Canine prostatic disease is commonly evaluated with abdominal ultrasound and radiographs. Mineralization of the prostate is often reported, but the clinical relevance of this finding is currently not known. The purpose of this study was to characterize the relationship between ultrasonographic and radiographic prostatic mineralization and the final diagnosis. Medical records of 55 dogs with evidence of prostatomegaly or prostatic mineralization and a cytologic diagnosis were evaluated. Radiographs and ultrasound images were assessed for caudal retroperitoneal lymphadenopathy, vertebral lesions, or other signs of metastasis, and mineralization was assessed semiquantitatively. Twenty-two of 55 (40%) dogs had prostatic neoplasia. Regarding neoplasia, mineralization in neutered dogs had a positive predictive value (PPV) of 100%, a negative predictive value (NPV) of 50%, and a sensitivity and specificity of 84% and 100%, respectively. Mineralization in intact dogs had a PPV of 22%, an NPV of 96%, and a sensitivity and specificity of 67% and 77%, respectively. All neutered dogs with prostatomegaly but not prostatic neoplasia had bacterial prostatitis and were castrated within the previous 3 months. Intact dogs with prostatomegaly and mineralization but not neoplasia had paraprostatic cysts ($n = 3$), benign prostatic hyperplasia ($n = 2$) or prostatitis ($n = 2$). Mineralization score was not indicative of neoplasia. In conclusion, neutered dogs with prostatic mineralization were very likely to have prostatic neoplasia. Intact dogs were unlikely to have prostatic neoplasia if no mineralization was found on radiographs or ultrasound. Veterinary Radiology & Ultrasound, Vol. 50, No. 2, 2009, pp 167–171.

Key words: prostatic mineralization, prostatomegaly, radiography, ultrasound.

Introduction

Prostatic carcinoma is a highly malignant neoplasm in the dog with a prevalence of 0.2–0.6%.1 Prostatic neoplasia must be distinguished from nonmalignant prostatic disease so that appropriate management can be initiated. Castrated dogs appear to be at risk for prostatic carcinoma,2,3 with an odds ratio of 2.384–4.343 compared with intact dogs. Castration after sexual maturity does not reduce the risk of developing prostatic carcinoma.2–4

Adenocarcinoma is the most common tumor in intact dogs, while tumors of mixed morphology were more common in castrated dogs.5 Of 11 castrated dogs with prostatic disease, eight had prostatic neoplasia and three had bacterial prostatitis.6 However, two of the three castrated dogs with prostatitis had been neutered because of clinical signs associated with prostatic infection. This, in addition to a paucity of reports in the literature indicating otherwise, suggests it is rare for castrated dogs to develop prostatic disease other than neoplasia.

At our institution, the presence of mineralization in the prostate identified with either abdominal radiographs or ultrasound is considered highly suspicious for prostatic neoplasia. Prostatic mineralization is considered even more suspicious for neoplasia if the dog is neutered. A previous study supports this postulation in that multifocal, irregularly shaped, parenchymal mineral opacities were only seen in dogs with prostatic carcinoma and one dog with chronic bacterial prostatitis.7 Other reports describe the presence of mineralization associated with paraprostatic cysts but that the appearance of the cyst wall mineralization was characteristic and easily distinguishable from parenchymal mineralization.8,9

The purpose of this retrospective study was to determine the underlying disease process in a large number of dogs with radiographic or ultrasonographic evidence of prostatic mineralization. This was compared with a population of dogs with an imaging diagnosis of prostatomegaly but no evidence of mineralization. We hypothesized that most sexually intact dogs with prostatic mineralization would have prostatic neoplasia or paraprostatic cysts. In the event of prostatic mineralization in dogs with nonneoplastic disease, we anticipated that mineralization would be less severe than that seen in dogs with neoplastic disease.
prostatic disease. Moreover, we anticipated that all neutered dogs with prostatic mineralization would have prostatic neoplasia.

Materials and Methods

Dogs with radiographic or ultrasonographic evidence of prostatomegaly or prostatic mineralization imaged between March 1993 and April 2006 were identified. Dogs were included if a cytologic or histopathologic diagnosis had been made and if the radiographs or ultrasonographic images were available for review and there was evidence of prostatomegaly or prostatic mineralization. Dogs were excluded if the time between imaging and final diagnosis was greater than 1 month, or if there was questionable radiographic or ultrasonographic evidence of either prostatomegaly or prostatic mineralization.

Records were reviewed by two of the authors (R.E.P. and C.M.B.) and information regarding signalment, radiographic and ultrasonographic findings, cytologic and histopathologic findings, and method of tissue sampling was recorded. When radiographs were available, the ratio of prostatic height to the pubic brim–sacral promontory dimension as measured on the lateral abdominal radiograph was calculated. Prostatomegaly was defined as a ratio greater than 0.70.

