

Heartworm: The Parasite

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What is a Heartworm?

Heartworm (*Dirofilaria immitis*) is a fairly large worm (up to 14 inches long) that, in adulthood, lives in the heart and pulmonary arteries of an infected dog. Dogs acquire this infection through mosquito bites as mosquitoes readily pick up larval heartworms from infected dogs and carry them to new dogs. Some geographic areas have severe heartworm problems while other areas have none. In order for the parasite to establish its presence in an area, the following conditions must be met:

- Types of mosquitoes capable of carrying larval heartworms must be present
- The weather must be warm enough to allow heartworm larval development within the mosquito
- There must be infected dogs (or coyotes) in the area
- There must be vulnerable host dogs in the area

When these conditions come together, an area becomes "endemic" for heartworm disease.

THE DETAILED VERSION OF THE HEARTWORM STORY: LET'S FOLLOW THE WORM'S LIFE CYCLE

THE ADULT HEARTWORM

The adult heartworm is fairly large, several inches in length, and it prefers to live, not in the heart, but in the pulmonary arteries. It swims into a cozy tubular artery, where it is massaged and nourished by the blood coursing past it. In the pulmonary arteries of an infected dog, the worm's presence generates a strong inflammatory response and a tendency for blood to inappropriately clot. If enough worms are present, the heart must work extra hard to pump blood through the plugged up arteries.

If the worm infection is a heavy one (over 25 worms for a 40 lb dog), the worms begin to back up into the right ventricle (the chamber which pumps blood through the lung). The worms actually take up a significant amount of space within the heart, leading to less blood being pumped.

When over 50 worms are present, the ventricle is full and the atrium, the chamber receiving blood from the rest of the body begins to contain worms.

When over 100 worms are present, the entire right side of the heart is filled with worms and there is very little room for any blood to be pumped. This drastic phenomenon is called "Caval Syndrome" and most dogs do not survive it.

MICROFILARIAE (First Stage Larvae)

With adult male and female worms present, mating begins to occur. Heartworms do not lay eggs like other worm parasites; instead they give live birth and the baby worms are called Microfilariae. Microfilariae are released into the circulatory system in hope that they will be slurped up by a mosquito taking a blood meal and carried to a new host. Microfilariae may live up to two years within the host dog in whom they were born; if after this period a mosquito has not picked them up, they die of "old age." Microfilariae may also be transmitted across the placental barrier to unborn puppies if the mother dog is infected with heartworm. It is important to realize that such puppies will not develop adult heartworms or heartworm disease from these microfilariae; in order for a heartworm to reach adulthood, it must be passed through a mosquito.



Parasitic worms have 5 larval stages and are termed "L1," "L2," "L3," etc. Heartworm microfilariae are first stage larvae: "L1"s.

Note: Heartgard30 and Interceptor, the main heartworm preventives available commercially,



will kill microfilariae. Dogs on heartworm preventive, even if infected with adult heartworms, will not test positive for microfilariae.

INSIDE THE MOSQUITO

Within the mosquito's body, the microfilariae will develop to L2's and finally to L3's, the stage capable of infecting a new dog. How long this takes depends on the environmental conditions. In general, it takes a few weeks. A minimum environmental temperature of 57 degrees F is required throughout this period. The process goes faster in warmer weather.

INFECTING A NEW DOG

When a dog is bitten by an infected mosquito, the L3 is not deposited directly into the dog's bloodstream. Instead, it is deposited in a tiny drop of mosquito "spit" adjacent to the mosquito bite. For transmission to occur, there must be adequate humidity to prevent evaporation of this fluid droplet before the L3's can swim through the mosquito bite and into the new host.

Once safely inside the new host, the L3 will spend the next week or two developing into an L4 within the host's skin.



The L4 will live in the skin for three months or so until it develops to the L5 stage and is ready to enter the host's circulatory system. The L5, which is actually a young adult, migrates to the heart and out into the pulmonary arteries (if there is room) where it will mate, approximately 5-7 months after first entering the new host.



Note: L3's are readily killed by Interceptor but not by Heartgard30. Interceptor and Heartgard30 both act primarily on the L4's living in the skin. After a dose of either medication, any L4's present will be wiped out. Heartgard30 is also able to kill the younger L5's.

