Comparison of bronchoalveolar lavage fluid examination and other diagnostic techniques with the Baermann technique for detection of naturally occurring *Aelurostrongylus abstrusus* infection in cats

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**Objective**—To evaluate the diagnostic sensitivity and specificity of bronchoalveolar lavage (BAL) fluid examination and other diagnostic techniques, compared with the use of the Baermann technique performed on fecal samples as the reference standard, for detection of naturally occurring *Aelurostrongylus abstrusus* infection in a population of cats.

**Design**—Cross-sectional study.

**Sample Population**—Cadavers of 80 semiferal domestic cats.

**Procedures**—BAL fluid collection and analysis, necropsy, examination of fecal samples and minced lung tissue via the Baermann technique, fecal sedimentation-flotation, and histologic examination of lung tissue were performed. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for detection of *A abstrusus* infection were calculated.

**Results**—On the basis of fecal Baermann test results, prevalence of infection was 13.8%. Sensitivity (NPV) of tests was as follows: Baermann technique on minced lung tissue, 81.8% (97.2%); fecal flotation-sedimentation, 63.6% (94.5%); stereomicroscopic examination of BAL fluid combined with cytologic examination of BAL fluid, 94.5% (93.2%); stereomicroscopic examination of BAL fluid alone, 94.5% (92.0%); cytologic examination of BAL fluid alone, 81.8% (97.2%); histologic examination of lung tissue, 94.5% (91.8%); and gross lung appearance, 94.5% (91.8%). Specificity and PPV of all tests were 100%, with the exception of histologic examination of lung tissue (specificity, 97.1%; PPV, 71.4%), which identified infected cats that had negative fecal Baermann test results.

**Conclusions and Clinical Relevance**—The Baermann technique was the most sensitive test for detection of *A abstrusus* infection. On the basis of the prevalence of 13.8% in this study, *A abstrusus* infection should be considered in pet cats. (*J Am Vet Med Assoc* 2009;235:43–49)

*Aelurostrongylus abstrusus*, a lungworm, is a ubiquitous nematode of domestic cats. Clinical signs of *A abstrusus* infection in cats are nonspecific and include coughing, tachypnea, tachycardia, weight loss, dyspnea, and rarely death.1 With most lungworm infections being self-limiting in cats, infections are probably frequently overlooked,2 although severe illness occurs in some infected cats and lung lesions can persist for long periods.3 Lungworm infection should be considered as a differential diagnosis in any cat with signs of respiratory tract disease, even in kittens as young as 3 months old.3,5

Diagnosis is central to the control of *A abstrusus* infections. The only reported diagnostic technique for *A abstrusus* infection that does not rely on the direct detection of adults or larvae (apart from necropsy) is an indirect fluorescent antibody technique for detecting specific anti–third-stage *A abstrusus* larva antibody in serum.6 This technique is highly specific but cannot differentiate between current and past infections. Techniques of microscopic examination of feces are rapid and simple but are labor intensive and can lack sensitivity.7 In 1 study,8 *A abstrusus* was detected in only 21.7% of infected cats by use of a standard fecal examination. The formalin-ethyl acetate sedimentation technique is reported to be less sensitive than the Baermann technique for the detection of active nematode larvae.9
The Baermann technique, in various modified forms, has been determined to be the most sensitive diagnostic technique for the detection of live nematode larvae in feces of several species. The technique has been reported to be more sensitive than necropsy or histologic examination of tissues for the diagnosis of lungworm infection in cats and has also been used on minced lung tissue to identify A. abstrusus infection when gross lesions were absent. Examination of fecal samples or minced lung tissue via the Baermann technique is recommended as the only reliable method for the diagnosis of A. abstrusus infection. However, larvae may also be recovered from pleural effusions, expectorated material, transtracheal wash fluid, or BAL fluid.

The Baermann technique is stated to be more sensitive than the examination of BAL fluid because small numbers of larvae may be diluted in lavage fluid. However, because larvae are excreted intermittently in feces, the concurrent use of both techniques has been recommended.

