Comparison of serologic evaluation via agar gel immunodiffusion and fungal culture of tissue for diagnosis of nasal aspergillosis in dogs

Jill S. Pomrantz, DVM, DACVIM; Lynelle R. Johnson, DVM, PhD, DACVIM; Richard W. Nelson, DVM, DACVIM; Erik R. Wisner, DVM, DACVR

**Objective**—To compare the sensitivity and specificity of serologic evaluation and fungal culture of tissue for diagnosis of nasal aspergillosis in dogs.

**Design**—Prospective study.

**Animals**—58 dogs with nasal discharge and 26 healthy dogs.

**Procedures**—Dogs with nasal discharge were anesthetized and underwent computed tomography and rhinoscopy; nasal tissues were collected for histologic examination and fungal culture. Sera were assessed for antibodies against *Aspergillus* spp (healthy dog sera were used as negative control specimens). Nasal aspergillosis was diagnosed in dogs that had at least 2 of the following findings: computed tomographic characteristics consistent with aspergillosis, fungal plaques detected during rhinoscopy, and histologically detectable fungal hyphae in nasal tissue. Histologic characteristics of malignancy were diagnostic for neoplasia. Without evidence of neoplasia or fungal disease, nonfungal rhinitis was diagnosed.

**Results**—Among the 58 dogs, 21 had nasal aspergillosis, 25 had nonfungal rhinitis, and 12 had nasal neoplasia. Fourteen aspergillosis-affected dogs and 1 dog with nonfungal rhinitis had serum antibodies against *Aspergillus* spp. Fungal culture results were positive for *Aspergillus* spp only for 17 dogs with aspergillosis. With regard to aspergillosis diagnosis, sensitivity, specificity, and positive and negative predictive values were 67%, 98%, 93%, and 84%, respectively, for serum anti-*Aspergillus* antibody determination and 81%, 100%, 100%, and 90%, respectively, for fungal culture.

**Conclusions and Clinical Relevance**—Results suggest that seropositivity for *Aspergillus* spp and identification of *Aspergillus* spp in cultures of nasal tissue are highly suggestive of nasal aspergillosis in dogs; however, negative test results do not rule out nasal aspergillosis.


*Aspergillus* spp are saprophytic fungi that are ubiquitous in the environment. Various species of *Aspergillus* can cause disease in the nasal cavity and sinuses or, less commonly, are associated with invasive systemic infection of other organs, such as kidneys or bones.\(^1\)\(^2\)\(^3\)\(^4\)\(^5\)\(^6\) The nasal form of disease in dogs is usually caused by infection with *Aspergillus fumigatus*. Nasal aspergillosis typically affects young to middle-aged dolicocephalic and mesocephalic dogs. Common clinical signs in dogs include chronic nasal discharge, signs of facial pain, and depigmentation with ulceration of the nasal planum.\(^5\)\(^6\)

*Aspergillus* spp are a common cause of chronic nasal discharge in dogs, and the reported prevalence is 12% to 34% of dogs examined because of nasal discharge.\(^5\)\(^6\) diagnosis of nasal aspergillosis is based on a combination of the findings of diagnostic imaging, serologic evaluation, rhinoscopy, histology, and mycotic cultures.\(^7\)\(^8\)\(^9\) Several serologic tests for *Aspergillus* spp are available, including AGID assay, ELISA, and counterimmunoelectrophoresis.\(^4\) The most commonly used serologic test involves AGID. Sensitivity and specificity of AGID assessment for diagnosis of nasal aspergillosis was 100% in 1 study,\(^3\) but another study\(^6\) revealed that the rate of false-positive results in dogs with nasal tumors was 15%.

Fungal culture of nasal tissue samples has also been used to establish the diagnosis of nasal aspergillosis in dogs. However, positive results of fungal culture alone are not definitive for nasal aspergillosis. Histologic confirmation of fungal invasion of nasal tissue is perhaps the most definitive diagnostic test but, depending on the sampling technique used, drawbacks include the need for anesthesia, rhinoscopy, surgery, and development of potentially severe epistaxis. The rate of false-positive results for aspergillosis associated with fungal

