Diagnosis is the most challenging part of feline heartworm disease because no single test can reliably detect heartworms at all stages. Veterinarians must be willing to conduct multiple and even repeat tests (Table 1 and Figure 1) to obtain a diagnosis and to correctly interpret and apply the results.  

**DIAGNOSIS**  
**Microfilariae**  
Filtration tests for microfilariae are virtually useless in cats because cats are only transiently microfilaremic, if at all. To be microfilaremic, a cat must have both a mature male and a mature female worm, and because cats typically only have one or two worms, the infections are often single sex. When microfilariae are produced, they are only present for 1 or 2 months, at which time the cat’s immune system eliminates them and suppresses further embryogenesis.  

**Radiology**  
The most common radiographic finding in feline heartworm disease is an enlargement of the right caudal lobar artery (see Figure 2 in the companion article beginning on page 382). This is best seen on a ventrodorsal view. A bronchointerstitial pulmonary pattern (Figure 2) may also be noted, but this finding is not unique to feline heartworm disease. The use of radiology has limitations, as only 55% of heartworm antigen–positive cats had radiographic signs consistent with heartworm disease in one study.  Follow-up on some of these cats showed improvement in radiographic scores in 50% of cases and worsened scores in 16%. Because cats can tolerate adult worm infections fairly well and it is common for clinical signs to either resolve or become intermittent, such results are to be expected.  

**Echocardiography**  
In skillful hands, ultrasonography has been shown to detect 100% of adult feline heart-
worm infections, but the technician must be able to follow the caudal pulmonary arteries to their bifurcation within the lung fields.\(^3\) Other reports cite echocardiography as detecting 68% of natural infections\(^4\) and 88% of experimental infections in cats.\(^5\)

The cuticle of the adult heartworm is strongly echogenic, producing short, segmented, parallel lines where the imaging plane crosses the worm. Heartworm signatures on echocardiography have been described as equal signs (=; Figure 3). However, the imaging beam may cross the same worm multiple times, making quantifying the number of worms difficult.

### Table 1. Interpretation of Heartworm Diagnostic Tests in Cats

<table>
<thead>
<tr>
<th>Test</th>
<th>Purpose</th>
<th>Result and Interpretation</th>
<th>Limitations</th>
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</table>
| Antibody test           | Detects antibodies produced in response to late L4, juvenile, and adult worms. May detect infections as early as 8 weeks posttransmission | • Negative—Decreases index of suspicion  
• Positive—Increases index of suspicion; confirms cat is at risk | Antibodies confirm recent infection to at least late L4 stage but do not confirm disease causality |
| Antigen test            | Detects antigen from an adult female heartworm, >5 dying male heartworms, or a dying female heartworm | • Negative—Decreases index of suspicion  
• Positive—Confirms presence of heartworms | Immature or male-only worm infections are rarely detected |
| Thoracic radiography    | Detects vascular enlargement (inflammation and hypertrophy caused by a juvenile worm), pulmonary parenchymal inflammation, and (more rarely) edema | • Normal—Decreases index of suspicion  
• Signs consistent with feline heartworm disease—Enlarged arteries greatly increase index of suspicion | Radiographic signs are subjective and affected by clinical interpretation |
| Echocardiography        | Detects echogenic walls of the immature or mature heartworm residing in the lumen of the pulmonary arterial tree (only within the visual ultrasonographic window) | • No worms seen—No change in index of suspicion  
• Worms seen—Confirms presence of heartworms in the structure | Accuracy depends in part on the ultrasonographer’s experience with heartworm detection |

© American Heartworm Society

The antibody test was initially very promising. In experimental studies, it detected 93% to 100% of heartworm infections, including late L4 larvae as well as juvenile and adult worms.\(^7,10,11\) However, a significant number of cats with adult heartworms are antibody negative. For example, in a retrospective study of 50 cats with known heartworm disease, there was a 14% false-negative rate.\(^12\) Most of the cats in the study (72%) had clinical signs indicating active disease.

A necropsy study of shelter cats in Texas\(^6\) reported a 50% false-negative rate for one antibody test, and a similar study in Florida had an 11% to 68% false-negative
rate on eight different antibody tests. Twenty-one of 31 cats with heartworm disease had a negative result on at least one of the eight antibody tests evaluated. All of these studies have drawbacks, but collectively they demonstrate that a negative antibody test result cannot be used to rule out heartworm infection.