The purpose of the study presented here was to evaluate the diagnostic sensitivity and specificity of BAL fluid examination and other diagnostic techniques (ie, Baermann technique performed on minced lung tissue, fecal flotation-sedimentation test, gross appearance of the lungs at necropsy, and histologic examination of lung tissue), compared with the use of the Baermann technique performed on fecal samples as the reference standard, for detection of naturally occurring A. abstrusus infection in a population of cats.

Materials and Methods

Sample population—Cadavers of 80 semiferal urban cats were obtained from a shelter northeast of Melbourne, VIC, Australia, throughout August, September, November, and December of 2003 and in April and May of 2004. Cats that were unable to be handled safely were trapped in a high-density urban environment as part of a local government control program and were euthanized within 24 hours of capture via administration of an overdose of sodium pentobarbital. All cats were housed individually prior to euthanasia and did not receive anthelmintics. Kittens estimated to be <12 weeks of age were excluded as the BAL technique used for this study cannot be applied to kittens under 12 weeks of age without causing substantial pulmonary trauma, which may make interpretation of cytologic examination of BAL fluid difficult. Use of feline cadavers for this study was approved by the Executive Director of the shelter from which they were obtained. No cats were euthanatized for the purposes of this study.

Following collection of feline cadavers, a sequentially numbered identification collar was attached and the mouth was held open with a syringe cap to facilitate later endotracheal intubation. For each feline cadaver, the date of collection, breed, sex, and estimated age were recorded. Age was estimated by examining the mouth for the presence of deciduous and permanent teeth, observing wear and damage to the teeth, and noting the severity of periodontal disease. Size, body condition, and the general appearance of the skin and coat were also used to assist in a subjective assessment of age.

Collection of BAL fluid—Samples of BAL fluid were collected immediately following euthanasia. Feline cadavers were placed in left lateral recumbency. A fiberoptic laryngoscope with a straight blade was used to assist endotracheal intubation with either a 3.5-mm- or 4.5-mm-internal diameter cuffed disposable endotracheal tube. For each feline cadaver, a length of single-lumen, polyethylene endoscopy tubing (inner diameter, 1.2 mm; outer diameter, 1.7 mm) was measured from the tip of the endotracheal tube to the most caudal rib and trimmed. With an 18-gauge, 1.5-inch-long needle inserted as a syringe adaptor, the free end of the tubing was passed through the endotracheal tube until the tip lodged in a small bronchus. Five milliliters of sterile saline (0.9% NaCl) solution was flushed down the tubing and suction immediately applied with a 5-mL syringe to retrieve fluid. The fluid was placed into a 2.5-mL collection tube containing EDTA. The feline cadaver was rolled into right lateral recumbency and the BAL repeated; the second fluid sample was placed in a separate tube.

Necropsy and collection of tissue and fecal samples—After collection and processing of BAL samples, feline cadavers were necropsied sequentially in a standard fashion. Necropsies were complete within 12 hours of euthanasia. Potential A. abstrusus infection was considered when there were 1- to 2-mm-diameter, firm, round, white foci scattered across the surface of the lungs or there was a mottled white and pink appearance to the lungs at necropsy. For each feline cadaver, a section of the caudal part of the left caudal lung lobe was excised and preserved in neutral-buffered 10% formalin. The remaining respiratory tract was removed en bloc with the heart for further processing. Feces in the rectum were extruded into a container and refrigerated at 4°C prior to further analysis.

Cytologic examination of BAL fluid—Slides of BAL fluid were made for cytologic examination and air-dried immediately following fluid collection to minimize sample deterioration. Samples of BAL fluid were rotated on a benchtop mixer, and for each sample, a slide was prepared by use of a cytocentrifuge. Depending on sample turbidity, 1 to 6 drops of fluid per sample per slide were dispensed from a 200-µL pipette prior to cytocentrifugation at approximately 100 × g for 5 minutes. In addition, mucus or flocculent debris (if present) was selected from each of the 2 fluid samples for every feline cadaver and combined on a third slide. This sample was smeared as for a squash preparation and air-dried. Slides were stained with Giemsa.