**Abbreviations**

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<tr>
<td>AGID</td>
<td>Agar gel immunodiffusion</td>
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<td>VMTH</td>
<td>Veterinary medical teaching hospital</td>
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<td>CT</td>
<td>Computed tomography</td>
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From the Veterinary Medical Teaching Hospital (Pomrantz) and the Departments of Veterinary Medicine and Epidemiology (Johnson, Nelson) and Veterinary Surgical and Radiological Sciences (Wisner), School of Veterinary Medicine, University of California, Davis, CA 95616. Dr. Pomrantz’s present address is Institute of Comparative Medicine, Columbia University New York, NY 10032. Supported by the Center for Companion Animal Health (03-73-R), University of California, Davis, and the Bailey Wrigley Fund. Presented in part at the 23rd Annual Forum of the American College of Veterinary Internal Medicine, Baltimore, June 2005. Address correspondence to Dr. Johnson.
culture of tissues from healthy dogs and dogs with nasal neoplasia is 30% to 40%.\textsuperscript{6,9}

We hypothesized that advances in serologic testing and fungal culture techniques should improve the sensitivity and specificity of these tests with regard to definitively establishing the cause of nasal disease, specifically in the diagnosis of aspergillosis. The purpose of the study reported here was to determine the sensitivity and specificity of serologic evaluation and fungal culture of tissue in the diagnosis of nasal aspergillosis in dogs. To achieve this, results of these tests for dogs with confirmed nasal aspergillosis and those for dogs with nasal neoplasia or nonfungal rhinitis were compared.

Materials and Methods

All dogs for which a full diagnostic evaluation of nasal discharge had been performed at the VMTH at the University of California, Davis, between November 2003 and August 2005 were eligible for inclusion in the study. Physical examination and routine clinicopathologic analyses were completed for all dogs. The diagnostic evaluation of nasal discharge included assessment of serum anti-Aspergillus spp antibodies, CT imaging of the nasal cavity, rhinoscopy, and procurement of nasal tissue samples for histologic examination and fungal culture.

Serologic evaluations for Aspergillus spp were performed in the VMTH immunology laboratory by use of a commercially available AGID test.\textsuperscript{4} This immunodiffusion system is based on the principle of double diffusion, as described by Ouchterlony and Oudin.\textsuperscript{10,11} Briefly, a sample of the dog’s serum and a positive control sample were placed in wells of an agar plate surrounding a center well containing Aspergillus antigen (aspergillin). The aspergillin was composed of a purified, alcohol-prepitated carbohydrate preparation from mycelial phase cultures of A fumigatus, Aspergillus niger, and Aspergillus flavus. The positive control sample contained antibodies against A fumigatus, A niger, and A flavus. The antigen diffused outward toward the wells containing the positive control or patient serum sample. A visible line of precipitate formed at the point of equivalence if the sample well contained antibodies against Aspergillus spp. The agar gel was stored in an incubator at 25°F (77°C) for a minimum of 72 hours before the test was interpreted. Interpretation was facilitated by use of a calibrated viewer.\textsuperscript{12} Test results were qualitative, and each was reported as a positive or negative result for antibodies against Aspergillus spp. The sera obtained from study dogs were either submitted immediately or stored for as long as 1 month at –20°C (–4°F) prior to testing, according to test kit instructions.

For CT imaging and rhinoscopy, dogs were premedicated according to individualized protocols (determined by the attending anesthesiologist) and were anesthetized with isoflurane. Dogs were positioned in sternal recumbency, and CT images were acquired by use of a helical CT scanner.\textsuperscript{13} Images were reviewed by a board-certified radiologist (ERW), who was unaware of the final diagnosis, for the presence or absence of imaging features characteristic of aspergillosis, including cavitated turbinate lysis, thick mucosa along the nasal turbinates, and a frontal sinus proliferative mass effect.\textsuperscript{12-14} An ordinal score was assigned to each CT image for the level of certainty of aspergillosis as a diagnosis (score of 1, definitely not; 2, unlikely; 3, equivocal; 4, likely; and 5, definite). Dogs with scores of 4 and 5 were placed in the aspergillosis group if 1 additional criterion was met, and dogs with a CT score of 3 were included if 2 additional criteria were met.

Rhinoscopy included use of a 5.0-mm flexible endoscope\textsuperscript{4} to examine the caudal aspect of the nasopharynx and a 2.8-mm 0° or 30° viewing rigid endoscope\textsuperscript{4} to examine the nasal cavity. Abnormalities recorded during examination included the presence of mass lesions, destructive rhinitis (turbinate loss and cavitation in the nasal cavity), mucosal hyperemia, mucus accumulation, and detection of fungal plaques (white, yellow, black, or light green) on the mucosa of the nasal cavity.