What Happens in Heartworm Disease

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HEARTWORM DISEASE VS. HEARTWORM INFECTION

Before reviewing the clinical signs seen in heartworm disease, an important distinction must be made between heartworm disease and heartworm infection. "Heartworm infection" by definition means the host animal (generally a dog) is parasitized by at least one life stage of the heartworm (*Dirofilaria immitis*). Dogs with heartworms in their bodies do not necessarily have adult worms in their hearts; they may have larval heartworms in their skin only. Dogs with heartworms in their bodies are not necessarily sick, either. Dogs with only larvae of one stage or another are not sick and it is controversial how dangerous it is for a dog to have only one or two adult heartworms. These dogs are certainly infected but they do not have heartworm disease.

On the other hand, dogs with heartworm disease are sick. They not only have the infection but they have any of the problems listed below because of it. Fortunately, heartworm disease is both treatable and preventable. Further sections of this web area explain both treatment and prevention; we will now discuss the damage heartworms can do to a dog's body.

DAMAGE TO THE PULMONARY ARTERIES

Arteries do not do well having worms living inside them. The lining of the artery becomes damaged within days of the worm's arrival. Cells of the immune system are called into the area but the worm is far too big for these tiny cells to destroy. The resulting inflammation, however, continues to damage the artery. The arteries dilate and become tortuous (which may be visible on a radiograph); aneurysms and abnormal blood clotting (embolism) results. Blood is shunted to other arteries which are not plugged up by worms and fluid begins to accumulate in the lung around the worm-filled arteries. Blood being sent to the lung is not efficiently oxygenated

and areas of lung become consolidated and unable to participate in providing oxygen to the blood.

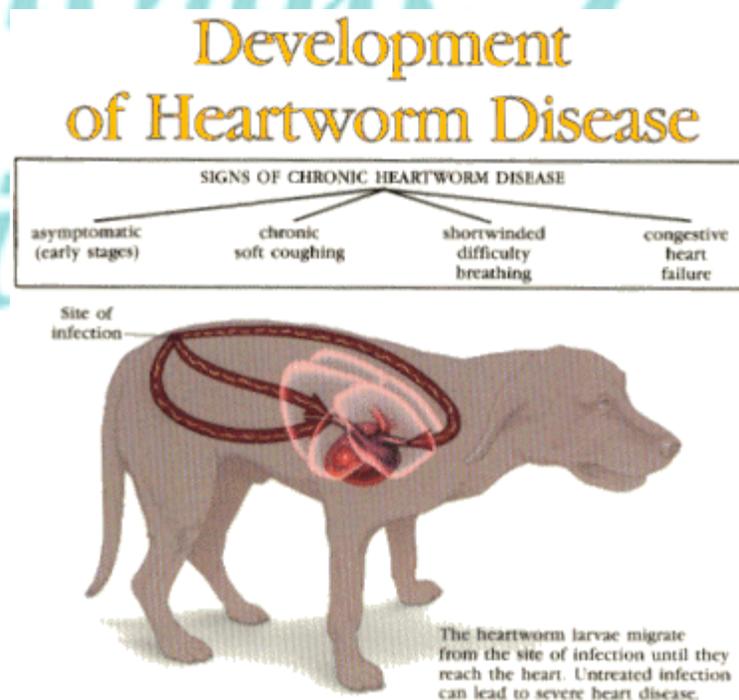
- Coughing and exercise intolerance result as areas of the lung are lost to the blood oxygenation process.
- Nose bleeds may occur due to abnormal blood clotting in the lung.
- A form of non-infectious pneumonia ("pulmonary eosinophilic granulomatosis") can result from excessive infiltration of inflammatory cells into the lung in response to the parasite.

HEART FAILURE

Blood normally is pumped with ease through the arteries of the lung. With the arteries plugged with worms, the heart must pump harder against the pressure of the plugged arteries. This condition is called "*PULMONARY HYPERTENSION*" and the right side of the heart must drastically increase its ability to work. It may be strong enough and it may not.

If worms begin backing up into the heart, there will be less space in the pumping chamber for blood to be pumped. The heart must pump through the high pressure system of the plugged arteries using less blood than normal. In order to meet the body's oxygen demand, the heart must pump faster and stronger still. There may come a point when the heart simply is not strong enough.