Each cytospin slide was screened at 100× magnification and each smear at 40× magnification by use of a compound microscope. The presence and number of larvae, consistent in morphology with A. abstrusus, were recorded. Cytologic examination was then performed in detail by use of 200× magnification and additionally 1,000× magnification with oil immersion, where required. Total nucleated cell counts were not performed.

Steremicroscopic examination of BAL fluid—Each BAL fluid sample was placed in a Petri dish and...
examined under a stereomicroscope at 20× magnification by use of oblique transmitted light to enhance larval refractivity. The base of the dish was scanned for larvae, and mucus was examined at different planes of focus to detect trapped larvae. Samples of BAL fluid were recorded as positive or negative for larvae. Larvae were confirmed as first-stage larvae of *A. abstrusus* by examination of 1 to 3 larvae under a compound microscope at 200× or 400× magnification. Features used to identify larvae were a length of 360 to 400 μm, the lack of a sheath, the presence of a small buccal capsule and copulatory bursa, a coiled or S-shaped appearance, and a subterminal spine on the tail.

**Modified Baermann apparatus**—For each feline cadaver, modified Baermann examinations were performed on fecal samples and minced lung tissue within 24 hours of euthanasia. The apparatus consisted of a 500-ml conical jug with a 10- or 12-cm-diameter sieve (mesh size, 2 mm) suspended across the rim, lined with 3 pieces of tissue paper that were rotated approximately 45° relative to each other.

Feces (1.5 ± 0.1 g to 30 ± 0.1 g) were placed in the first apparatus. The weight of feces used was dependent upon the size of the available sample and was recorded to allow later calculation of the number of larvae per gram of feces. The entire right lung was sectioned into pieces approximately 5 × 15 × 15 mm by use of scissors and placed in the second apparatus. Edges of the tissue paper were folded over samples (to prevent flotation), and conical jugs were filled with lukewarm tap water to just cover samples and encourage larval migration.

Samples were allowed to stand overnight at room temperature (22° to 24°C). Each sieve and sample (feces or minced lung tissue) was then removed and supernatant liquid poured off to leave a residual volume of 20 to 50 mL in each conical jug. Conical jugs were refilled to the 500-ml mark with tap water to reduce opacity and turbidity of the sample. Larvae were allowed to settle for 20 to 30 minutes before the supernatant was again decanted to leave 20 to 50 mL of sediment. The entire residual sediment, containing washed larvae, was poured into individual small Petri dishes and allowed to settle again for 10 to 15 minutes. The base of each Petri dish was scanned at 20× magnification under a stereomicroscope with an obliquely transmitted light. The total number of larvae was recorded. Several randomly selected larvae from each sample were examined under a compound microscope to confirm the identity of larvae as *A. abstrusus*.

**Histologic examination of lung tissue**—The section of left lung preserved in neutral-buffered 10% formalin was processed routinely, sectioned, and stained with H&E. The pleura, airways, vasculature, bronchial-associated lymphoid tissue, alveolar septae, and alveolar spaces were sequentially examined and any lesions recorded.

Infections of *A. abstrusus* were confirmed by the presence of eggs or larvae identified histologically, and only confirmed infections, rather than the inclusion of probable or possible infections, were used to calculate prevalence, sensitivity, and specificity. Eggs or larvae were not seen in probable infections, but the histologic lesions were otherwise typical for an active *A. abstrusus* infection.20 The approximate duration of confirmed or probable infection was estimated from previous descriptions of experimentally induced infections.20–22 Possible infections had milder inflammatory or structural histologic changes that were more consistent with previous or chronic *A. abstrusus* infection than with other pathologic processes. Equivocal lesions had mild inflammatory, bronchial, and parenchymal smooth muscle alterations that were not specific for either *A. abstrusus* infection or bronchial disease in cats.