Because rhinoscopy was performed by multiple clinicians, independent confirmation of the presence of fungal plaques was performed by evaluation of the rhinoscopic images by an individual who was unaware of the final diagnosis. Available images from 33 of 38 study dogs were reviewed by one of the authors (RWN) to convey the level of certainty for identification of fungal plaques; an ordinal score was assigned (score of 1, definitely not a plaque; 2, equivocal; and 3, definitely a plaque). Dogs with scores of 3 were placed in the aspergillosis group if 1 additional criterion was met, and dogs with scores of 2 were placed in the aspergillosis group if 2 additional criteria were met.

Separate nasal tissue samples for histologic examination and for fungal culture were obtained from 1 or both sides of the nasal cavity by use of 2- or 3-mm cup biopsy instruments.\textsuperscript{11} In dogs with lesions suggestive of fungal plaques, samples of a plaque and adjacent mucosa were collected with endoscopic guidance for histologic examination and culture. In dogs with mass lesions, nasal samples of abnormal regions were obtained with endoscopic guidance for histologic examination and culture. If mucus or blood obscured collection sites of nasal samples, cold saline (0.9% NaCl) solution was instilled and suction was applied to clear the field of view. Approximately 3 to 5 nasal biopsy specimens were obtained from both nasal cavities of each dog. Nasal samples for histologic examination were immersion fixed in neutral-buffered 10% formalin, routinely processed, embedded in paraffin, sectioned at a thickness of 4 μm, and stained with H&E for evaluation by a board-certified pathologist. Histologic evidence supportive of a diagnosis of aspergillosis was identification of fungal elements, including infiltrating tissue hyphae (septate and branching) in the nasal biopsy sample.

Nasal samples for culture of Aspergillus organisms were placed in a sterile serum separator tube and transported immediately to the VMTH microbiology laboratory, where they were initially plated on inhibitory mold agar\textsuperscript{6} to assess fungal growth. The inhibitory mold agar contained chloramphenicol to inhibit bacterial growth. Inoculated agar was incubated at 30°C (86°F) for a maximum duration of 1 month. If the initial culture was positive for fungal growth, speciation was performed for isolates grown on potato flake agar\textsuperscript{6} and Czapek-Dox agar.\textsuperscript{b} Fungal identification was based on the gross appearance of the colonies on the agar, as well as mor-
phologic features of the fungus that were identified via light microscopy, including the shape of the vesicle and uniseriate or biseriate appearance of the phialides. For microscopic evaluation, a tape preparation was stained with lactophenol cotton blue. On potato flake agar, the gross surface of A fumigatus was most commonly blue-green to gray-green, the texture was downy to powdery, and the reverse color was pale or yellowish. Microscopically, A fumigatus was distinguished by its columnar conidial heads and uniseriate phialides that are concentrated on the upper third portion of the vesicle.13

Serologic control specimens were obtained from 26 healthy dogs lacking nasal discharge that were part of the veterinary school spay and neuter program. All dogs were obtained from a local humane shelter and placed in the care of the program organizers during the procedures. A history was obtained and physical examination and routine clinicopathologic analyses were performed for each dog in that program, and permission to use the unused portion of the serum as control specimens in the study was granted by the program organizers. Nasal biopsy specimens for histologic examination and fungal culture were not collected from the healthy dogs because of program constraints.

On the basis of clinical findings, study dogs were categorized as having aspergillosis, neoplasia, or nonfungal rhinitis. A diagnosis of aspergillosis was made if findings of at least 2 of 3 diagnostic tests (CT imaging, rhinoscopy, and histologic examination of nasal tissue) were consistent with aspergillosis. A diagnosis of neoplasia was made on the basis of interpretation of histologic findings (ie, characteristics of malignancy) in nasal biopsy specimens. A diagnosis of nonfungal rhinitis was made on the basis of exclusion of neoplasia or fungal rhinitis by use of the aforementioned diagnostic tests, as well as the lack of progression of disease during the study period.

