenchyma showed microspongiosis, diffuse and reactive gliosis and perivascular cuffs of inflammatory and neoplastic cells.

The pulmonary nodules consisted of neoplastic proliferations of similar fusiform cells, with more pleocytosis than those in the brain. The nodules were non-encapsulated

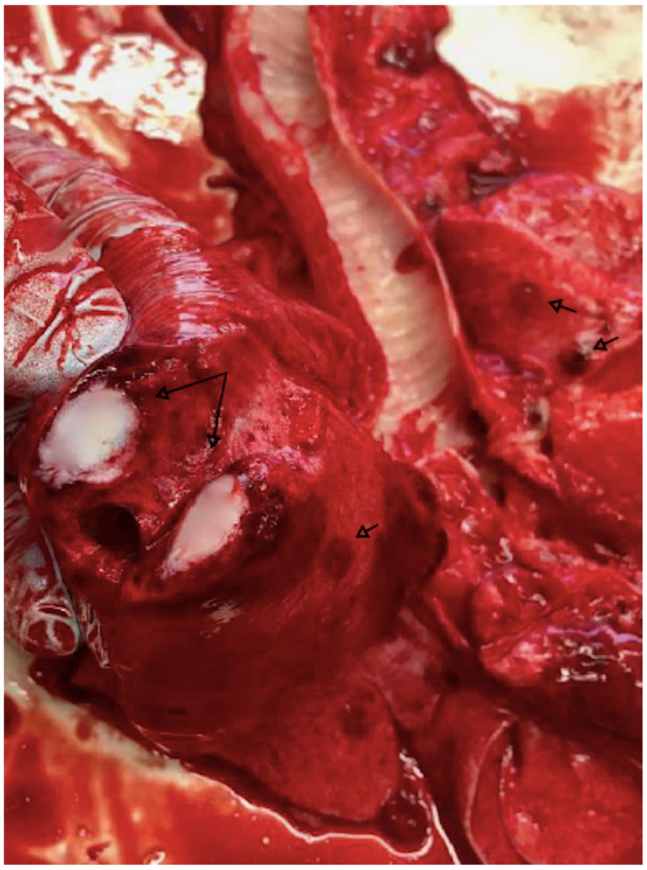

FIGURE 4 Macroscopic view of the fresh lungs. Several firm nodules, from 2 to 4 cm diameter (arrows), are seen throughout the parenchyma, spreading among all lobules

but well delimited, and compressed the lung parenchyma (Figure 5e). Marked anisokaryosis with large and ovoid or lobed nucleus and elongated eosinophilic cytoplasm were present (Figure 5f,g). Mitoses were frequent. The growth pattern included solid areas of neoplastic cells organised in dense bundles, mixed with areas in which neoplastic cells were surrounding an eosinophilic material made of necrotic cellular debris, with the presence of a purulent inflammatory infiltrate.

A Masson's trichrome stain of the brain sections evidenced the presence of scarce collagen fibres mainly located in the perivascular spaces. In the lung mass, large amounts of collagen fibres were found between the neoplastic cell population.

Immunohistochemistry was also used to characterise the neoplastic cell population. On brain sections S100 protein immune-stained positively up to 60% of cells (Figure 5d), and up to 80% of cells stained positively in the pulmonary mass (Figure 5h). Small numbers of neoplastic cells were positive to vimentin (VIM) in the encephalic mass, but 40%–60% of neoplastic cells were positive to the same marker in the pulmonary mass. No positivity was observed (brain or lung) to glial fibrillary acidic protein (GFAP), epithelial membrane antigen (EMA) or cytokeratins (CK).

The findings were consistent with a malignant brain meningioma (WHO grade III) with pulmonary metastasis.

DISCUSSION

This report describes the clinical, imaging and histopathological characteristics of a malignant meningioma with pulmonary metastasis in a dog.