The use of antigen and antibody tests must be tempered by an awareness of these limitations. It is difficult to establish a diagnosis with a single method unless the antigen test result is positive or a worm is detected on ultrasonography. Diagnosis generally requires multiple tests. If antibody or antigen testing is used for initial screening, the practitioner should be prepared to conduct additional tests if the results do not support the clinical suspicions. This is illustrated by the results of a study of 22 heartworm-infected cats in which thoracic radiography, echocardiography, and antigen and antibody tests were conducted. Pulmonary enlargement was seen in 64% of the cats, worms were visualized by echocardiography in 64%, 55% were antigen positive, and 82% were antibody positive. In a multicenter study of 215 cats in which clinical signs were correlated to serology and radiographic findings, 44% of the cats that presented with coughing or dyspnea and intermittent vomiting unrelated to eating were antibody positive. This was twice the antibody base rate for the area. Of the cats with radiographic signs consistent with heartworm disease, 60% were antibody positive.

IMPLICATIONS

Because heartworm disease in cats is primarily caused by juvenile worms, antibody serology data can be used to estimate the percentage of cats infected at some point in their life span, thus establishing regional risk. In 1997, 15.9% of the 25,277 cats tested at Heska's reference laboratory were antibody positive. A second study mainly conducted in the Northeastern and Midwestern states reported a 12% antibody-positive rate. Analysis of data from IDEXX reference laboratories shows the national rates of feline heartworm antigen, FeLV, and FIV detection to be 1%, 1.9%, and 1%, respectively, indicating that heartworm disease is a significant health risk in cats. As a result, IDEXX is adding a heartworm antigen spot to its point-of-care test for FeLV and FIV. This new format should increase the number of cats tested yearly for heartworms from tens of thousands to millions. It is important for practitioners to understand that they will be testing for the presence of the adult female worm. Although all cats with adult worms have heartworm-
The positive rate is 16%, 50% of cats with known HARD lesions (including 25% to 30% of cats with adult heartworms\(^6\)) are antibody negative 8 months after infection.\(^{18}\) Based on these numbers, it could be argued that the percentage of cats at risk for HARD in a given area is twice the base antibody rate (32%). At the same time, Browne et al\(^{19}\) have showed that half of antibody-positive cats (50% of 16% = 8%) have lung lesions consistent with HARD. If, at a conservative estimate, an additional 2% of cats that are negative on all tests have HARD, there may be as many as 10 cats with HARD for every one cat identified as having adult heartworms. Given that the adult heartworm infection rate in cats is 10% of the rate in unprotected dogs and that for every cat with an adult infection there may be 10 cats with HARD from juvenile infections, it is possible that cats are infected at the same rate as dogs.

**TREATMENT**

Because no form of medical adulticidal therapy has been shown to increase the survival rate of cats harboring adult heartworms, treatment is aimed at controlling clinical signs. On diagnosis, thoracic radiographs should be obtained or reviewed to look for any evidence of vascular, bronchointerstitial, or parenchymal disease. Cats exhibiting clinical or radiographic signs of disease should be given antiinflammatory doses of glucocorticosteroids (prednisone, 1 to 2 mg/kg/day), reduced weekly over a 3- to 4-week period. If clinical signs recur or persist, alternate-day glucocorticosteroids should be given at the lowest effective dose. Radiography and serology are then repeated every 6 months to monitor the course of the disease. A monthly heartworm preven-

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**Figure 1. Summary of interpretation of heartworm diagnostic tests in cats.**

- **Antibody Test or Radiography**
  - Positive result increases index of suspicion
  - Negative result lowers index of suspicion

- **Antigen Test or Echocardiography**
  - Positive result is diagnostic
  - Negative result lowers index of suspicion

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**Treatment is also difficult because no form of medical adulticidal therapy has been shown to increase the survival rate of cats harboring adult heartworms.**
tion regimen should be initiated for all cats; because microfilaremia is typically rare or marginal in cats (unlike dogs), it is safe to administer preventive agents to heartworm-positive cats.

Cats presenting in acute respiratory distress should be given oxygen, “shock” doses of glucocorticosteroids (dexamethasone sodium phosphate, 1 to 2 mg/kg IM or IV, or prednisolone sodium succinate, 50 to 100 mg/kg/cat IV), and a bronchodilator (e.g., aminophylline, 6.6 mg/kg IV). Supportive therapy (IV fluids and thermal support) is maintained until the cat’s condition is stabilized. Retrospective studies indicate that 10% to 20% of cats with adult heartworm infections die as a result of complications from a dead or dying heartworm. Owners of cats

Figure 2. Radiographic evidence of heartworm infection. Bronchointerstitial pattern.

