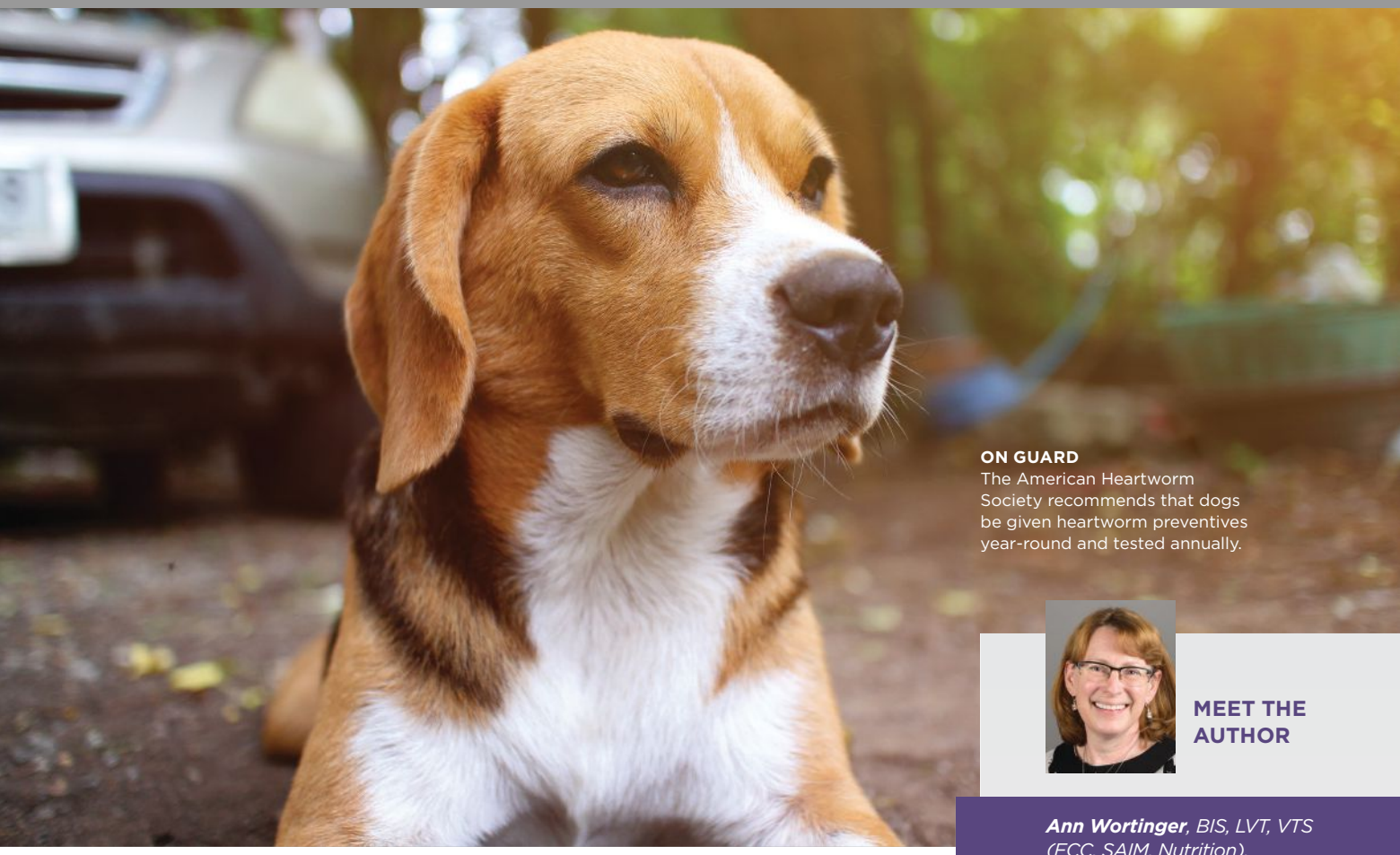

ON GUARD
The American Heartworm Society recommends that dogs be given heartworm preventives year-round and tested annually.

