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Review

Canine and feline intracranial meningiomas: An updated review

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ABSTRACT

Meningiomas are the most common primary brain tumours in dogs and cats. There are several morphological phenotypes of this extra-axial neoplasm and they show predilections for certain anatomical locations. There have been a number of attempts to apply the current World Health Organization (WHO) classification for human meningiomas to dogs and cats and to obtain a universal classification scheme for domestic animals. Recently, certain enzymes involved in tumour growth have been recognised as biological markers and have been related to degrees of malignancy. The secondary effects of meningiomas have also been investigated, and vascular endothelial growth factor and peritumoural oedema have been reported to reduce survival rate.

Breed and age predisposition are recognised in both dogs and cats and the presenting clinical signs are quite consistent. Magnetic resonance imaging and computed tomography are the techniques of choice for the presumptive diagnosis of meningiomas in domestic animals but advanced imaging techniques are constantly being developed and applied. Treatment methods for meningiomas involve a combination of de-bulking surgery, chemotherapy and radiotherapy, and detailed accounts of several treatment protocols have been reported.

Introduction

Meningioma is the most commonly reported primary brain tumour in dogs and cats (Troxel et al., 2003; Snyder et al., 2006). It arises from the cap cells covering the arachnoid granulations, particularly at the point where they project into the venous sinuses (Summer et al., 1995). In view of their development from mesenchyme and neural crest and of the wide array of functions performed by arachnoid cells (Kepes, 1986), it is not surprising that meningiomas exhibit highly variable morphological and immunophenotypic patterns. Nevertheless, the biological behaviour of meningiomas, except for the anaplastic type, is generally considered benign in humans (Louis et al., 2007) as is also the case in dogs and cats.

The aim of this review is to provide updated information both for clinicians and pathologists who may deal with canine and feline intracranial meningiomas. Clinical signs, diagnosis, gross anatomy, histopathological classification, treatment, prognosis and future potential studies of canine and feline meningiomas are reviewed.

In recent retrospective analyses of canine and feline primary intracranial neoplasia, meningioma has been diagnosed in 45% (Snyder et al., 2006) and 85% (Troxel et al., 2003) of cases, respectively; meningiomas account for about 22.3% (Snyder et al., 2006, 2008) and 59% (Troxel et al., 2003) of canine and feline brain tumours.

Meningiomas are extra-axial central nervous system (CNS) tumours growing within the dura mater but outside the brain and spinal cord parenchyma, although direct invasion of the nervous tissue can occur. In humans, most meningiomas occur over the cerebral convexities, often in parasagittal locations in association with the falx cerebri and the venous sinuses (Louis et al., 2007). Most canine meningiomas are adjacent to the calvarium and a significant number of these tumours involve the olfactory/frontal region, the floor of the cranial cavity, the optic chiasm or the suprasellar and parasellar regions (Patnaik et al., 1986; Snyder et al., 2006; Sturges et al., 2008) (Fig. 1). Other uncommon intracranial localisations include the cerebello-pontomedullary region (Bagley et al., 2000; Kaldrymidou et al., 2001; Kitagawa et al., 2004; Sturges et al., 2008; Holland et al., 2010), the retrobulbar space (Patnaik et al., 1986; Willis et al., 1997; Pérez et al., 2005) and the middle ear cavity (Owen et al., 2004).

In cats, common locations include the tela choroidea of the third ventricle, the supratentorial meninges (Troxel et al., 2003; Mandara et al., 2006) (Fig. 2) and, rarely, the cerebellar meninges (Quesnel and Parent, 1995; Kaldrymidou et al., 2000; Troxel et al., 2003; Tomek et al., 2008). Feline multiple meningiomas are common (Luginbohl, 1961; Zaki and Hurvitz, 1976; Nafe, 1979; Averill, 1987; Gordon et al., 1994; Lobetti et al., 1997; Troxel et al., 2003; Forterre et al., 2007; Tomek et al., 2008), occurring in approximately 17% of

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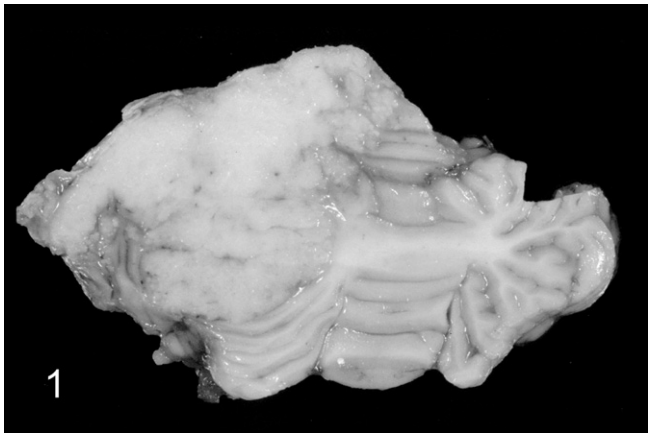

Fig. 1. Canine infratentorial meningioma (meningothelial histotype) in the left cerebellar hemisphere. Note the multilobular pattern and the granular aspect of the neoplastic tissue.