**Fecal sedimentation-flotation technique**—Within 48 hours of collection of feline cadavers, a semiquantitative fecal sedimentation-flotation technique was used to examine feces for *A. abstrusus* first-stage larvae. Feces (2 ± 0.1 g) were placed in a 60-ml container and made into a thick paste by use of distilled water and a spatula, which was sieved through a fine tea strainer and divided equally between two 15-ml centrifuge tubes. Each tube was filled with distilled water and centrifuged at approximately 600 × g for 5 minutes, the supernatant decanted, and the sediment resuspended with a minimal volume of water to create 1 to 1.5 ml of sediment/tube, which was mixed and divided equally between the 2 tubes by use of a Pasteur pipette. One tube (1 g of feces) was filled with a saturated solution of sodium nitrate having a specific gravity of 1.4. The tube was covered and inverted several times to mix the contents and then centrifuged at approximately 600 × g for 5 minutes. The top of the tube was rimmed with a Pasteur pipette and approximately 0.5 ml of fluid collected from the meniscus, avoiding particulate matter. This harvested supernatant was placed in a clean 15-ml tube that was then filled with distilled water, inverted several times, and centrifuged at approximately 600 × g for 5 minutes. Water was removed via manual suction with a long Pasteur pipette to leave 100 to 150 μl of sediment. This sediment was diluted to 150, 200, 300, 400, or 600 μl with distilled water such that the sample was moderately turbid. A 30-μl aliquot was placed on a microscope slide and covered with a 22 × 32-mm coverslip, and the preparation was immediately scanned under a compound microscope at 40× magnification. Larvae were counted and the approximate number of larvae per gram of feces calculated. Detailed examination and measurements were performed at higher magnification to confirm their identification as *A. abstrusus* first-stage larvae.

**Statistical analysis**—Data were analyzed by use of standard software programs.23 Examination of fecal samples via the Baermann technique was used as the reference standard for calculation of the sensitivity and specificity of other tests. Sensitivity was calculated as the percentage of cats infected with *A. abstrusus* that were correctly identified as infected by the test. Specificity was calculated as the percentage of cats not infected with *A. abstrusus* that were correctly identified as such by the test. The 95% CI was calculated for sensitivity and specificity by use of the Wilson method.24 The prevalence of infection in the study population for the purpose of calculating the NPV and PPV of each test was determined on the basis of findings on examination of fecal samples via the Baermann technique.
alone. The 93% CI for prevalence was calculated by use of the Wilson method.23 The proportion of female cats in infected and uninfected groups was compared by use of the Fisher exact test. The median age of infected and uninfected cats was compared by use of a Mann-Whitney U test.

The PPV for each test was calculated as the percentage of cats with positive test results (both true- and false-positive results) that were truly infected. The NPV was calculated as the percentage of cats with negative test results (both true- and false-negative results) that were truly uninfected. The 95% CI of the PPV and NPV for each test was calculated according to the method described by Zou.23 Differences in test sensitivity were tested by use of the exact McNemar test for paired proportions in samples with positive results on the basis of examination of fecal samples via the Baermann technique. For all comparisons, differences were considered to be significant at a value of P ≤ 0.05.

**Results**

Eighty feline cadavers were examined for *A. abstrusus* infection; 13 of these cats were found to be infected by a combination of all techniques, giving an estimated prevalence of 16.3% (95% CI, 10% to 26%). Fourteen of 80 (17.5%) cats were domestic medium-hair cats and 66 (82.5%) were domestic shorthair cats. There were 46 (57.3%) sexually intact female cats, 31 (38.8%) sexually intact male cats, and 3 (3.8%) castrated male cats. Estimated ages were used to group cats, such that 16/3 (13/80) were juveniles <6 months of age, 52.5% (42/80) were young adults between 6 months and 2 years old, 22.5% (18/80) were >2 years old and ≤4 years old, and 8.8% (7/80) were >4 and ≤8 years old. Seven of 13 (53.8%) *A. abstrusus*–infected cats were females, and 39 of 67 (58.2%) uninfected cats were females; this difference was not significant (P = 0.77). None of the 17 cats aged <12 months were infected, whereas 13 of 63 (20.6%) cats ≥12 months old were infected (P = 0.06). The median age of infected cats was 24 months and that of uninfected cats was 18 months. This difference was not significant (P = 0.07).