MEET THE AUTHOR

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Heartworm Disease in Dogs

Heartworm disease is a vector-borne disease. The nematode parasite, *Dirofilaria immitis*, is transmitted to susceptible mammals by infected mosquitoes seeking a blood meal. Of the 20-plus species of mosquitoes that can become infected with *D. immitis* parasites, approximately 10% have been found to carry the larval form.[1,2] All canids, including domestic dogs, foxes, coyotes, and wolves, can be definitive or natural hosts for heartworms.[3]

Heartworm disease has been reported in all 50 U.S. states according to the Companion Animal Parasite Council (**FIGURE 1**). Prevalence is increasing even in states previously considered to be low risk, such as California, Oregon, and Colorado.[1] In Canada, according to the Alberta Animal Health Source, heartworm disease can occur in the warmer provinces. These areas include southern Ontario, Quebec, Manitoba, and British Columbia, where the temperatures are warm enough to support development of the mosquito species that transmit heartworm.[4]

Some of the driving forces behind the spread of heartworm disease include the frequency with which people travel with their dogs (between low- and high-risk areas) and the false belief that heartworms are not found in certain areas (leading to prevention complacency). Another source of spread is the influx of rescued animals into previously low-risk areas.[1,4] **BOX 1** lists facts to help address misconceptions with clients.

BOX 1

Client Communication Tips

- Although risk varies by region, heartworm disease has been found in all 50 U.S. states.
- Treatment can be a one-time large expense, whereas cost of prevention is spread out over the dog's life.
- For heartworm-infected dogs, the multimodal treatment schedule recommended by the American Heartworm Society has proven safer and more effective than previous treatment protocols.
- Heartworm prevention is generally easier and safer than treatment.
- Effective heartworm preventive medications are readily available.
- Prevention needs to be started early, by the time a puppy is 8 weeks of age.
- Consistent administration of preventive medications throughout the year, per labeled directions, is essential.

D. IMMITIS HEARTWORM LIFE CYCLE

Infection starts when a mosquito bites a heartworm-infected dog (**FIGURE 2**). Along with the blood meal, the mosquito also ingests immature first-stage (L1) heartworm larvae (microfilariae) from the infected dog. The microfilariae mature inside the mosquito until they become third-stage (L3) larvae, which migrate to the mosquito's mouth parts ready to infect the next host. After the infected mosquito bites the next host (for this article we will assume a dog), the larvae migrate through the dog's subcutaneous tissue into the bloodstream. They migrate through the body tissues until they become juvenile/immature adults, travel to the preferred site for mature heartworms—the pulmonary and heart vessels—and complete their development and start reproducing there.[1,3]

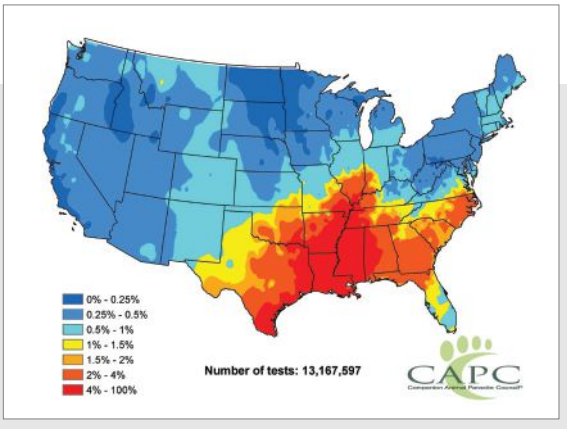

FIGURE 1. Prevalence of heartworm disease in dogs in the continental United States, 2019.[2]

The mature female heartworm produces microfilariae. This cycle takes 6 to 7 months, during which time the host dog is largely unaffected by the larvae. Problems within the host start to arise as the heartworms mature to adults, which reside inside the major blood vessels of the heart and lungs, primarily the pulmonary artery. Adult worms physically disrupt blood flow through the heart and lungs.[3]

DIAGNOSIS

Clinical Signs

It can take years after infection before the clinical signs of heartworm disease become apparent. Early clinical signs include a persistent soft cough, reluctance to exercise, fatigue after moderate activity, decreased appetite, and weight loss. As the disease progresses, right-sided congestive heart failure can develop as the heart works harder to pump blood around the worms living and breeding in the