Radiographic prostatic mineralization was defined as the presence of mineral opacities within the prostate. For ultrasound images, prostatomegaly was defined subjectively based on impressions noted by the clinician in the imaging report. Prostatic mineralization on abdominal ultrasonography was defined as areas of high reflectivity within the prostatic parenchyma that caused distal acoustic shadowing. A semiquantitative scale of mineralization was established where a score of 0 indicated no mineralization, 1 indicated mild mineralization, 2 indicated moderate mineralization, and 3 indicated severe mineralization (Fig. 1).

Radiographs and ultrasonographic images and reports were reviewed and evidence of caudal retroperitoneal lymphadenopathy, vertebral lesions, and pulmonary metastatic disease was recorded.

Ultrasound-guided fine-needle aspiration (FNA) and cytologic evaluation are often used to determine the underlying etiology of prostatic disease. Although histopathologic diagnosis of prostatic disease remains the gold standard, there is agreement between cytologic and histopathologic diagnoses for prostatic disease. Therefore, both types of sampling techniques were included in our study. All cytologic and histopathologic samples were prepared and evaluated in our institution. Samples for cytologic diagnosis were collected by ultrasound-guided FNA or traumatic catheterization. Histopathologic diagnosis was made from samples collected via biopsy or necropsy.

When dogs had evidence of mineralization, they were divided into two groups based on neoplastic and nonneoplastic diagnoses. The age, prostatic mineralization score, and prostatic size were compared between neoplastic and nonneoplastic groups using an unpaired Student’s t-test (Excel*). A P-value ≤ 0.05 was considered significant. The positive and negative predictive values (PPV, NPV), specificity, and sensitivity of evidence of mineralization in intact and in castrated dogs were calculated.

Results

Of 199 records reviewed, 55 dogs met the inclusion criteria. A variety of breeds were included with no breed be-
ing overrepresented. Thirty-four dogs (62%) were sexually intact while 21 (38%) were castrated. All dogs had either radiographs (n = 17), ultrasound images (n = 12), or both (n = 26) available for review. Diagnoses were obtained in 21 dogs via prostatic aspirates, 19 by biopsy, two had traumatic catheterization, and in 13 dogs, a diagnosis was obtained at necropsy.

Of the 55 dogs, 22 (40%) had prostatic neoplasia and 33 (60%) had nonneoplastic diseases. Table 1 defines the cytologic diagnosis in the 55 dogs. Nineteen of 22 (86%) dogs with neoplasia were castrated and three (14%) were intact. Eighteen of the 22 (82%) dogs with prostatic neoplasia had evidence of mineralization; of the four dogs without mineralization, two had prostatic carcinoma, one had transitional cell carcinoma, and one had anal sac adenocarcinoma. The mean (± standard deviation) age for dogs with neoplasia was 9.45 (± 1.97) years.

Thirty-one of 33 (94%) dogs with nonneoplastic disease were intact. The two neutered dogs in the nonneoplastic group had been neutered within the previous 3 months due to clinical signs associated with prostatic disease and neither dog had evidence of mineralization. Seven of 33 (21%) dogs with nonneoplastic prostatic disease had evidence of mineralization; of those, two had benign prostatic hyperplasia, two had prostatitis, and three had paraprostatic cysts. The mean (± standard deviation) age for dogs without neoplasia was 8.34 (± 3.14) years. Age was not significantly different between neoplastic and nonneoplastic groups (P = 0.07).

Of the 43 dogs that had radiographs available for review, 14 (33%) had prostatic neoplasia and 29 (67%) had nonneoplastic prostatic disease. There was no significant difference in the ratio of prostatic height to the pubic brim–sacral promontory dimension when comparing dogs with and without neoplasia [0.70 ± 0.17 vs. 0.76 ± 0.13 (mean ± standard deviation); P = 0.22]. Furthermore, when evaluating the mean prostatic mineralization score, no significant difference between dogs with prostatic neoplasia and those with nonneoplastic processes was found (1.8 ± 0.62 vs. 1.6 ± 0.24; P = 0.60). Additional radiographic lesions such as pulmonary metastatic disease (n = 4), or periosteal reaction on the vertebra (n = 3), ilium (n = 1), or femurs (n = 1), and/or enlarged caudal retroperitoneal lymph nodes (n = 6) were seen in dogs with prostatic neoplasia. Only two dogs with nonneoplastic disease had retroperitoneal lymph node enlargement.