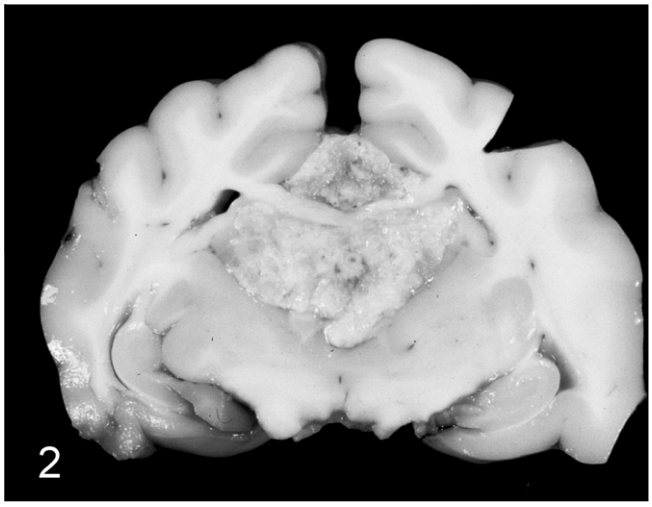

Fig. 2. Feline meningioma (granular cell histotype) extending from the third ventricle to the cingulate gyrus crossing the corpus callosum. This mass has a widely calcified and irregular cut surface.

meningioma cases (Nafe, 1979; Summer et al., 1995; Troxel et al., 2003) (Fig. 3) whereas it is very uncommon to detect more than one meningioma in dogs (McDonnell et al., 2007; Sturges et al., 2008).

Canine and feline intracranial meningiomas have been diagnosed with concurrent neural (Stacy et al., 2003; Troxel et al., 2003; Snyder et al., 2006; Ginel et al., 2009) or extra-neural disorders such as mucopolysaccharidosis type 1 (Haskins and McGrath, 1983), thymic lymphoma (Lobetti et al., 1997) and other unrelated neoplasia (Snyder et al., 2006). In particular, 13.9% of cats and 19% of dogs develop a meningioma in addition to another intracranial neoplasm (Stacy et al., 2003; Troxel et al., 2003; Snyder et al., 2006). Furthermore, cats may have concurrent benign and malignant multiple meningiomas (Lu et al., 2003).

Clinical findings and diagnosis

Signalment and neurological signs

Generally, meningioma occurs in dolichocephalic breeds, especially German Shepherds, Golden Retrievers and Labrador Retrievers, with no consistent sex predisposition (Snyder et al., 2006; Sturges et al., 2008). Boxers are known to have an increased prevalence (Snyder et al., 2006; Sturges et al., 2008). Domestic shorthaired cats seem to be predisposed to develop meningioma and no significant difference between sexes has been found (Troxel et al., 2003; Tomek et al., 2006). In most reports, meningioma has been diagnosed in dogs over 7 years of age and in cats over 9 years of age (Nafe, 1979; Troxel et al., 2003; Snyder et al., 2006; Tomek et al., 2006), although they have occasionally been observed in young cats <3 years old (Haskins and McGrath, 1983; Lobetti et al., 1997) and in young dogs <6 months (Keller and Madewell, 1992).

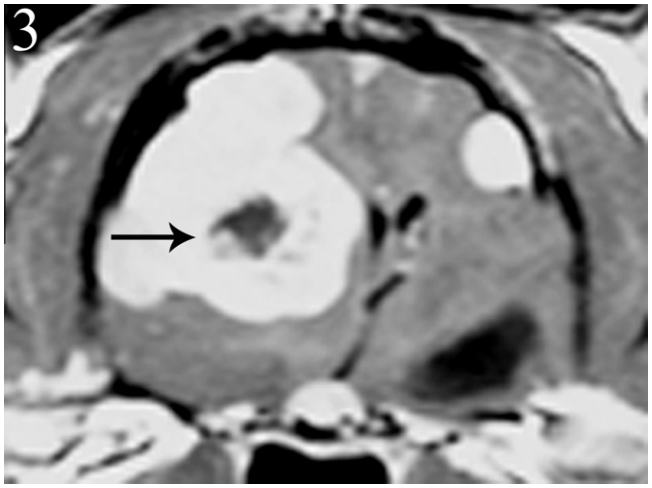

Fig. 3. Cat, 8 years old. Transverse post-contrast T1-weighted MR image at the level of the pituitary gland showing multiple mass-like lesions histopathologically confirmed as meningiomas. There is a severe shift of the falx cerebri. Note the hypointense cyst-like lesion within the tumour (black arrow) signifying necrosis.

Although the majority of animals affected by brain neoplasms present an array of mild or ill-defined neurological signs, the most common clinical signs in dogs and cats with intracranial meningioma are altered consciousness, seizures and vestibular dysfunction (Gordon et al., 1994; Troxel et al., 2003; Greco et al., 2006; Snyder et al., 2006; Tomek et al., 2006; Negrin et al., 2010). These clinical signs are likely to be related to the neuroanatomical distribution of canine and feline meningiomas. Epileptic seizures are generated in the cerebral cortex and in the diencephalon (Fisher et al., 2005); these are neuroanatomical areas frequently invaded by feline and canine meningiomas (Troxel et al., 2003; Snyder et al., 2006; Sturges et al., 2008). In addition, compression and/or damage of the diencephalon may result in altered consciousness because of the dysfunction of the ascending reticular activating system, a network of neurons responsible for maintaining the state of wakefulness (De Lahunta and Glass, 2009). Finally, diencephalic damage may lead to vestibular signs as the thalamus functions as a relay station for afferent vestibular inputs to the cortex (Dieterich et al., 2005).

Other specific neurological deficits associated with intracranial meningiomas, e.g. external and internal ophthalmoplegia, have been rarely reported (Larocca, 2000; Webb et al., 2005; Holland et al., 2010; Seruca et al., 2010).

Blood and cerebrospinal fluid analysis

There are no clinical studies evaluating the influence of the parameters of haematology, serum biochemistry, and urinalysis in dogs or cats with intracranial meningiomas. General anaesthesia may lead to clinically important hyperlactatemia in dogs with intracranial meningiomas (Sullivan et al., 2009) but the degree