Figure 3. Heartworm signatures of echocardiography (arrows). (Image courtesy of Clarke Atkins, DVM, DACVIM [Internal Medicine and Cardiology], North Carolina State University)
with an adult heartworm infection diagnosed either by antigen testing or echocardiography should be informed about this risk and instructed to seek prompt medical attention at any sign of respiratory distress. It may be prudent to give the owner a syringe containing 10 mg of dexamethasone sodium phosphate with instructions to administer in the event of a respiratory crisis to initiate treatment, but it must be emphasized that this does not eliminate the need for emergency veterinary care.

There is anecdotal evidence that antileukotrienes (e.g., montelukast, 2 mg/day) may help to thwart an acute, fatal lung injury when an adult worm dies. Dil-lon has been using this approach for more than 6 years, and no cat so treated has yet presented in acute respiratory distress. There is also interest in the use of doxycycline in heartworm-positive cats. Heartworms harbor an intracellular endosymbiont of the genus Wolbachia, which is found in many of the filarial nematodes that cause disease in humans and animals (including Onchocerca volvulus, Wuchereria bancrofti, Brugia malayi, and Dirofilaria immitis). Doxycycline is now being used to treat some filarial nematode infections in humans. Studies indicate that pretreating a dog with doxycycline before administering adulticidal medication reduces the pathology associated with worm death, but similar studies have not yet been completed in cats.

**PREVENTION**

All indoor and outdoor cats in endemic areas should receive heartworm prevention because the risk for indoor cats has been shown to be similar to that for outdoor cats. There are four products on the market labeled for cats that are safe and virtually 100% effective in preventing heartworm infection. Ivermectin is available as a chewable treat, milbemycin as a flavored tablet, and selamectin and moxidectin as topical applications. Spectra vary among products, but all control multiple parasites in addition to heartworms.

**CONCLUSION**

Although the promise of universal heartworm antigen testing in cats will not translate into universal detection, the concept of monthly prevention in all cats should be readily understandable to owners. With veterinarians leading the way in public education, preventive measures for cats may soon be as acceptable as they currently are for dogs.
REFERENCES


**ARTICLE #2 CE TEST**

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1. Because heartworm infection in cats typically involves only one or two juvenile worms, it rarely causes
   a. pulmonary symptoms.
   b. a host reaction.
   c. microfilaremia.
   d. vascular inflammation.

2. Radiographic signs of heartworm infection in cats
   a. are present in only about 55% of cases.
   b. generally improve in about 50% of cats that have them.
   c. often appear as an enlargement of the right caudal lobar artery.
   d. all of the above

3. The echocardiographic signature of feline heartworm disease consists of
   a. an equal (=) sign.
   b. a wavy (−) sign.
   c. a V sign.
   d. a C sign.

4. Antigen testing has limited value in cats because
   a. it primarily detects only mature, female worms.
   b. cats seldom have an immune reaction to the presence of worms.
   c. it has a low sensitivity in both cats and dogs.
   d. it is effective only in the microfilaremic stage.

5. Antibody testing cannot be used to rule out heartworm infection in cats because
   a. it cannot detect all stages of the worm’s life cycle.
   b. it has a high false-negative rate.
   c. frequent false-positive results can lead to overtreatment.
   d. all of the above

6. When diagnostic tests were compared in the same group of infected cats, heartworm infection was most consistently detected by
   a. thoracic radiography.
   b. echocardiography.
   c. antibody testing.
   d. antigen testing.

7. Data from a group of reference laboratories show similar infection rates for feline heartworm disease and
   a. FeLV.
   b. feline infectious peritonitis.
   c. FIV.
   d. Lyme disease.

8. The primary advantage of increased antigen testing is the identification of cats
   a. that need adulticidal therapy.
   b. that should be quarantined.
   c. with compromised immunity.
   d. at risk for HARD.

9. The mainstay of symptomatic therapy for cats with heartworm disease is
   a. glucocorticosteroids.
   b. bronchodilators.
   c. NSAIDs.
   d. parasiticidal agents.

10. A heartworm disease prevention regimen should be initiated
    a. only in cats found to be antigen negative on two consecutive tests.
    b. only in cats younger than 6 months.
    c. in all cats that show no signs of HARD.
    d. in all cats, regardless of infection status.