Of the 38 dogs that had ultrasound images available for review, 18 (47%) had prostatic neoplasia and 20 (53%) had nonneoplastic disease. The mean mineralization score for dogs with prostatic neoplasia was significantly higher compared with dogs with nonneoplastic disease [2.4 ± 0.81 vs. 1.1 ± 1.01; (mean ± standard deviation) P = 0.02]. Assessment for additional lesions was compromised by a limited number of available images; however, six dogs with prostatic neoplasia had retroperitoneal lymph node enlargement, whereas only two dogs with nonneoplastic disease had lymphadenopathy. Of the 26 dogs that had both radiographs and ultrasound images available for review, the mineralization score was not significantly different for the two imaging modalities (P = 0.74).

Sixteen of 21 intact dogs in this study had prostatic mineralization and all 16 (100%) had neoplasia. Nine of 34 intact dogs in this study had evidence of mineralization and two (22%) had neoplasia. The PPV and NPV, sensitivity, and specificity for the presence of mineralization in cases of neoplasia are shown for neutered and intact dogs in Table 2. Note that the PPV of prostatic mineralization in neutered dogs is 100%, meaning that the presence of mineralization indicates neoplasia. The high NPV indicates that intact dogs without prostatic mineralization are very unlikely to have neoplasia.

Table 1. Cytologic Diagnosis for 55 Dogs with Prostatomegaly and/or Prostatic Mineralization

<table>
<thead>
<tr>
<th>Cytologic Diagnosis</th>
<th>Number of Dogs (%)</th>
<th>Cytologic Diagnosis</th>
<th>Number of Dogs (%)</th>
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</thead>
<tbody>
<tr>
<td>Prostatic carcinoma</td>
<td>14 (64%)</td>
<td>Prostatitis</td>
<td>22 (67%)</td>
</tr>
<tr>
<td>Transitional cell carcinoma</td>
<td>5 (24%)</td>
<td>Benign prostatic hyperplasia</td>
<td>7 (21%)</td>
</tr>
<tr>
<td>Undifferentiated carcinoma</td>
<td>1 (4%)</td>
<td>Paraprostatic cyst</td>
<td>3 (9%)</td>
</tr>
<tr>
<td>Anal sac adenocarcinoma</td>
<td>1 (4%)</td>
<td>Cystic hyperplasia</td>
<td>1 (3%)</td>
</tr>
<tr>
<td>Lymphosarcoma</td>
<td>1 (4%)</td>
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</tr>
</tbody>
</table>

Dogs are divided into neoplastic and nonneoplastic categories.

Results for intact and neutered dogs are shown separately.

**Discussion**

Based on our results, castrated dogs with prostatic mineralization have a high likelihood of having prostatic neoplasia. Furthermore, intact dogs with prostatic mineralization may have diseases other than neoplasia including
paraprostatic cysts, benign prostatic hyperplasia, or prostatitis. Differentiation of these diseases is essential to provide veterinarians with the tools needed to manage each disorder properly.

In people, prostatic disease is a frequent disorder in older men. We suspected that dogs with severe mineralization and the specific disease was not characterized. We ascertained. The radiographic mineralization score, was significantly higher in dogs with malignant prostatic disease. Differentiation between neoplastic and nonneoplastic disease cannot be explained properly.

Furthermore, in our population was 100%, whereas intact male dogs with prostatic mineralization may have either neoplastic or nonneoplastic prostatic disease. Intact dogs without radiographic or ultrasonographic evidence of prostatic mineralization were unlikely to have prostatic neoplasia, having an NPV of 96%. The size of the prostate gland was not useful for differentiating between malignant and benign prostatic disease. Sonographic mineralization score, but not radiographic mineralization score, was significantly higher in dogs with malignant prostatic disease. Differentiation between neoplastic and nonneoplastic disease cannot be made in intact dogs based on concurrent prostatic mineralization and caudal retroperitoneal lymphadenopathy, but if pulmonary metastatic disease or periosteal reactions on vertebra, ilium, or femur were only seen in dogs with prostatic neoplasia.

In summary, neutered dogs with prostatic mineralization are likely to have prostatic neoplasia as the PPV and specificity in our population was 100%, whereas intact male dogs with prostatic mineralization may have either neoplastic or nonneoplastic prostatic disease. Intact dogs without radiographic or ultrasonographic evidence of prostatic mineralization were unlikely to have prostatic neoplasia, having an NPV of 96%. The size of the prostate gland was not useful for differentiating between malignant and benign prostatic disease. Sonographic mineralization score, but not radiographic mineralization score, was significantly higher in dogs with malignant prostatic disease. Differentiation between neoplastic and nonneoplastic disease cannot be made in intact dogs based on concurrent prostatic mineralization and caudal retroperitoneal lymphadenopathy, but if pulmonary metastatic disease or periosteal reactions on vertebra, ilium, or femur were only seen in dogs with prostatic neoplasia, then neoplasia is highly likely.

REFERENCES