

Use of echocardiography for the diagnosis of heartworm disease in cats: 43 cases (1985–1997)

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Objective—To determine the usefulness of echocardiography in the diagnosis of heartworm disease in cats and to compare this modality with other tests.

Design—Retrospective study.

Animals—43 cats with heartworm infection that had echocardiographic examinations at 2 veterinary teaching hospitals between 1985 and 1997. Twenty-two of these 43 cats also underwent radiography of the thorax and heartworm antibody and heartworm antigen testing.

Procedure—Cats were determined to be infected with *Dirofilaria immitis* infection on the basis of 1 or more of the following findings: positive modified Knott or antigen test result, echocardiographic evidence of heartworm disease, or confirmation of the disease on postmortem examination. The percentage of echocardiographs in which heartworms were evident was compared with the percentage of radiographs in which pulmonary artery enlargement was evident and results of antigen or antibody tests in cats in which all tests were performed.

Results—Overall, heartworms were detectable by use of echocardiography in 17 of 43 cats, most often in the pulmonary arteries. In the 22 cats in which all tests were performed, antibody test results were positive in 18, antigen test results were positive in 12, and pulmonary artery enlargement was evident radiographically and heartworms were identifiable echocardiographically in 14. Heartworm infection was diagnosed exclusively by use of echocardiography in 5 cats in which the antigen test result was negative.

Conclusions and Clinical Relevance—Although echocardiography was less sensitive than antigen testing, it was a useful adjunctive test in cats that had negative antigen test results in which there was a suspicion of heartworm disease. The pulmonary arteries should be evaluated carefully to increase the likelihood of detection of heartworms echocardiographically. (*J Am Vet Med Assoc* 2001;218:66–69)

Hearthworm infection is increasingly recognized as a cause of illness in cats living in endemic areas.¹ In

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the southeastern United States, heartworms are detected at postmortem examination in up to 16% of cats examined.² Despite increased awareness of the disease, our ability to definitively diagnose heartworm (*Dirofilaria immitis*) infection in cats remains less than optimal. The diagnosis is challenging because of variable clinical presentation, insensitivity of antigen testing, and transient microfilaremia.^{3–5} Although a positive antigen or modified Knott test result provides a definitive diagnosis, radiographic detection of pulmonary artery enlargement and a positive antibody test result only provide supportive evidence for the diagnosis of heartworm disease.^{6–8}

It has been suggested that echocardiography is a useful aid in the diagnosis of heartworm disease in cats. Selcer et al⁷ identified heartworms by use of echocardiography in 7 of 9 experimentally infected cats. There were no false-positive identifications when results of echocardiography were compared with findings at postmortem examination. We previously reported echocardiography as being useful in the diagnosis of naturally occurring heartworm disease in cats, with echocardiographic identification of worms in 7 of 9 cats that had antigen positive test results.⁹ Genchi et al⁸ and Prieto et al¹⁰ reported that echocardiography was more sensitive than antigen testing in the diagnosis of heartworm infection in clinically infected cats and nonclinically infected cats in Italy.

The purpose of the study reported here was to evaluate the usefulness of echocardiography in the diagnosis of naturally occurring heartworm disease in cats in endemic areas of the southern United States. Detection of heartworms by use of echocardiography was compared with results of antigen and antibody testing and radiography as diagnostic aids in heartworm disease in cats.

Criteria for Selection of Cases

All hospital records in which a clinical diagnosis of heartworm disease was made in a cat between 1985 and 1997 at the veterinary medical teaching hospitals of the North Carolina State University and Texas A&M University were reviewed. The diagnosis was confirmed in 60 of 69 cats on the basis of positive antigen or microfilaria test results, or detection of heartworms on postmortem or echocardiographic examination. Forty-three of these 60 cats received an echocardiographic examination.