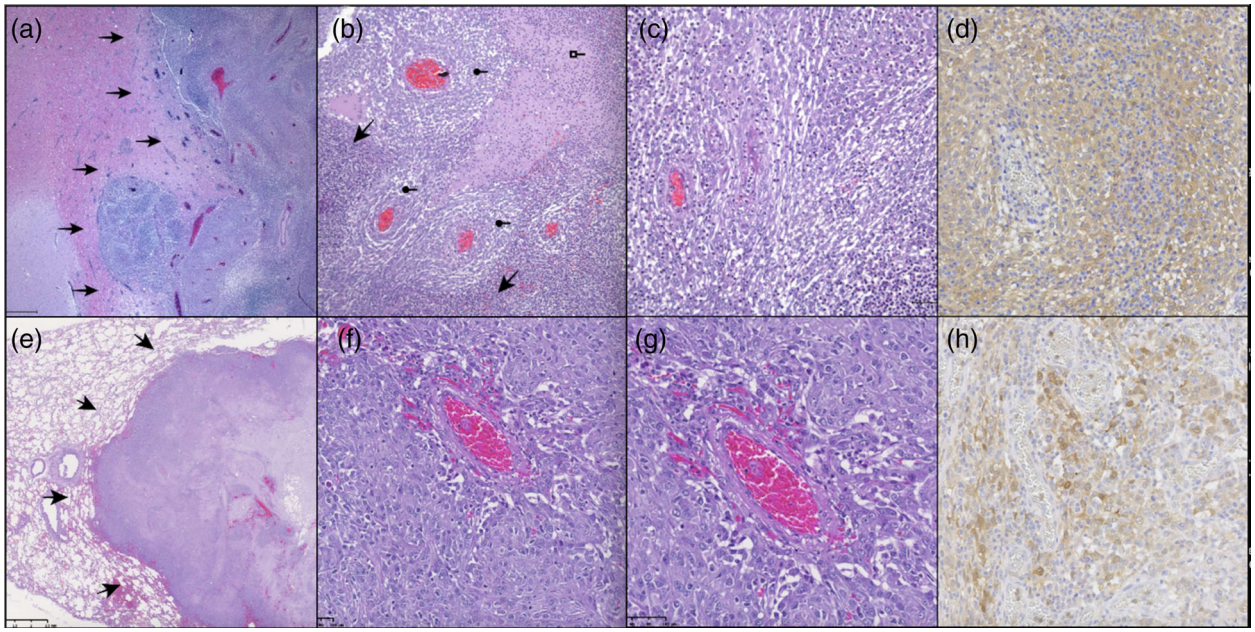

FIGURE 5 Four microscopic images of the brain mass (a–d) and four microscopic images of the pulmonary mass (e–h) at different magnifications. (a) Meningioma stained with haematoxylin eosin (HE) compressing the adjacent brain parenchyma (arrows). Bar = 1 mm. (b) Meningioma stained with HE with perivascular and papillary pattern (round markers). Abundant and wide necrotic areas (square marker), with large number of active macrophages and neutrophils (arrows). Bar = 200 μm. (c) At high magnification, medium to large size, fusiform or irregular, neoplastic cells with a big round or irregular nucleus. Bar = 100 μm. (d) Immunohistochemical staining for S100 protein. High numbers of perivascular brown-stained immunopositive cells within the brain mass are mixed with an inflammatory cell population. Bar = 100 μm. (e) A well-delimited pulmonary metastatic meningioma compressing the lung parenchyma is shown. Bar = 2.5 mm. (f) Metastatic meningioma composed of fusiform or irregular neoplastic cells, with large and ovoid or lobed nucleus (marked anisokaryosis) and eosinophilic cytoplasm. Bar = 100 μm. (g) High magnification of the previous image of the pulmonary metastatic meningioma with HE. Bar = 100 μm. (h) Immunopositive S100 protein staining of the pulmonary metastatic meningioma. Bar = 100 μm

Malignant meningiomas are uncommon in dogs. Of 112 dogs with intracranial meningiomas in a study published by Sturges et al., just one of them was classified as malignant.[1] A similar scenario is reported in human beings, with a recent review indicating that malignant meningiomas represent 1%–3% of all meningiomas.[4] Intracranial meningiomas with metastatic spreading to extra-CNS organs are even less common. In dogs, just a prior study reported the clinicopathological features of intracranial meningiomas with pulmonary metastasis in three dogs and the CT images in two of them, but no MRI study or immunohistochemical characterisation was performed in any of them.[7]

The MRI characteristics of the mass described herein were identical to those reported for intracranial meningiomas.[1,9,10] The mass was large and occupied more than 25% of the cranial volume. However, the MRI features of meningiomas cannot predict the pathological grade or the potential growth of the neoplasm.[1] In human medicine, a large tumour volume is the most reliable predictor for high-grade meningioma.[11,12] In fact, Magill et al. found that tumour sizes greater than 3.2 cm increased the likelihood of being WHO grade II instead of WHO grade I meningiomas.[12] In our case, the tumour diameter was 2.40 cm, which was a significant size for a dog's brain.

Neutrophilic pleocytosis in the CSF analysis has been frequently associated with intracranial meningiomas.[13] However, Dickinson et al. published a retrospective study of 56 dogs with intracranial meningioma and identified neutrophilic pleocytosis in only 19% of them.[14] In addition, it was less likely in animals with meningiomas located within the mid or rostral portions of the cranial fossa. In the case described here, the meningioma was located within the lateral ventricles, and a moderate neutrophilic pleocytosis was identified in the CSF analysis.

Clinical signs associated with meningiomas are related to localisation, size and the presence of secondary changes (oedema, necrosis and inflammation). In the clinical case described here, the response to corticosteroids was most likely due to a reduction of secondary vasogenic oedema. And the main goal of phenobarbital was to reduce the frequency and the severity of tumour-associated seizures.

Histopathology confirmed that the tumour was a malignant meningioma with pulmonary metastasis, and that the neoplastic cells in the lungs had even more malignant characteristics than those in the brain. These findings were similar to those reported in one of the three cases described by Schulman et al.[7] The immunohistochemical reaction to S100 protein was similar to the one described in human high-grade meningiomas, and the VIM immune-stained positive results also confirmed the leptomeningeal origin of these cells.[3,15]

To the best of our knowledge, this is the first description of the imaging and immunohistochemical characteristics of a primary malignant meningioma and its pulmonary metastases in a dog.

