

First autochthonous case of *Angiostrongylus vasorum* in a domestic dog in the United States

Laura B. A. Williams, DVM, PhD, DACVP, DACVM^{1*}; Minden L. Buswell, DVM, MPH, DACVPM²; Nicolle A. Perisho, DVM³

¹Department of Veterinary Microbiology and Pathology, Washington Animal Disease Diagnostic Laboratory, College of Veterinary Medicine, Washington State University, Pullman, WA

²Washington State Department of Agriculture, Olympia, WA

³Poulsbo Marina Veterinary Clinic, Poulsbo, WA

*Corresponding author: Dr. Williams (lartz@wsu.edu)

OBJECTIVE

To describe the clinical presentation, diagnostic findings, and medical management of the first suspected autochthonous case of a dog in the US diagnosed with *Angiostrongylus vasorum*, the French heartworm.

ANIMAL

A 10-month-old Goldendoodle born in Oregon and residing in Washington State.

CLINICAL PRESENTATION, PROGRESSION, AND PROCEDURES

The dog presented for evaluation of intermittent vomiting and diarrhea. Bloodwork revealed leukocytosis with mild lymphocytosis, monocytosis, eosinophilia, and basophilia. Larvae were detected on a fecal flotation, and fecal PCR confirmed *A vasorum*.

TREATMENT AND OUTCOME

Administration of milbemycin oxime PO once a week for 4 weeks was initiated with recommendation to continue monthly treatment at label dose. The patient improved over the course of treatment.

CLINICAL RELEVANCE

This case highlights the clinical and diagnostic findings and medical management of *A vasorum*, also known as the French heartworm, in a dog in the US. Few cases of *A vasorum* have been reported in wild foxes in North America, mostly in eastern Canada and 1 within the eastern US. Here we report for the first time an autochthonous case of *A vasorum* in a domestic dog in the US and the first report of any canid in the western US. This case highlights the importance of considering *A vasorum* as a differential for respiratory disease, gastrointestinal disease, or inexplicable eosinophilia in canine veterinary patients in the US and raises awareness for veterinary practitioners to incorporate appropriate preventative and diagnostic measures for their canine patients.

Keywords: dog, United States, French heartworm, *Angiostrongylus vasorum*, respiratory

History

A 10-month-old female Goldendoodle presented to the veterinarian in western Washington State for intermittent vomiting and diarrhea prior to a scheduled elective ovariohysterectomy. The owner parenthetically reported a cough at this time. Appetite and water intake were described as normal, and no abnormalities were detected on physical exami-

nation, apart from a cough noted while the patient was pulling on the leash.

The puppy had initially presented 3 months earlier for vomiting and diarrhea. At the time, abdominal radiographs were concerning for paralytic ileus due to gastroenteritis, toxicity, pancreatitis, or partial intestinal obstruction. Complete blood count yielded a mild leukocytosis due to lymphocytosis and eosinophilia. Fecal flotation was negative, and the clinical signs fully resolved following conservative supportive treatment with maropitant PO at the label dose of 2 mg/kg and probiotic supplements PO (Provable-Forte; Nutramax Laboratories Veterinary Sciences Inc).

Originally, the puppy was procured at 8 weeks of age from a dog breeder based in Oregon, with

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no known previous health conditions in the breeding population. Beginning at 4 months of age, the puppy began monthly parasite prevention including afoxolaner (NexGard) for flea and tick protection and ivermectin and pyrantel (Heartgard Plus) for endoparasite protection. There was no travel history outside of Washington State and Oregon; the dog was living on the Puget Sound coast and was reportedly known to have ingested snails.

Diagnostic Findings and Interpretation

Given the continuous and intermittent gastrointestinal signs, the owner approved a second CBC and chemistry profile, as well as a 4DX SNAP test (Idexx Laboratories Inc) prior to the scheduled ovariohysterectomy. Complete blood count results yielded a mild leukocytosis due to lymphocytosis, monocytosis, eosinophilia, and basophilia. Apart from a mild hyperglobulinemia, the chemistry profile was normal. The SNAP test results were negative for heartworm, *Ehrlichia canis*, Lyme, and *Anaplasma phagocytophilum*. Following the CBC results and in light of the clinical signs, the elective surgery was postponed and the following additional diagnostic testing was recommended to identify potential underlying causes of gastrointestinal disease: comprehensive fecal diagnostic testing to screen for parasitism and bacterial and viral infectious diseases, baseline cortisol quantification and/or ACTH stimulation testing to assess for Addison disease, abdominal ultrasound, and potentially gastrointestinal biopsies to rule out anatomic abnormalities and other inflammatory diseases.

The owner consented to comprehensive fecal diagnostic testing. Fecal antigen test (Idexx Laboratories Inc) results were negative for flea tapeworm, hookworm, whipworm, and roundworm. Canine Diarrhea RealPCR panel testing (Idexx Laboratories Inc) did not detect *Campylobacter coli*, *Campylobacter jejuni*, canine circovirus, canine distemper virus, canine enteric coronavirus, canine parvovirus 2, *Clostridium difficile* toxin A/B gene, *Clostridium perfringens* CPnetE/F toxin gene, *Cryptosporidium* spp, *Giardia* spp, or *Salmonella* spp. RealPCR detected low levels of *C perfringens* α toxin gene and *C perfringens* enterotoxin gene.

Zinc sulfate fecal flotation (Idexx Laboratories Inc) yielded moderate numbers (11 to 30) of larvae with a kinked tail and dorsal spine. Following identification of larvae, canine lungworm RealPCR panel testing (IDEXX Laboratories Inc) was pursued, and results were negative for *Crenosoma vulpis* and positive for *Angiostrongylus vasorum*.