Procedures

Each echocardiogram was evaluated retrospectively by a board-certified cardiologist for presence and location of heartworms. Whenever possible, hard copy or the videotape recording of the echocardiogram were

reviewed in addition to the written report. In 22 of the 43 cats, radiography of the thorax and serologic testing for heartworm were also performed. The percentage of heartworm identifications by use of echocardiography in these 22 cats was then compared with the percentage of positive or suggestive findings by use of radiography or serologic testing. A board-certified radiologist or board-certified cardiologist reviewed the radiographs for evidence of pulmonary artery enlargement. In the dorsoventral (or ventrodorsal) projection, pulmonary artery enlargement was defined as a caudal pulmonary artery being 1.6 times greater in diameter than the width of the 9th rib at the 9th intercostal space.⁶ Antigen testing was performed by use of various in-house test kits^{a,b} and outside laboratory testing.^c

Results

Overall, heartworms were evident in 17 of 43 cats that underwent echocardiographic examinations. When the 17 echocardiograms were reviewed, heartworms were most often evident in the pulmonary arteries (71%; Fig 1 [left]), and to a lesser extent in the right ventricle (41%), right atrium (35%; Fig 1 [right]), and caudal vena cava (6%). In 7 cats, echocardiographic examination revealed heartworms in multiple chambers of the heart.

In the 22 cats in which echocardiography, radiography, and antigen and antibody testing were per-

formed, the findings for each diagnostic test were as follows: antibody testing yielded positive results in 18 cats, antigen testing yielded positive results in 17 cats, and pulmonary artery enlargement by use of radiography and heartworm identification by use of echocardiography were evident in 14 cats (Fig 2). Heartworm infection was diagnosed exclusively by use of echocardiography in 5 cats in which antigen test results were negative. Four of these 5 cats had positive antibody test

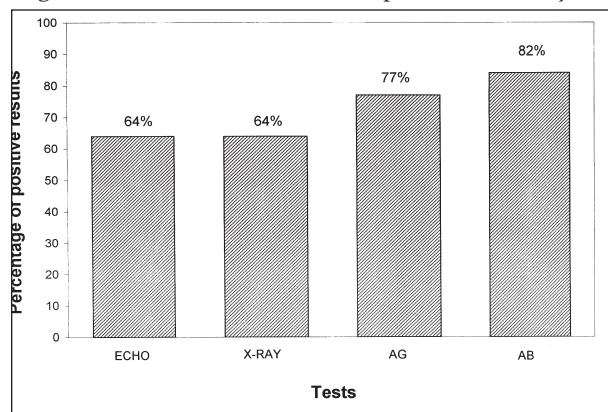


Figure 2—Comparison of positive results among the various diagnostic tests used in 22 cats with heartworm infection. ECHO = Heartworm infection identified by echocardiographic examination. X-RAY = Pulmonary artery enlargement detected radiographically. AG = Antigen test results. AB = Antibody test results.