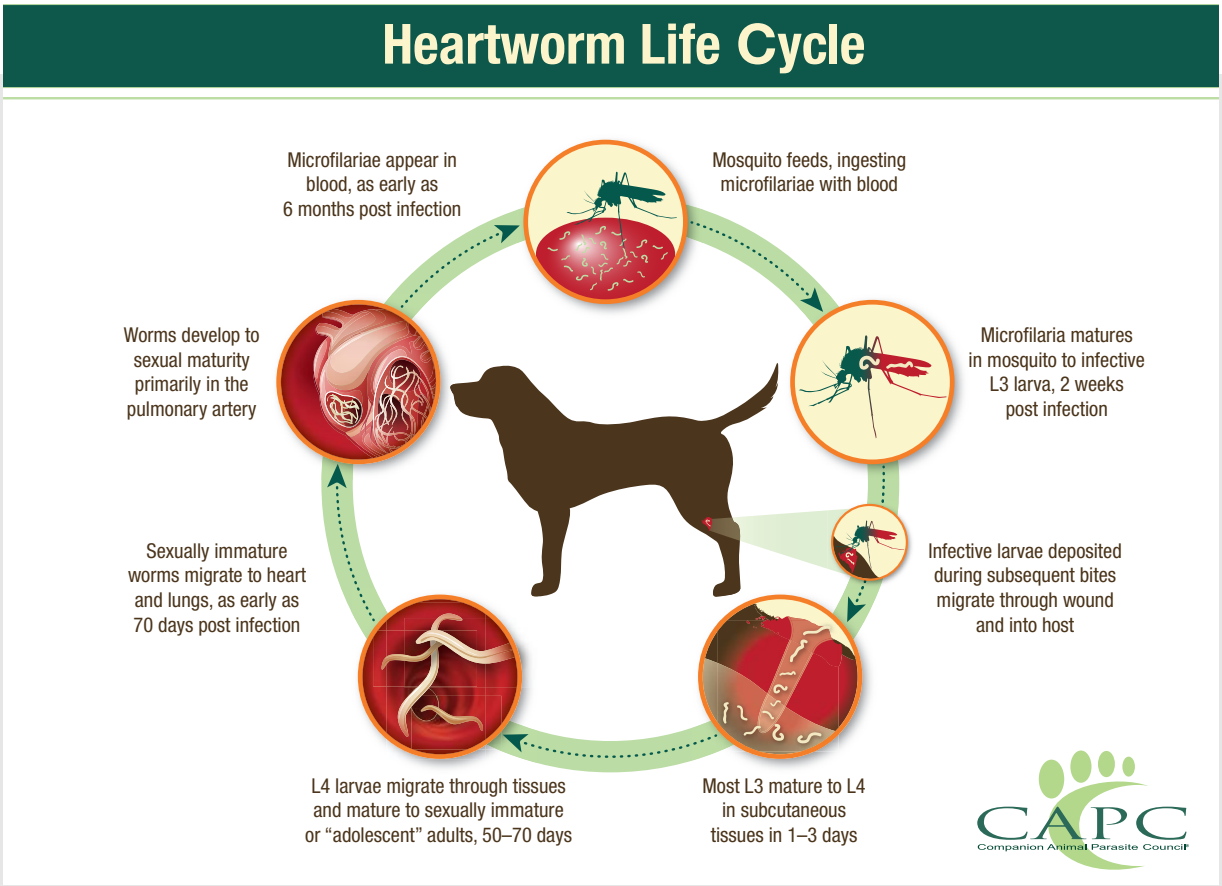

FIGURE 2. Life cycle of *Dirofilaria immitis* heartworms in the dog.[2]

blood vessels.[3] As a result, fluid accumulates in the abdomen as ascites. Vessels can suddenly become blocked by large numbers of worms, leading to caval syndrome, which requires emergency treatment.

Antigen Tests

Available from a number of manufacturers, types of antigen tests include enzyme-linked immunosorbent assays (ELISAs), immunochromatographic tests, and solid substratum ELISAs. ELISAs typically must be stored in the refrigerator, but immunochromatographic tests can usually be stored at room temperature. The choice as to which system to use may come down to how much refrigerator space is available.[1-3]

Antigen testing detects antigens found in the adult female worm reproductive tract. Until the L3 larvae mature to adults, this protein cannot be detected.[3] Thus, because circulating antigens will not be detected until 6.5 to 7 months after infection, testing puppies younger than 7 months is not effective.