A comparison of the diagnostic techniques used in this study confirmed that the fecal Baermann test was the most sensitive diagnostic technique, detecting 84.6% (11/13) of all infected cats (determined as infected by any technique). This test was used as the reference standard. The prevalence of *A. abstrusus* infection in the study population as determined by positive fecal Baermann test results was 13.8% (11/80; 95% CI, 8% to 23%).

The combination of stereomicroscopic and cytologic examination of BAL fluid detected more infected cats (Table 1) than either of these tests on their own (combined sensitivity, 54.5%; 95% CI, 28% to 79%). Stereomicroscopic examination of BAL fluid alone had a sensitivity of 45.4% (95% CI, 21% to 72%), whereas cytologic examination of BAL fluid alone had a sensitivity of 36.4% (95% CI, 13% to 64%). Examination of BAL fluid resulted in detection of fewer infections than the use of the fecal flotation-sedimentation test, which had a sensitivity of 63.6% (95% CI, 35% to 84%).

Of the necropsy-based techniques, the Baermann technique performed on minced lung tissue had a sensitivity of 81.8% (95% CI, 52% to 93%). Histologic examination of lung tissue had a sensitivity of 43.4% (95% CI, 21% to 72%), equivalent to that of stereomicroscopic examination of BAL fluid. Gross inspection of the lung was the least useful diagnostic technique, with a sensitivity of 36.4% (95% CI, 15% to 64%). There were no significant differences in sensitivity between any of the techniques studied.

The 11 cats determined to be infected on the basis of positive fecal Baermann test results were each also considered infected on the basis of 1 to 6 of the additional diagnostic test results. Specificity was thus 100% (95% CI, 95% to 100%) for all these tests, with the exception of histologic examination of lung tissue. Histologic examination of lung tissue identified 2 cats as infected that were classified as uninfected on the basis of negative fecal Baermann test results. This resulted in a specificity of 97.1% (95% CI, 90% to 99%) for histologic examination of lung tissue and a PPV of 71.4% (95% CI, 35% to 90%). The PPV of each of the other tests was 100%, although the 95% CI varied with each test (Table 1). Negative predictive values were >90% for all tests, and the 95% CIs were narrower and less variable than for the PPV.

An association between results of cytologic examination of BAL fluid and histologic examination of lung tissue was observed for the 13 infected cats identified as such by all methods combined, with 3 cats having *A. abstrusus* infection identified by both cytologic ex-

<table>
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<th>Technique</th>
<th>Se (%)†</th>
<th>Sp (%)†</th>
<th>PPV*</th>
<th>NPV*</th>
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<tr>
<td>Stereomicroscopic examination of BAL fluid</td>
<td>45.4 (21–72)</td>
<td>100 (95–100)</td>
<td>5/5</td>
<td>69/75</td>
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<td>100 (95–100)</td>
<td>4/4</td>
<td>69/76</td>
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<td>Combination of both BAL fluid examinations</td>
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<td>100 (95–100)</td>
<td>6/6</td>
<td>69/74</td>
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<td>Baermann technique (lung)</td>
<td>81.8 (52–95)</td>
<td>100 (95–100)</td>
<td>9/9</td>
<td>69/71</td>
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<td>Fecal flotation-sedimentation test</td>
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<td>100 (95–100)</td>
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<td>69/73</td>
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<td>Gross appearance of lung at necropsy</td>
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<td>100 (95–100)</td>
<td>4/4</td>
<td>69/76</td>
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<tr>
<td>Histologic examination of lung tissue</td>
<td>45.4 (21–72)</td>
<td>97.1 (90–99)</td>
<td>5/7</td>
<td>67/73</td>
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**Table 1**—Sensitivity, specificity, PPV, and NPV (95% CI) of diagnostic techniques for the detection of *Aelurostrongylus abstrusus* infection in cats.