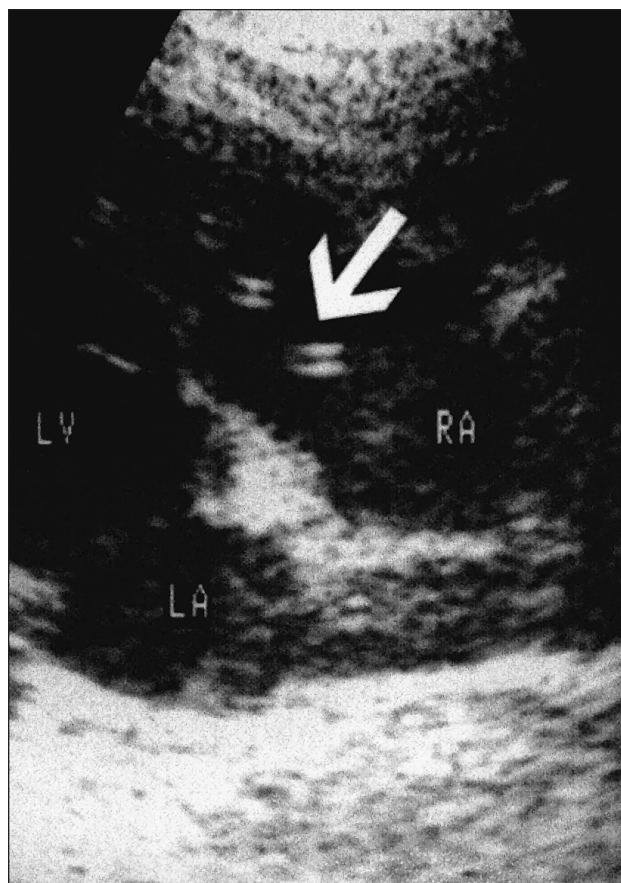
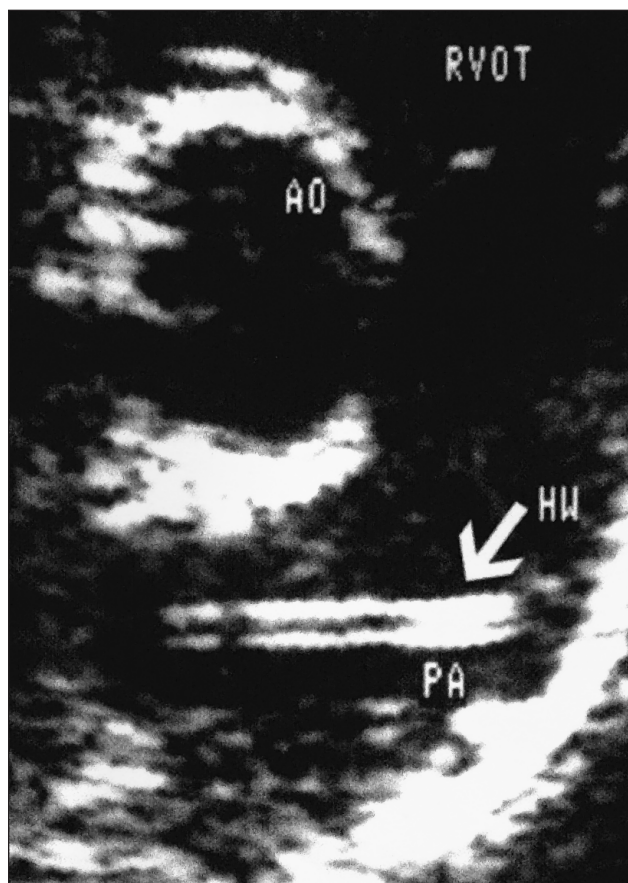


Figure 1—Two-dimensional echocardiogram of two cats with heartworm disease. Notice adult heartworms (arrow) within the main pulmonary artery (left) and right atrium and right ventricle (right). AO = Aorta. HW = Heartworm. LA = Left atrium. PA = Pulmonary artery. RA = Right atrium.

results. Heartworms were identified by use of echocardiography in only 1 of 5 cats that did not have clinical signs of heartworm infection.

Discussion

Despite recent increased interest and awareness in heartworm disease in cats, the antemortem diagnosis of this disease remains challenging. The difficulty stems in part from the extreme variability of clinical signs, which range from intermittent vomiting or coughing to neurologic deficits, dyspnea, and death.³ Serologic identification of heartworms in cats is problematic because of the decreased sensitivity of antigen testing associated with low worm burdens and infection with only male worms.^{1,3,4} Antibody testing is helpful in determining the diagnosis, because it is suggestive of exposure to heartworms and at least partial maturation of worms; however, it does not provide a definitive diagnosis.⁸ Radiographic evidence of pulmonary artery enlargement and parenchymal abnormalities are common and, along with other signs, may be useful in supporting a diagnosis of heartworm disease.^{6,7} Unfortunately, these findings may be transient⁷ and do not provide a definitive diagnosis.