Statistical analysis—Clinical characteristics (age, weight, and duration of clinical signs) were compared among groups. Data were assessed for normality by use of a Kolmogorov-Smirnov test, and normally distributed data were compared by use of a 1-way ANOVA. Data that were not normally distributed were compared by use of a Kruskal-Wallis analysis. Data are presented as mean ± SD or median with range where applicable. Characteristics of clinical signs (presence of nasal discharge, sneezing, and epistaxis) were analyzed for significant differences among groups by use of a $\chi^2$ test. For all comparisons, significance was set at a value of $P < 0.05$. The aforementioned statistical analyses were performed by use of computer software.1

Sensitivity, specificity, and positive and negative predictive values (with regard to the diagnosis of aspergillosis) were calculated for the AGID test and fungal culture of tissue by use of computer software. Sensitivity was calculated as the number of dogs with aspergillosis that had positive test results divided by the total number of dogs with aspergillosis; specificity was calculated as the number of dogs without aspergillosis that had negative test results divided by the total number of dogs without aspergillosis. Positive predictive value was calculated as the number of dogs with aspergillosis that had positive test results divided by the total number of dogs with aspergillosis; negative predictive value was calculated as the number of dogs without aspergillosis that had negative test results divided by the total number of dogs with negative test results. Results are presented as proportions with 95% confidence intervals. The results of the AGID test obtained from the healthy dogs (negative control group) and the neoplasia and nonfungal rhinitis groups were used in the calculation of specificity for the AGID test. The results of fungal culture obtained from the neoplasia and nonfungal rhinitis groups were used in the calculation of specificity for fungal culture of tissues. The AGID test results obtained from the healthy dogs were not used in the calculation of the negative predictive value.

Results

Fifty-eight dogs with nasal discharge were entered into the study and were subsequently categorized as having nasal aspergillosis (n = 21), nonfungal rhinitis (25), or neoplasia (12). Dogs with aspergillosis included 12 castrated males, 1 sexually intact male, and 8 spayed females. Dogs with nonfungal rhinitis included 11 castrated males, 1 sexually intact male, and 13 spayed females. Dogs with nasal neoplasia included 8 castrated males, 1 sexually intact male, and 3 spayed females. Mean ± SD weight was 31.0 ± 12.7 kg (68.2 ± 27.9 lb), 31.2 ± 10.7 kg (68.6 ± 23.5 lb), and 25.4 ± 15.6 kg (55.9 ± 34.3 lb) for the aspergillosis, neoplasia, and nonfungal rhinitis groups, respectively ($P = 0.28$). Mean age was 6.3 ± 3.7 years, 9.1 ± 2.2 years, and 7.4 ± 3.8 years for the aspergillosis, neoplasia, and nonfungal rhinitis groups, respectively ($P = 0.10$). Healthy control dogs were obtained from a shelter; for each dog, age was listed as juvenile or mature on the basis of physical appearance and condition of the teeth. Healthy control dogs included 1 juvenile and 25 mature dogs; 16 dogs were sexually intact males, and 10 were sexually intact females. Mean ± SD weight of the healthy dogs was 22.3 ± 9.4 kg (49.1 ± 20.7 lb). There was no significant difference ($P = 0.06$) in weights between healthy dogs and dogs with nasal disease.

Clinical signs included nasal discharge (20/21, 10/12, and 22/25 dogs), sneezing (17/21, 7/12, and 15/25 dogs), and epistaxis (12/21, 10/12, and 6/25 dogs) in the aspergillosis, neoplasia, and nonfungal rhinitis groups, respectively. There were no significant differences among groups with respect to presence of nasal discharge or sneezing, but epistaxis was reported significantly more often in dogs with neoplasia and dogs with aspergillosis, compared with dogs with rhinitis ($P = 0.001$ and $P = 0.02$, respectively). The prevalence of epistaxis was similar between dogs with neoplasia and aspergillosis ($P = 0.08$). Duration of clinical signs did not differ ($P = 0.65$) among groups; the median (range) values were 120 days (range, 7 to 345 days), 123 days (range, 36 to 730 days), and 180 days (range, 9 to 1,825 days) in the aspergillosis, neoplasia, and nonfungal rhinitis groups, respectively.

Results of CT examinations were consistent with aspergillosis in 20 of 21 dogs in the aspergillosis group (score = 4 or 5). One dog had an equivocal score of 3.
Via rhinoscopy, nasal plaques were detected in this dog (score = 3), and histologically, fungal elements were detected in biopsy specimens; therefore, the dog met the criteria for inclusion in the group of dogs with a diagnosis of aspergillosis. Thirty-six of 37 dogs without aspergillosis were assigned CT scores of 1 or 2. In 1 dog with nonfungal rhinitis, the CT images were considered highly indicative of aspergillosis (score = 5); however, fungal plaques were not identified during rhinoscopy and fungal elements were not detected via histologic examination of nasal biopsy specimens. For this dog, the final diagnosis was an extensive oronasal fistula.