*Se = Sensitivity. Sp = Specificity. TP = Number of true-positive test results. FP = Number of false-positive test results. TN = Number of true-negative test results. FN = Number of false-negative test results.*
amination of BAL fluid and histologic examination of lung tissue. One cat had eosinophilic inflammation on cytologic examination of BAL fluid and essentially normal findings on histologic examination of lung tissue apart from a questionable increase in eosinophils in the pulmonary interstitium. Two cats had a predominantly eosinophilic inflammation on cytologic examination of BAL fluid and *A. abstrusus* identified on histologic examination of lung tissue. Three cats had eosinophilic inflammation on cytologic examination of BAL fluid, in conjunction with inflammatory and structural changes upon histologic examination of lung tissue, which were suggestive of prior or chronic *A abstrusus* infection (1 possible and 2 probable infections). One cat had *A. abstrusus* identified on cytologic examination of BAL fluid, with the histologic examination of lung tissue being consistent with probable previous or chronic *A abstrusus* infection. Two of the remaining 3 cats had *A. abstrusus* infection identified by histologic examination of lung tissue, and the other had histologic changes equivocal for prior or chronic infection. For these 3 cats, the BAL fluid samples were of poor quality.

**Discussion**

The examination of feces by the Baermann technique has been reported to be the most sensitive test for the diagnosis of *A. abstrusus* infection in cats. Results of the current study support this finding. The 2 infected cats that were not identified as infected on the basis of negative fecal Baermann test results did not appear to be shedding larvae, as these cats were only identified by histologic examination of lung tissue. These results support those of Willard et al., who reported that 90% of *A. abstrusus* infections were detected by Baermann examination of feces and the remaining 10% by histologic examination of lung tissue.

The advantage of histologic examination of lung tissue over other diagnostic tests with a similar sensitivity (such as the fecal sedimentation-flotation test) is in the ability to detect infection before and after larval shedding in addition to patent infections. However, in the present study, sections of lung tissue for histologic examination were obtained from the middle of a lung lobe and are not equivalent to the smaller peripherally located lung biopsy specimens typically obtained from a live patient. For such patients, lung biopsy is an expensive and invasive procedure not routinely performed in the evaluation of respiratory tract disease, unless a diagnosis cannot be made after a series of less invasive procedures. The examination of a fecal sample by use of the Baermann apparatus is noninvasive, rapid, sensitive, inexpensive, and technically simple. The modified technique reported in this study does not require fragile glassware or specialized equipment, making it readily available in clinical practice. The sensitivity of this test may also be greater when applied to clinically affected cats, as the most severe clinical signs occur 6 to 13 weeks after infection, coinciding with the period of peak larval output.

In the present study, first-stage larvae of *A. abstrusus* were identified on cytologic examination of BAL fluid in 4 of 11 cats. In 3 of these cats, first-stage larvae were identified only on a direct stained smear of mucus and not on the standard cytospin preparation. Mucus is typically avoided when cytospin preparations are made and each preparation represents the contents of a minute subsample of the wash fluid. In addition to standard cytospin preparations, it is recommended that a direct smear of a larger fluid sample, or any gross mucus present, also be examined. Examination of BAL fluid under a stereomicroscope allows examination of the entire fluid sample and, in this study, resulted in the detection of an additional 2 cats with an *A. abstrusus* infection. This approach is recommended as an adjunct technique for the analysis of BAL fluid of cats, although the overall sensitivity of combined cytologic examination of BAL fluid and examination of BAL fluid under a stereomicroscope was 54.5%. Samples that were positive on the basis of BAL fluid examination tended to be from cats with higher larval outputs as determined on the fecal Baermann test. All cats diagnosed as infected on the basis of BAL fluid examination findings were also positive on the basis of the fecal Baermann test results; hence, this examination technique is an alternative to performing the full range of screening tests for lungworm on BAL fluid when a fecal sample is available.