IMAGE QUIZ

Figure 1 Thoracic radiographs. Right lateral (a) and ventrodorsal view (b). In both hemithoraxes, multiple nodular structures of soft tissue opacity, small size, rounded shape and moderately defined edges are observed.

MULTIPLE CHOICE QUESTION

What is the likely diagnosis?

POSSIBLE ANSWERS TO MULTIPLE CHOICE QUESTION

a) Fungal granulomas
b) Parasitic granuloma
c) Pulmonary abscesses
d) Primary pulmonary neoplasia (adenocarcinoma, carcinoma, squamous cell carcinoma or anaplastic carcinoma)
e) Metastatic pulmonary neoplasia (meningioma)

CORRECT ANSWER

e) Metastatic pulmonary neoplasia (meningioma).

A primary malignant intracranial meningioma with pulmonary metastases was diagnosed in this dog. It has been described (in a very few cases) as 0.5–4 cm diameter, firm, round-shaped nodules scattered throughout both lungs.

It is an unusual presentation, but pulmonary metastasis should be ruled out in patients with meningiomas.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. No ethical approval was required as this is a case report article with no original research data. The owner gave informed written consent for all the investigations.

FUNDING INFORMATION

The authors received no specific funding for this work.

ORCID

Sonia Añor https://orcid.org/0000-0002-1099-7698

REFERENCES

1. Sturges BK, Dickinson PJ, Bollen AW, Koblik PD, Kass PH, Kortz GD, et al. Magnetic resonance imaging and histological classification of intracranial meningiomas in 112 dogs. J Vet Intern Med. 2008;22:586–95.
2. Motta L, Mandara MT, Skerritt GC. Canine and feline intracranial meningiomas: an updated review. Vet J. 2011;192(2):153–65.
3. Higgins RJ, Bollen AW, Dickinson PJ, Sisó-Llonch S. Tumors of the nervous system. In: Meuten DJ, editor. Tumors in domestic animals. 5th ed. Raleigh, NC, USA: Wiley-Blackwell; 2016. p. 834–91.
4. Miller AD, Miller CR, Rossmeisl JH. Canine primary intracranial cancer: a clinicopathologic and comparative review of glioma, meningioma, and choroid plexus tumors. Front Oncol. 2019;9:1.
5. Louis DN, Perry A, Reifenberger G, von Deimling A, Figarella-Branger D, Cavenee WK, et al. The 2016 World Health Organization classification of tumors of the central nervous system: a summary. Acta Neuropathol. 2016;131(6):803–20.
6. Ather Enam S, Abdulrauf S, Mehta B, Malik GM, Mahmood A. Metastasis in meningioma. Acta Neurochir (Wien). 1996;138(10):1172–8.
7. Schulman FY, Ribas JL, Carpenter JL, Sisson AF, Lecouteur RA. Intracranial meningioma with pulmonary metastasis in three dogs. Vet Pathol. 1992;29(3):196–202.

8. Di Terlizzi R, Platt SR. The function, composition and analysis of cerebrospinal fluid in companion animals: part II - analysis. Vet J. 2009;180(1):15–32.
9. Hathcock JT. Low field magnetic resonance imaging characteristics of cranial vault meningiomas in 13 dogs. Vet Radiol Ultrasound. 1996;37(4):257–63.
10. Thomas WB, Wheeler SJ, Kramer R, Kornegay JN. Magnetic resonance imaging features of primary brain tumors in dogs. Vet Radiol Ultrasound. 1996;37(1):20–7.
11. Hale AT, Wang L, Strother MK, Chambless LB. Differentiating meningioma grade by imaging features on magnetic resonance imaging. J Clin Neurosci. 2018;48:71–5.
12. Magill ST, Young JS, Chae R, Aghi MK, Theodosopoulos PV, Dermott MW. Relationship between tumor location, size, and WHO grade in meningioma. Neurosurg Focus. 2018;44(4):1–50.
13. Bailey CS, Higgins RJ. Characteristics of cisternal cerebrospinal fluid associated with primary brain tumors in the dog: a retrospective study. J Am Vet Med Assoc. 1986;188(4):414–7.
14. Dickinson PJ, Sturges BK, Kass PH, Lecouteur RA. Characteristics of cisternal cerebrospinal fluid associated with intracranial meningiomas in dogs : 56 cases (1985–2004). J Am Anim Hosp Assoc. 2006;228(4):564–7.
15. Boulagnon-Rombi C, Fleury C, Fichel C, Lefour S, Bressenot AM, Gauchotte G. Immunohistochemical approach to the differential diagnosis of meningiomas and their mimics. J Neuropathol Exp Neurol. 2017;76(4):289–98.

How to cite this article: Ortiz-Nisa S, de la Fuente C, Sant´Ana F, Pumarola M, Añor S. Clinical, imaging and histopathological characteristics of a malignant intracranial meningioma with pulmonary metastasis in a dog. Vet Rec Case Rep. 2022;e365. https://doi.org/10.1002/vrc2.365