Intracranial Meningioma: A Comparative Pathologic Study of 28 Dogs

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Abstract. Intracranial meningiomas were identified in 28 dogs based on histologic examination of tissue. The average age of the dogs was 11 years, and 83% (20/24) were 10 years old or older. German shepherd and mixed breed were most common (31% each, 8/26). Grossly, meningiomas were oval, dome-shaped and flattened masses adherent to the dura and compressing the brain. Forty-eight percent (15/26) of the tumors affected the dorsal surface of the brain, and two thirds of these were located in the anterior half. Histologically, tumor types were transitional (13), meningiotheliomatous (11), angioblastic (three), and fibroblastic (one). There was direct invasion of the brain in 27% (6/22) although we observed neurologic signs and pathologic changes in 88% (23/26) and 90% (18/20) of the dogs, respectively. Intracranial meningioma can be compared and contrasted with this tumor in man and cats.

Results

The 28 cases of meningioma were almost equally divided between male (13) and female (12) dogs (in three cases sex was not recorded). The average age was 11 years (range, 2 to 16 years), and 83% (20/24) were 10 years or older. Twelve different breeds of dogs were recorded; German shepherd and mixed breed were the most common, each accounting for 31% (8/26). Clinical signs were recorded in 26 cases. Of the 26 dogs, 88% (23) had neurologic signs; the remaining three dogs did not have neurologic signs.

Gross pathology

One dog had two meningiomas. Location of the meningiomas was recorded in 26 dogs (Table 1). The dorsal surface of the brain was the area most commonly affected (58%, 15/26), and 67% (10/15) of these were in the anterior half of the brain. The next most commonly affected areas were the hypothalamus and optic chiasm (23%, 6/26). Most of the meningiomas were firmly attached to the dura as oval, hemispherical or flattened tumors. They compressed the brain and most of them formed well-demarcated excavations in the adjoining brain tissue. Tumors were soft or firm, gray-white or pink, and lobulated. Grossly, invasion of the brain was seen in only three dogs. In one dog the tumor was partially mineralized. The neoplasms ranged in size from 1 cm³ to 27 cm³, but 68% (13/19) were less than 10 cm³.

Histopathology

The distribution of the histologic types of meningioma and the location of tumors that infiltrated adjoining neural tissue is given in Table 2. Transitional...
(46%, 13/28) and meningotheliomatous (39%, 11/28) types were more common than angioblastic (11%, 3/28) and fibroblastic (4%, 1/28).

Transitional meningiomas (13) were characterized by interwoven bundles of spindle cells and various-sized, concentric whorls formed by closely-wrapped spindle cells (Fig. 1). Blood vessels were seen in the center of most whorls, and a few contained psammoma bodies. In two tumors, the central spaces of the whorls were replaced with chondroid or mineralized tissue (Fig. 2). In general, the tumors had a lobular pattern, and in three the interlobular septa were thick and cellular with hyalinized areas. Cells forming bundles and whorls had pale, eosinophilic, granular cytoplasm and

**Table 1.** Location of 26 intracranial meningiomas in the dog.

<table>
<thead>
<tr>
<th>Location</th>
<th>No. (%)</th>
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</thead>
<tbody>
<tr>
<td>Dorsal surface of the brain:</td>
<td>15 (58)</td>
</tr>
<tr>
<td>Frontal cortex</td>
<td>10</td>
</tr>
<tr>
<td>Occipital area</td>
<td>4</td>
</tr>
<tr>
<td>Area dorsal to cerebellum</td>
<td>1</td>
</tr>
<tr>
<td>Ventral surface of the brain:</td>
<td>9 (35)</td>
</tr>
<tr>
<td>Brain stem</td>
<td>3</td>
</tr>
<tr>
<td>Hypothalamus and optic chiasm</td>
<td>6</td>
</tr>
<tr>
<td>Lateral surface of the brain:</td>
<td>2 (8)</td>
</tr>
<tr>
<td>Temporal area</td>
<td>1</td>
</tr>
<tr>
<td>Acoustic nerve area</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 2.** Histologic distribution of 28 meningiomas in the dog.

<table>
<thead>
<tr>
<th>Histologic Type</th>
<th>No. (%)</th>
<th>Infiltration of Neural Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Location</td>
<td>No.</td>
</tr>
<tr>
<td>Transitional</td>
<td>13 (46)</td>
<td>Frontal</td>
</tr>
<tr>
<td>Meningotheliomatous</td>
<td>11 (39)</td>
<td>Hypothalamus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brain stem</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Apex</td>
</tr>
<tr>
<td>Angioblastic</td>
<td>3 (11)</td>
<td>None</td>
</tr>
<tr>
<td>Fibroblastic</td>
<td>1 (4)</td>
<td>Frontal cortex</td>
</tr>
</tbody>
</table>
nuclei with scattered chromat and indistinct nucleoli. Two tumors were more anaplastic than the others, and their cells were characterized by large, vesiculated nuclei, but no mitotic cells were seen in these or in any of the other neoplasms. We noted random, cyst-like spaces and areas with lipid or xanthomatous changes in the tumor cells in nearly 50% of the tumors. In two neoplasms, there were extensive areas of necrosis; one also had areas of mineralization. Two of the 13 transitional meningiomas had invaded adjoining neural tissue.

Meningotheliomatous meningiomas (11) were characterized by relatively large, ovoid, or polygonal cells with ample eosinophilic or granular cytoplasm, pale nuclei with scattered chromatin, and one to two small nucleoli. The cells were irregularly arranged or formed whorls. Occasional cells with clear cytoplasm and others with grooved nuclei were seen (Fig. 3). In some areas, the central vessels of the whorls were thick and predominant. Psammoma bodies were very rare and mitotic cells were not seen. Three of 11 tumors invaded the adjoining neural tissue.