It has been suggested that echocardiography is a useful means for definitively diagnosing heartworm disease in cats. Adult heartworms are identified as double-lined hyperechoic structures within a cardiac chamber or large vessel. The double-lined appearance results from the echogenicity of the body wall of the parasite.¹¹ There are several reports of identification of heartworms in cats, often with caval syndrome, by echocardiographic examination.^{8,12-16} Moreover, Selcer et al⁷ demonstrated that echocardiography was useful in the antemortem detection of experimentally induced heartworm infection in cats. In that study, 2-dimensional echocardiography was used to identify heartworms in 7 of 9 cats proven to be heartworm-infected by postmortem examination. There were no false-positive echocardiographic identifications. The cats in which heartworms could be identified echocardiographically had burdens ranging from 3 to 18 worms. The 2 cats in which worms were not identified only had 2 adult worms each. These findings suggest that a higher worm burden may increase the ability to detect adult heartworms by use of echocardiography. It should be emphasized that most cats with naturally occurring heartworm infection have low worm burdens, often with only 1 worm. Ryan et al³ reported that single worm infections develop in approximately 50% of cats, whereas infection with 2 to 4 worms develops in 34% of cats. Therefore, studies of experimentally infected cats with heavy worm burdens may give an overly optimistic estimation of the diagnostic usefulness of echocardiography. However, Atkins et al⁹ provided supportive evidence that echocardiography is sensitive and has a meaningful role in the diagnosis of naturally occurring heartworm disease in cats. In that study, which evaluated the prevalence of heartworm infection in cats that were examined because of cardiorespiratory abnormalities, echocardiography allowed identification of worms in 7 of 9 cats. Furthermore, 2 studies performed in Italy revealed

nearly 100% echocardiographic sensitivity in the identification of heartworms in cats with and without clinical signs.^{10,d}

Overall, echocardiography was useful in identifying heartworms in only 17 of 43 (40%) heartworm-positive cats examined in our study. When echocardiographic examinations were performed before 1992, when heartworm infection in cats was considered rare, heartworms were identified in only 2 of 17 (12%) cats examined. In both of these cats, heartworms were identified only in the right atrium and ventricle, which are locations typically studied during routine echocardiographic examination. During and after 1992, heartworms were identified in 15 of 17 (88%) cats. This increase in echocardiographic sensitivity mirrors the more recent increase in the index of suspicion of heartworm disease in cats. Careful evaluation of the pulmonary arteries should enhance the diagnostic usefulness of echocardiography.

In our study, when the analysis was limited to only those cats in which echocardiography, radiography, and antigen or antibody testing were performed, echocardiography provided a diagnosis in 14 of 22 (64%) cats. The improved frequency of positive echocardiographic findings in the 22 cats, compared with all cats examined, was most likely related to an enhanced clinical suspicion for the disease, when sonographers more carefully evaluated the pulmonary arteries in search of heartworms. Despite the lower sensitivity of echocardiography, compared with serologic testing, it should be emphasized that echocardiography allowed a definitive diagnosis to be made in 5 cats in which antigen test results were negative. These 5 cats had clinical and radiographic findings suggestive of heartworm disease and 4 of these 5 cats had positive antibody test results. Echocardiography appears to be most useful in instances in which the antigen test result is negative, and there is still suspicion of heartworm disease on the basis of compatible clinical signs, radiographic abnormalities, and a positive antibody test result.

Some investigators have suggested that echocardiography may be a useful screening tool for heartworm infection. Prieto et al¹⁰ found echocardiography relatively more sensitive than antigen testing in a population of nonclinically infected cats in a hyperendemic area of Italy in which the prevalence of heartworm infection in cats is 22%. In that study, echocardiographic examination had 100% relative sensitivity, whereas antigen testing identified only 4 of 12 infected cats. In our study, although most of the cats had clinical signs, echocardiography did not appear to be a useful screening test for identifying nonclinical infections. Of the cats with nonclinical infections in our study, use of echocardiography identified a heartworm in only 1 of 5 cats examined. A number of possible reasons could explain the disparity in these studies, including our potential less-than-optimal evaluation of the pulmonary arteries in these cats that did not have clinical signs of infection. Some areas of Italy have a higher prevalence of heartworm infection in cats, compared with the southeastern United States,² and the higher echocardiographic sensitivity in Prieto's study may also reflect a higher worm burden per cat in Italy.