Rhinoscopic images were available for review from 33 of 38 dogs. Among 19 dogs with aspergillosis, the rhinoscopic image was considered definitely indicative of a plaque lesion in 17 (score = 3) and equivocal in 2 (score = 2) dogs. For the 2 dogs with equivocal findings, CT characteristics were consistent with aspergillosis (score = 3) and fungal elements were detected histologically in nasal biopsy specimens. Among 8 dogs without neoplasia, the rhinoscopic image was considered equivocal for plaques in 2 and definitely not plaque lesions in 6. In 6 dogs with nonfungal rhinitis, all rhinoscopic images were graded as definitely not plaque lesions (score = 1). Plaques were identified during rhinoscopy by the primary clinician in all dogs with aspergillosis and in none of the dogs in other groups.

Fungal hyphae were detected during histologic examination of tissue specimens from 17 of 21 (81%) dogs with aspergillosis. For dogs with neoplasia, histologic diagnoses included carcinoma (n = 6 dogs), sarcoma (3), lymphoma (1), plasmacytoma (1), and mesenchymal tumor (1). The most common histologic findings in dogs with nonfungal rhinitis were lymphoplasmacytic and neutrophilic rhinitis (19/25 [76%] dogs). Two dogs had foreign bodies (which were subsequently removed), 3 dogs had eosinophilic inflammation, and 1 dog had no histologic abnormalities.

Evaluations of sera for antibodies against *Aspergillus* spp yielded positive results for 14 of 21 dogs with aspergillosis and 1 of 25 dogs with nonfungal rhinitis; no antibodies against *Aspergillus* spp were detected in any of the 12 dogs with neoplasia or the 26 healthy dogs. The positive AGID test result in the nonfungal rhinitis group was obtained from a 2-year-old spayed female Rottweiler that had a history of bilateral serous nasal discharge for 23 days; the dog had a CT score of 2 (unlikely) for aspergillosis and no evidence of fungal infection detectable via rhinoscopy and microbiologic and histologic examinations (the latter of which revealed lymphoplasmacytic rhinitis). Fungal culture of nasal tissue yielded growth of *A. fumigatus* in 17 of 21 dogs with aspergillosis; positive culture results were not obtained for any of the 25 dogs with rhinitis or the 12 dogs with neoplasia. No growth of other *Aspergillus* spp was identified via fungal culture. In regard to diagnosis of aspergillosis in dogs with nasal discharge, sensitivity, specificity, and positive and negative predictive values with 95% confidence intervals were calculated for the AGID test and fungal culture of tissue (Table 1).

### Discussion

For the diagnosis of aspergillosis in dogs with nasal disease, results of the present study have suggested that serologic evaluation (via an AGID test) and fungal culture of nasal tissue for detection of *Aspergillus* spp have high specificity. Negative results of serologic evaluation and fungal culture cannot be used to rule out nasal aspergillosis, but positive results should be considered highly suggestive of the infection.

Diagnosis of nasal aspergillosis is difficult because currently there is no single test with which that diagnosis can be definitively established. In 1 study in dogs,14 the diagnosis was made on the basis of various combinations of radiographic, serologic, rhinoscopic, and mycologic culture findings, although there were no clear recommendations for confirmation of the diagnosis. In other studies,7,8,16 the diagnosis was made on the basis of gross evidence of aspergillosis detected during surgery or histologic examination, or a combination of positive results of testing for anti-*Aspergillus* spp antibodies and either growth of the organism in culture or radiographic evidence of fungal disease. Importantly, most studies have relied on invasive tests for the diagnosis or exclusion of nasal aspergillosis.

Results of our study confirm that these tests are required to make a definitive diagnosis in many dogs; however, our data also suggest that positive results of serologic evaluation and fungal culture of tissue for *Aspergillus* spp can be considered highly suspicious for disease.

Sensitivity of the AGID serologic test for detection of *Aspergillus* infection in the present prospective study was only 67%, which is less than the 100% sensitivity determined for that test in a previous study7 in 10 dogs. This suggests that aspergillosis as the cause of nasal discharge cannot be ruled out on the basis of negative AGID test results alone.