Treatment and Outcome

The patient began PO milbemycin oxime and praziquantel (Interceptor Plus) at label dose every 7 days for 4 weeks, with directions to continue monthly thereafter. By the end of the 4-week treatment pe-

riod, the clinical signs had resolved and no parasites were detected on a recheck fecal float. Clinicopathologic abnormalities also improved; the basophilia and monocytosis resolved completely, and the eosinophilia and lymphocytosis improved.

Comments

Angiostrongylus vasorum, commonly known as the French heartworm, is a metastrongylid nematode that primarily exists in a sylvatic indirect life cycle involving wild canid definitive hosts and gastropod intermediate hosts. Canids harbor the adult metastrongyle in the pulmonary vasculature. Eggs are produced in the lungs and are coughed up and swallowed, with subsequent release of the first-stage larvae in the feces of infected canids. Gastropod intermediate hosts ingest the first-stage larvae from the infected canid feces, and the larvae molt into the infectious L3 stage within the gastropod intermediate host. Following ingestion of the gastropod intermediate host or paratenic host by the canid, the larvae penetrate the intestinal wall and enter circulation to mature in the pulmonary vasculature. The prepatent period ranges from 1 to 4 months.¹

The parasite is endemic in regions of Europe, Africa, and South America and has been reported in North America. Most North American cases are reported in wild canids from the Canadian province of Newfoundland, although recent reports have emerged from other regions in eastern Canada.² The only known autochthonous case of *A vasorum* reported in the US was in a red fox in West Virginia.³ A single case was reported in a domestic dog imported into the US from Ireland in 1985; however, autochthonous cases have not been reported from domestic dogs originating within the US.³ This was the first case of *A vasorum* reported in Washington and the first autochthonous case of *A vasorum* detected in a domestic dog in the US.

Typically, clinical signs associated with angiostrongylosis in dogs are related to the vascular damage caused by the adult worms in the pulmonary vessels and the eosinophilic and granulomatous pneumonia caused by egg and larvae embolization. Most often, this manifests clinically as respiratory disease and coagulation abnormalities.¹ The presenting cough in the dog of the present case may have reflected pulmonary damage from nematodes in the cardiopulmonary vasculature. However, the primary clinical complaint reported by the owner in this case was related to gastrointestinal disease. After ingestion of an infected intermediate host, *A vasorum* larvae penetrate the intestinal wall to gain access to circulation. This can result in intestinal damage, and *A vasorum* has been reported to cause gastrointestinal signs in infected dogs.¹ Parasite migration was considered the likely cause of the gastrointestinal signs in this dog and may also have explained the bout of gastrointestinal signs noted 3 months earlier, especially in light of the eosinophilia at the time. No parasites were detected on the initial fecal float, which is unsurprising considering the intestinal dam-

age occurs from the larval stages of *A vasorum* during the prepatent period. The eosinophilia persisted on the second CBC 3 months later, and larvae detected on the fecal flotation confirmed the presence of a patent parasitic infection. Additionally, because the reported cough was thought to be irrelevant to the primary clinical complaint in this dog, a Baermann test was not pursued during the clinical work-up.

Diagnosis of angiostrongylosis can be difficult, even in severely affected dogs in endemic regions, due to the sensitivity of fecal testing, intermittent larval shedding, and lack of pathognomonic clinical signs and imaging findings. Fortunately in this case, a combination of compatible clinical signs and clinicopathologic abnormalities, a history of snail ingestion, the detection of morphologically consistent larvae on fecal float, PCR confirmation of *A vasorum* from the feces, and the improvement in clinical signs and clinicopathologic abnormalities following appropriate anthelmintic treatment all supported the diagnosis of this as the first case of *A vasorum* in a domestic dog in the US.

Some formulations of heartworm prevention have demonstrated efficacy in preventing *A vasorum* infection, including a spot-on formulation containing moxidectin and various oral formulations of milbemycin oxime.^{1,4} In this case, the dog was on monthly parasite prevention that included PO afoxolaner (NexGard) and PO ivermectin with pyrantel pamoate (Heartgard Plus). While ivermectin administered SC at a dose of 0.2 mg/kg twice with a 7-day interval has been successfully used in treating *A vasorum* cases,⁵ there are no published reports that indicate whether monthly oral formulations of ivermectin at typical heartworm-prevention doses of 0.006 mg/kg are efficacious in preventing or treating *A vasorum*. This dog developed a patent infection with *A vasorum* while on these oral heartworm-prevention medications. It is unknown whether this represents an inherent insusceptibility of *A vasorum* to this dose or route of ivermectin, potential issues with anthelmintic resistance, or other factors. Thus, veterinarians in areas where autochthonous cases of *A vasorum* have been reported, or in regions that are predicted to harbor *A vasorum*, may consider providing year-round prevention to dogs through the use of chemoprophylactics shown to be effective at preventing *A vasorum*, including certain formulations of moxidectin or milbemycin oxime.

In addition to chemoprophylactic usage, preventative measures should also include the proper and prompt disposal of canine feces in endemic regions. Veterinarians and owners should recognize that dogs that inhabit areas where wild canids and snails are common are at an increased risk for infection with this parasite. Routine fecal diagnostic testing, including both a fecal flotation and a fecal Baermann, is recommended to help identify infections that warrant treatment. Lastly, clinician vigilance is important, as angiostrongylosis should be considered a differential diagnosis for dogs with compatible clinical signs in regions not previously known to harbor the parasite.

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