The finding of a positive antigen test result is considered to be specific and diagnostic for heartworm disease.³ Antigen test results were positive in 17 of 22 (77%) cats in which all 4 diagnostic modalities were used. Antigen test results were, however, negative in 5 cats in which echocardiography allowed detection of heartworm infection. The high relative sensitivity of the antigen tests used in our study mirrors that of our previous study, in which we reported a similar relative antigen sensitivity (89%).⁹ The cats in both these studies typically had clinical signs of infection. Thus, on the basis of results of these 2 studies, the antigen test had a relative sensitivity of approximately 80 to 90% in a population of cats with clinical infection. These findings must, however, be interpreted with caution. In a report of 215 random-source cats, McCall⁸ reported that antigen test results were positive in only 38% of cats in which heartworms were identified at post-mortem examination. This disparity is likely reflective of differing cat populations (ie, differing prevalence in random-source vs cats with clinical signs of infection) and study designs. In this report and our earlier report,⁹ necropsy-based confirmation of heartworm status is lacking. Antigen testing provided a diagnosis but some cases were likely missed, thereby overestimating the overall sensitivity of the test. This concern holds true for echocardiography as well. In other words, tests such as echocardiography or antigen testing that have high specificity (ie, considered to be diagnostic in and of themselves) will have a falsely increased sensitivity if there is no gold standard for negativity (ie, necropsy).

Unlike the antigen test, a positive antibody test result is only supportive of a diagnosis of heartworm infection. A positive antibody test result may detect cats infected with immature worms, such as microfilarial stage L3, that do not develop into adult heartworms, or past infections. In our study, antibody test results were positive in 82% (18/22 cats) of cats tested. Although the antibody test is more sensitive than use of echocardiography, radiography, and antigen testing, it does not provide a definitive diagnosis. Nevertheless, it should also be emphasized that the combination of a positive antibody test result, pulmonary artery enlargement (as detected radiographically), and appropriate clinical signs are highly suggestive of heartworm disease.

As in previous studies,^{6,7,9} abnormalities detected radiographically, such as pulmonary artery enlargement, were common in our study. The most specific radiographic feature appeared to be caudal pulmonary artery enlargement, defined as a caudal pulmonary artery 1.6 times the 9th rib at the 9th intercostal space.⁶ Most of the cats in our study (64%; 14/22 cats) had pulmonary artery enlargement. Radiography, similar to antibody testing, can only complement other diagnostic tests.

In this study, there was no true gold standard for the presence of heartworm infection (such as post-mortem confirmation). Because of the lack of a gold standard, the incidence of false-positive and false-negative test results cannot be evaluated. As mentioned, false-negative antigen and echocardiographic results

are likely underestimated, and false-positive antibody test results could not be detected. In addition, dying, partially resorbed or embolized worms, or those in the distal pulmonary arteries may not be detected ultrasonographically. The likelihood of false-positive heartworm identification by use of echocardiography is low. The heartworm has a distinctive echocardiographic appearance, a double-lined structure that is not easily mistaken for any other cardiac structures.

^aGenchi C, Venco L, Prieto G. Feline heartworm infection: clinical study in Northern Italy (abstr). *Assoc Advancement Vet Parasitol* 1997;110:81.

^bSnap IDEXX Laboratories, Westbrook, Me.

^cDiroCHEK and ASSURE/CH tests, US Synbiotics Corp, San Diego, Calif.

^dAnimal Diagnostics Laboratory, St Louis, Mo.

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