For dogs old enough to be tested, antigen tests are less effective when the worms are old (no longer reproducing), the worm burden is low (<3 adult female worms), or the worms are predominately male.[1,2]

Diagnosis can be enhanced by heat pretreatment of a sample before testing. This procedure is not always indicated but can be helpful when heartworm disease is strongly suspected but the initial antigen test result is negative.[5] Heat pretreatment denatures circulating immune complex proteins (antibody bound to heartworm antigen), causing the antibodies to precipitate out and freeing the antigen, making it easier to detect. This procedure can be performed by an outside laboratory, although in-house methods are also available.

Other Tests

Other diagnostic tools useful for identifying heartworm disease include visualization of microfilariae on a direct blood film (**FIGURE 3**) or on a stained slide

prepared for a complete blood count, radiography, and echocardiography. Note that echocardiography is rarely performed for the purpose of heartworm diagnosis unless the suspicion of infection is strong.[1,6]

TREATMENT

Dogs with caval syndrome require emergency treatment, which involves surgical removal of adult worms from the blocked vessel, usually by advancing endoscopic forceps through the right jugular vein.[3]

For heartworm-infected dogs in which caval syndrome has not developed, treatments are aimed at killing worms of all stages and preventing adverse events that can follow worm death. Effective treatment options are available; choice of treatment depends on the size of the dog, geographic location, and how sick the dog is at the time of treatment. The Companion Animal Parasite Council recommends immediate and aggressive treatment and discourages "slow kill" therapy options.[2] The American Heartworm Society recommends multimodal treatment.[6]

Treatment options include surgical removal (only for dogs with caval syndrome) and medical and supportive options. Surgical removal is outside the scope of this article; therefore only medical and supportive options will be discussed.

Melarsomine Dihydrochloride

The treatment of choice is melarsomine dihydrochloride. It can kill mature and immature heartworms. After melarsomine kills adult worms in the major blood vessels, the worms disintegrate and are removed by white blood cells, specifically neutrophils and monocytes.[1,3] The drug is administered intramuscularly into the epaxial muscles; pain management may be needed.

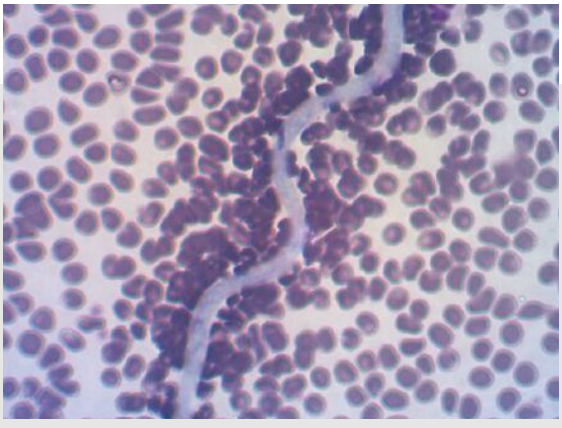

FIGURE 3. *Dirofilaria immitis* microfilariae on a blood film slide.

Macrocyclic Lactones

Because infected dogs can harbor worms at various life stages, treatment with the macrocyclic lactone preventives (ivermectin, selamectin, moxidectin) 2 months before administration of melarsomine is recommended to help remove microfilariae. The American Heartworm Society provides the treatment schedule and doses for the various medications.[5]

Supportive Therapies

Adjunct therapies address some of the secondary changes. Steroids administered in decreasing doses can help control signs of pulmonary thromboembolism. Doxycycline can be administered 1 month before melarsomine to minimize potential effects of *Wolbachia* bacteria released by dying heartworms.[1] These obligate intracellular bacteria help heartworms thrive and reproduce and are released when adult heartworms die naturally or as a result of melarsomine administration. Killing these bacteria further weakens the worms and improves the response to melarsomine.

Exercise Restriction

The only way that heartworms can exit the body is disintegration and ingestion by white blood cells. If a clump of dying worms lodges in another area of the body, blood flow can be cut off, creating an emergency situation. Therefore, after treatment, the patient's exercise must be strictly limited for up to 6 months while the worms are slowly removed by the body. If the worms have already done significant damage to the body, there is no guarantee that the damage will resolve.[5]

PREVENTION

There are 3 forms of very effective heartworm preventive medications available: oral, topical, or injectable (to be injected by a veterinarian). Only products approved by the Food and Drug Administration and licensed for use by a veterinarian should be used. Over-the-counter medications are not subjected to the rigorous Food and Drug