The only fibroblastic meningioma was characterized by elongated spindle cells forming interlacing bundles and occasional palisading; rare whorls and very rare psammoma bodies were seen (Fig. 4). Cellular features were similar to those seen in the transitional tumors. Rare mitotic cells were seen. The neoplasm had invaded the adjoining neural tissue.

Angioblastic meningiomas (three) were characterized by highly vascular lesions lined with prominent endothelial cells. Blood vessels were surrounded by spindle cells forming clefts and whorls. Neoplastic cells were similar to those seen in the meningotheliomatous tumors (Fig. 5). In two neoplasms the vessels were thickened, and there were meningotheliomatous areas. No mitotic cells were seen. There were areas with xanthomatous changes and necrosis. None of the tumors had invaded the surrounding tissue.

Specimens of brain tissue were available for histo-
logic examination in 20 of 23 dogs that had neurologic signs, and histologic changes were seen in 90% (18/20). In the 18 dogs, we noted edema or necrosis of the neural tissue adjoining the tumor, and in six dogs, direct invasion by the neoplasm. Brain sections in two dogs that did not have neurologic signs also were examined, and degenerative changes were seen. Thus, 20 of 22 dogs (91%) in which brain tissue was examined had pathologic changes in the brain.

Seven of the 28 dogs (25%) had tumors in addition to intracranial meningioma, including one pheochromocytoma, hemangiosarcoma, seminoma, nonchromaffin paraganglioma, adrenocortical adenoma, pulmonary adenocarcinoma, and two cavernous hemangiomas.

Discussion

Intracranial meningiomas, which are the second most common tumor of the central nervous system (CNS) in the dog, are usually reported as single or multiple case reports. A comprehensive review of 31 cases was published in 1973. The present series, however, is the largest group reported from a single institution. The study was made in conjunction with a separate study of paranasal meningiomas in the dog in order to compare the clinical and morphologic features of the two tumor types.

There was no sex predominance in the dogs with intracranial meningioma (13 males, 12 females). This finding agrees with data obtained in two previous reports of canine meningioma. It differs, however, from findings in cats and man; in cats, males predominate while in humans there is a clear predominance of females.

The mean age in our study was 11 years which is slightly higher than the mean age (9 years) of the 31 dogs of the review cited. It is similar to that in cats and comparable to that in human patients with intracranial meningioma. Eighty-three percent (20/24) of our dogs were 10 years or older, whereas only 35% (11/31) of the dogs in the 1973 review were 10 years old or older; the percentage is even lower for a group of nine subsequently reported cases. No explanation can be given for this difference in age distribution found among the various groups of dogs. It has been suggested that boxers, poodles, German shepherds, collies, and terriers have a higher prevalence of intracranial meningioma than other breeds. In our series, German shepherds and mixed-breed dogs, each accounting for 31% of the cases, were the most commonly affected breeds.

In contrast to previous reports, in 58% (15/26) of the dogs of this series, the meningioma involved the dorsal aspect of the cranial cavity, and the anterior half was far more frequently involved (67%, 10/15) than the posterior half. This is also true in man. In the cat, the dorsal surface and the supratentorial meninges are most commonly affected. Multiple intracranial meningiomas, not uncommon in man and reported in up to 17% of cats with meningioma, were seen in only one of our 28 dogs (4%) and not at all in the 1973 review. The ventricles were not involved in any of our dogs, whereas this is not an uncommon finding in cats and human patients with intracranial meningioma.

Meningiomas in animals have not been classified according to histomorphology, even though in man they have been classified into a wide variety of types and subtypes. We have observed that in the meningiomas of both the dog and cat, although some of them have more than one histologic pattern, one pattern predominates, and in some tumors there is only one pattern. In a few of the tumors of this study, there were areas characterized by changes similar to xanthomatous changes making them compatible with some of the subtypes of the human classification. However, we adopted only the main histologic types of the classification system which accommodate the tumors we saw. We believe that it is essential to classify these tumors so that future studies can determine the prevalence of histologic types and their biologic behavior.

There are no reports of angioblastic meningioma in...
the veterinary literature. The differentiating factors between angioblastic meningioma and vascular tumors are that angioblastic meningiomas are characterized by whorls as well as a vascular component; an intracranial location for primary angiosarcoma would be rare; and individual cells and nuclei of angiosarcomas, especially hemangiosarcomas, are much more anaplastic than the cells of meningiomas.

In this study, the transitional (46%) and meningotheliomatous (39%) meningiomas were the major histologic types, but no cytologic features of malignancy were seen, except in the fibroblastic tumor. In 27% (6/22) of the cases, infiltration of neural tissue rather than compression was seen, a sign of malignancy. Distant metastasis was not seen. Cases of malignant meningioma with distant metastasis have rarely been reported in man or dogs and never in cats.

We found no correlation between histologic type of tumor and invasion of the brain; in man it has been debatable whether or not histologic type and invasion are related. In our unpublished study of ten paranasal meningiomas in the dog, there was invasion of the surrounding tissue in 80% (8/10) of the cases; both grossly and histologically, the paranasal neoplasms were more malignant than the intracranial meningiomas of this study.

Eighty-eight percent (23/26) of the dogs in this series had neurologic signs. In 90% of the dogs in which the brain was examined (18/20), histologic changes were noted, including neoplastic invasion of the surrounding tissue in six dogs. Neurologic signs are the most common clinical signs on examination in dogs and human patients with intracranial meningioma, while in cats only 69% in one survey had neurologic signs.

According to the findings of this study, a high percentage of intracranial meningiomas do not invade the brain and a high percentage have clinical signs. It is important to find means of early diagnosis and treatment.

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References


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