In our study, the specificity of the AGID test for detection of *Aspergillus* infection was 98%, which is similar to the findings of a previous study3 wherein the specificity was 100%. However, in a separate report,6 15% of dogs with nasal tumors had false-positive results via AGID testing, although no specific case information was provided. The single false-positive AGID test result in our study was obtained for a 2-year-old spayed female Rottweiler that had bilateral serous nasal discharge of 23 days’ duration. At the

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<th>Test</th>
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<th>Specificity (%)</th>
<th>Positive predictive value (%)</th>
<th>Negative predictive value (%)</th>
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<tr>
<td>AGID</td>
<td>67 (43–86)</td>
<td>98 (92–100)</td>
<td>93 (68–100)</td>
<td>84 (69–95)</td>
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<tr>
<td>Fungal culture of tissue</td>
<td>81 (58–95)</td>
<td>100 (91–100)</td>
<td>100 (81–100)</td>
<td>90 (77–97)</td>
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Table 1—Sensitivity, specificity, positive predictive value, and negative predictive value with 95% confidence intervals (in parentheses) of a serum AGID test and fungal culture of nasal tissue for diagnosis of *Aspergillus* spp infection in dogs with nasal discharge as a result of aspergillosis (n = 21), nasal neoplasia (12), or nonfungal rhinitis (25).
time of evaluation, the dog had received treatment with amoxicillin, enrofloxacin, and ketoconazole for 12 days. For this dog, CT revealed no abnormalities, rhinoscopy did not reveal any fungal plaques, and results of fungal culture of tissue were negative; however, histologic analysis of nasal samples revealed findings indicative of lymphoplasmacytic rhinitis. Therefore, it was considered likely that the outcome of the AGID test was a true false-positive result. It is also possible that although the dog did not have evidence of an active infection, the dog had been exposed to Aspergillus spp in the past; this cannot be discounted because there is no information regarding the duration of seropositivity for Aspergillus spp in dogs, to our knowledge.

In our study, fungal culture of a nasal biopsy sample had 81% sensitivity for diagnosis of aspergillosis, which is lower than that reported in other studies. Positive culture results were reported for 44 of 49 (90%) dogs with aspergillosis in 1 study. The method of obtaining samples was not described in that report, although surgical trephination and treatment were performed in many dogs, and it is likely that more invasive methods were used to obtain material for culture, compared with the rhinoscopic method used in the present study. In another study, culture of samples collected from dogs via endoscopically guided nasal biopsy procedures was determined to have 100% sensitivity for detection of aspergillosis. It is possible that the lower sensitivity detected in our study was caused by sample collection problems. Two of the 4 cultures that yielded negative results were obtained from dogs that did not have detectable fungal hyphae in sections of nasal tissue, although fungal plaques were identified during endoscopy. In these dogs, it is possible that samples for fungal culture were collected from an unaffected region of the nasal cavity.

The specificity of fungal culture of nasal tissue samples for diagnosis of aspergillosis was 100%. Nasal tissue samples for fungal culture were not obtained from healthy control dogs in part because of the invasiveness of the sampling procedure. Despite the lack of negative control specimens for culture, the specificity could still be calculated from the culture results obtained for the dogs in the neoplasia and nonfungal rhinitis groups because the dogs in these 2 groups did not meet the criteria for diagnosis of aspergillosis. Other investigators have reported a rate of false-positive culture results of 4 of 15 (27%) among tissue samples collected from clinically normal dogs or dogs with nasal neoplasia, but their method for obtaining tissue samples was not stated. If samples of nasal discharge were submitted for fungal culture, that particular diagnostic test could have lower specificity for detection of aspergillosis than culture of a nasal biopsy sample collected with endoscopic guidance.

Four dogs that met 2 criteria (via CT and rhinoscopy) for aspergillosis did not have histologically detectable fungal hyphae in nasal tissues. For all dogs in the aspergillosis group in our study, the endoscopist attempted to obtain a sample from a plaque, but if hemorrhage was substantial and could not be cleared from view, additional endoscopically guided samples might not have been collected from the appropriate areas. In 2 dogs, the nasal cavity had severe turbinated tissue loss with plaques only detectable in the sinus. Biopsy specimens from the sinuses could not be obtained in either dog because of technical difficulties; had such samples from the sinus plaques been available, it is possible that hyphae may have been detected histologically.

Results of our study have indicated that assessment of serum antibodies against Aspergillus spp via an AGID test is useful as a noninvasive screening test for nasal aspergillosis in dogs because a positive test result is highly supportive of that diagnosis. Therefore, preprocedural screening of dogs with nasal discharge is recommended to assist in planning appropriate therapeutic intervention at the time of diagnostic testing. Although positive results of the serologic evaluation are suggestive of aspergillosis, performance of complete diagnostic assessments for nasal disease is recommended before treatment. Results of fungal culture of nasal tissue samples may be helpful in the diagnosis of nasal aspergillosis when those samples are collected with endoscopic guidance directly from plaques.

References