- When the heart muscle begins to thicken (as any over-worked muscle will), it may not conduct electrical impulses normally. This means that the pumping/filling rhythm can be disrupted and an "*ARRHYTHMIA*" may result. **IN ANY HEART DISEASE ARRHYTHMIA IS A POSSIBILITY AND WHEN ARRHYTHMIA IS A POSSIBILITY SO IS SUDDEN DEATH.**
- If the right side of the heart becomes too weak to keep up, fluid may accumulate in the chest cavity and abdominal cavity, leading to a pot-bellied appearance and/or difficulty breathing.



CHRONIC IMMUNE STIMULATION

When a dog goes without treatment for heartworm disease, its immune system becomes chronically stimulated. Antibodies, which are not only important tools of the immune system but are inflammatory proteins, are produced in high amounts all the time. These antibodies can cause a lot of trouble by precipitating in the delicate membranes of the eye, kidney, blood vessels, and joints. Antibodies stuck in these areas, call in inflammatory

cells and damage these delicate membranes thus setting up tremendous tissue damage and pain.

CAVAL SYNDROME

Caval syndrome represents an especially disastrous form of heartworm disease. Here, there are so many worms present (around 100) that the entire right side of the heart is filled with worms and they are backing out into the large veins that feed the right side of the heart. Usually there have been no signs of heart disease prior to the collapse, shock, and red blood cell destruction associated with this syndrome. Death usually occurs within 1-2 days and the only effective treatment is to open the dog's jugular vein and physically remove the worms with a special clamp. If enough worms can be removed to re-establish blood flow, the dog may survive.

Heartworm disease is a highly significant problem and must be managed both by dealing with the worms and by dealing with the heart disease.

Heartworm Treatment

Medications used in Treatment

An important basic concept in the treatment of heartworm infection is that there are adult heartworms in the heart and pulmonary arteries to be killed and there are microfilariae circulating in the bloodstream to be killed and one medication cannot be used to do both jobs. Let us first look at the medication that we use to kill adult heartworms.

MELARSOMINE DIHYDROCHLORIDE (Immiticide®, made by Rhone)

Because of the toxicity potential of Thiacetarsamide (no longer used widely and definitely not used here), much research has been devoted to the development of a safer anti-heartworm medication. Melarsomine dihydrochloride represents the result of this research. This medication, which is an arsenic derivative, is given deeply in the muscle by injection rather than intravenously. Previously, dogs that had no or mild clinical signs were treated with one injection a day for 2 consecutive days, and dogs with large numbers of worms (or showing more severe signs of canine heartworm disease) commonly received one injection to lower worm numbers and then one month later will receive the two-day course. Recent research reports (early 2003) have changed the way many hospitals, including ours, treat canine heartworms. The new research shows that the 2-injection treatment kills about 90% of the adult heartworms, and the 3-injection treatment, while safer for the dogs, is also more effective – more than 99% of the adults are killed. So, regardless of clinical signs, we have changed our therapy to the 3-injection treatment for all dogs that are treated. Muscle soreness and inflammation is not uncommon after treatment, and Rimadyl®, an anti-inflammatory drug is sent home to help control any discomfort. Melarsomine appears to be substantially more effective at killing adult worms than Thiacetarsamide and is not toxic to the liver and kidneys though, again, inflammatory and clotting reactions may occur as the worm die off after treatment. Exercise restriction is still imperative after therapy (and most important after the 2-injection portion of the therapy).

KILLING MICROFILARIAE

In the past, clearing of microfilariae was done using any of a number of de-worming medications, all of which had potential for undesirable side effects. The advent of ivermectin led to a simpler way to clear microfilariae and special doses were recommended with the understanding that some trouble with thromboembolism and inflammation could result if the microfilariae were killed too quickly. This posed a problem until it was discovered that the routinely used doses of ivermectin in Heartgard30 would clear microfilariae safely and without reaction. Milbemycin oxime (active ingredient of Interceptor) will clear them substantially faster yet (within days versus within months), though, as mentioned, this faster worm kill could lead to adverse inflammatory reactions if large numbers of microfilariae are killed at once.

AFTER TREATMENT OF AN ACTIVE HEARTWORM INFECTION, IT IS IMPORTANT TO ANTIGEN TEST THE DOG 4-5 MONTHS LATER TO INSURE THAT ALL WORMS HAVE BEEN KILLED.