Bronchoalveolar lavage, rather than endotracheal wash, was selected for this study, as the samples collected were primarily representative of the small airways and alveoli, the site of lungworm infestation and usually provides samples of high quality for cytologic examination. The blind BAL technique used for this study was similar to those published previously. Bronchoscopic guidance was not used, as bronchoscopic equipment is expensive, the technique is specialized, and *A. abstrusus* infection represents a diffuse pulmonary disease process. In addition, the narrow airway diameter of cats limits the access of even a pediatric bronchoscope into airways beyond the primary bronchi. Gross inspection of the lung at necropsy also allowed the detection of focal lung disease in this study without the aid of a bronchoscope. The latter is not a clinically applicable technique, but in live patients, thoracic radiographs can be used to differentiate focal from diffuse pulmonary disease.

In dogs with respiratory tract disease, lavage of multiple lung lobes has been shown to increase the chance of detecting the primary disease process. McCarthy and Quinn demonstrated that, by use of a blind technique in lateral recumbency, the BAL tubing most often is inserted into the caudal lobe of the dependent lung. Hence, BAL was performed in both left and right lateral recumbency for this study. Subjectively, the quality of samples appeared to be good in most instances, although the blind technique failed to adequately wash the alveolar spaces in 3 of 13 infected cats. It was only for these samples that findings on cytologic examination of BAL fluid and histologic examination of lung tissue were disparate. For 9 of the 10 remaining samples, the inflammatory process was identified by both techniques, irrespective of whether parasites were identified by one, both, or neither technique.

Greenlee and Roszel compared postmortem findings on cytologic examination of BAL fluid with findings on histologic examination of lung tissue obtained...
concurrently from 16 ill and 6 healthy cats. The best correlation between findings on histologic examination of lung tissue and cytologic examination of BAL fluid was obtained when lung lesions were diffuse and involved the airways, with the greatest agreement being reported in terms of the inflammatory processes. The present study revealed good agreement between findings on histologic examination of lung tissue and cytologic examination of BAL fluid. Although the sensitivity of BAL fluid analysis was low for the detection of *A. abstrusus* infection, it still provides useful information in the clinical evaluation of respiratory tract disease, and the detection of eosinophilic inflammation can indicate potential parasitic infection.

A standard fecal examination has been reported to be less sensitive than histologic and gross examination of lung tissue in detecting *A. abstrusus* infections, though the precise technique used was not described. The sedimentation-flotation technique used in the present study had a higher sensitivity (63.6%) than either gross inspection or histologic examination of lung tissue. However, all cats with positive results for *A. abstrusus* infection on the fecal sedimentation-flotation test also had positive fecal Baermann test results. The usefulness of the fecal sedimentation-flotation test lies in the ability to detect eggs of other parasites of the respiratory tract (such as *Eucocylea aerophila*) or of parasites of the gastrointestinal tract that undergo pulmonary migration (such as *Toxocara cati* and hookworms), and it should be performed in conjunction with the Baermann technique for cats being evaluated for respiratory tract disease.

The remaining techniques evaluated by the present study are not used for the clinical diagnosis of *A. abstrusus* infection but have been used in prevalence surveys for the detection of *A. abstrusus* infection. The gross appearance of the lung at necropsy was suggestive of infection in 4 of 11 infected cats. All of these cats had patent infections on the basis of findings on Baermann examination of fecal samples and minced lung tissue. This technique is insensitive, and normal gross lung appearance at necropsy does not exclude *A. abstrusus* infection.

Cats that had positive fecal Baermann test results but negative minced lung tissue Baermann test results had low numbers of larvae per gram of feces. The Baermann test with minced lung tissue is more rapid to perform and has greater sensitivity than histologic examination of lung tissue but is not a technique that is applicable to live patients. Because all cats with a positive Baermann test result on minced lung also had a positive fecal Baermann test result (a more sensitive test), there is no indication to perform this test at necropsy, unless feces cannot be obtained. Mincing lung tissue more finely to increase the surface area of exposed parenchyma might improve the sensitivity of the test, but this remains to be assessed.

In addition to the 7 cats identified as infected on the basis of findings on histologic examination of lung tissue, 5 of 6 cats confirmed as having patent infections on the basis of other test results had histologic changes that were suspicious for chronic or previous lungworm infection, and an additional 13 of 80 (16.3%) cats were considered to have probable chronic or previous lungworm infection on the basis of characteristic histologic changes without parasites being detected by any of the methods. Hamilton reported that by 24 weeks after experimentally induced infection of cats with *A. abstrusus*, eggs and larvae were completely absent and adult nematodes were only detected in 3 sections of lung tissue in almost 100 examined. He also stated that light or convalescent infections are frequently missed upon histologic examination of lung tissue, unless serial sectioning of lung tissue is performed. As each cat in this study was assessed on the basis of a single section of lung tissue, the prevalence of active *A. abstrusus* infection may have been underestimated. Serial sectioning, had it been evaluated, may have provided a better reference standard than the fecal Baermann test. The false-positive test result for histologic examination of lung tissue in this study arose from comparing histologic examination of lung tissue to an imperfect reference standard. With the exception of gross examination of the lung, where false-positive results are reported, a positive result on any other test confirms the diagnosis of *A. abstrusus* infection, as the organism is directly detected in this test.

When comparing PPV and NPV for diagnostic tests, a high NPV is required to rule out infection with *A. abstrusus* as a cause of signs of respiratory tract infection. The fecal Baermann test remains the reference standard in this respect. In the pet cat population, where the prevalence of infection might reasonably be expected to be substantially lower, the NPV of each test would improve further. However, the prevalence of infection in cats with clinical signs of respiratory tract disease would be greater than that in the general pet cat population; thus, the NPV may be closer to that of the study population. The sensitivity of these tests may also increase in cats with clinical disease, where clinical signs correlate to periods of peak infection. The sensitivity and specificity calculated for tests in this study provide a basis for a direct comparison of test performances but are not directly applicable to every cat population.

The high density of semiferal cats in suburban areas, in which there is additionally a high concentration of owned pet cats, makes these cats important in the epidemiology of parasitic infections of owned cats, and it is these cats that comprised the present study population. Semiferal cats were selected over stray cats as their individual housing following capture and lack of treatment with anthelmintics prior to euthanasia prevented loss or acquisition of parasitic infections. They fall within a spectrum between stray cats, which are generally more friendly toward humans, and truly feral cats, which have either been born in the wild or have reverted to the wild state, and are reported by some authors to inhabit more rural environs and to have a relatively low population density.

The breed and age composition of the study population provides supportive evidence that this survey was representative of the stray to semiferal urban cat population elsewhere in the world. The overall slight predominance of female cats has been reported in larger surveys of free-roaming cats. The present study revealed a tendency for *A. abstrusus* infection to be more prevalent in older cats, and this is expected for parasites
that are infective through an intermediate or paratenic host, with an increased chance of exposure of the definitive host with time and with greater hunting skill of the adult cat.

Given that infection is usually self-limiting, unless specific attempts are made to detect A. abstrusus in pet cats, clinical disease caused by A. abstrusus infection is likely to remain under-recognized. The high prevalence of A. abstrusus infection in semiwild cats in this study, and associated histopathologic findings in lung tissue and evidence of inflammation on cytologic examination of BAL fluid, should prompt greater clinical awareness by practicing veterinarians for the potential of lungworm infection to cause respiratory tract disease in pet cats, particularly those with outdoor access that share a common environment with free-living cats.

References