

Hookworms

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Etiology

Hookworms are nematodes in the superfamily Ancylostomatoidea. In their normal hosts, they are parasites of the intestinal tract. In humans, some zoonotic hookworms can cause cutaneous larva migrans. *Ancylostoma braziliense*, a hookworm of cats and dogs, is responsible for most cases of cutaneous larva migrans. *A. caninum* and *Uncinaria stenocephala*, hookworms of dogs and cats, and *Bunostomum phlebotomum*, a hookworm of cattle, are less often involved. Rare cases caused by *A. tubaeforme* and *A. ceylanicum*, hookworms of cats, have been reported. Some zoonotic hookworms can also reach the intestine and mature in humans, resulting in classic hookworm disease (ancylostomiasis) with bleeding and anemia.

Most cases of classic hookworm disease are caused by *Ancylostoma duodenale* or *Necator americanus*, species usually found only in humans. On rare occasions, these species have been reported in other mammals. Less often, classic hookworm disease is caused by the zoonotic species *A. ceylanicum*. Rare human intestinal infections with *A. malayanum*, *A. japonica*, *Necator suillis* and *N. argentinus* have also been reported, but the identification of these organisms is uncertain. Eosinophilic enteritis is a zoonotic intestinal infection characterized by abdominal pain but no blood loss. Eosinophilic enteritis is caused by the canine hookworm *A. caninum*.

Geographic Distribution

A. caninum is the most widespread of all hookworms and can be found in many parts of the world. *A. tubaeforme* is also widely distributed. *A. braziliense* is limited to tropical and subtropical regions including Central and South America, the Caribbean and parts of the U.S. *A. ceylanicum* is found in Asia, Brazil, Zimbabwe, Madagascar, the Philippines and possibly other tropical or semitropical regions. *B. phlebotomum* is a parasite of temperate regions, while *U. stenocephala* occurs in colder climates including Canada, the northern U.S. and Europe. In the U.S., cutaneous larva migrans is mainly reported from the southern states.

Transmission and Life Cycle

Adult hookworms live in the intestines of carnivores. The eggs are shed in the feces and hatch in the environment, often within one to a few days. The larvae feed on soil bacteria and molt twice in the environment before they become infective third stage larvae. The larvae develop best in warm, moist, sandy soil that is sheltered from direct sunlight. Under optimal conditions, they reach the infective stage in approximately 4 to 7 days. Third-stage larvae that are unable to enter a mammalian host die in approximately 1 to 2 months when their metabolic reserves are exhausted.

Third stage larvae can penetrate the skin of the host; this usually requires at least 5 to 10 minutes contact with contaminated soil. In their natural hosts, these larvae enter the dermis, where they are transported through the lymphatic vessels and veins to the lungs. In the lungs, they penetrate the alveoli and migrate up the respiratory tree to the trachea. They are swallowed and mature into adults in the intestines, where they are found attached to the mucosa.

In dogs more than three months old, *A. caninum* larvae may fail to complete the migration through the lungs and are arrested in the tissues, where they survive as dormant (hypobiotic) larvae. These larvae can move to the uterus or mammary gland during pregnancy, and are transmitted to the puppies. Hookworm infections transmitted in colostrum or *in utero* can become patent during the second week of life. This route of transmission does not seem to exist for *A. braziliense* or *U. stenocephala* in dogs, or for any hookworms in cats.

Infections can also be acquired by ingesting hookworm larvae. Most of these larvae develop for a period of time in the gastrointestinal wall before re-appearing in the lumen and maturing to adult worms. *A. caninum* and *A. braziliense* can either penetrate the skin or be ingested. *U. stenocephala* is usually acquired by ingestion.

In the intestines, adult hookworms change their location every few hours, leaving tiny, bleeding mucosal ulcerations behind. Some species such as *A. caninum* release



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a strong anticoagulant that can cause profuse bleeding. *A. braziliense* adults live for approximately 4 to 8 months, *A. tubaeforme* adults from 18 months to 2 years, and *U. stenocephala* for about 4 months to a year in dogs. Eggs may be shed intermittently.

Infections in paratenic hosts

Paratenic (transport) hosts can be infected orally or through the skin. Larvae do not develop further in paratenic hosts, but become dormant in various tissues. In mice, *A. braziliense* and *A. tubaeforme* larvae are mainly found in the head, particularly in the nasopharyngeal epithelium and salivary glands. *A. caninum* and *U. stenocephala* are found mainly in the muscles. If a definitive host ingests these larvae, they are released and complete their development to adults. Cats can also be infected by eating infected cockroaches.

Infections in humans

In humans, most zoonotic hookworm larvae cannot penetrate into the dermis. They remain confined to the epidermis, where they migrate for a period of time but eventually die. *A. ceylanicum* and *A. caninum* hookworms are occasionally found in the intestines. The route of infection with *A. caninum* is still unknown; either percutaneous or oral transmission may be possible. *A. ceylanicum* infections become patent but *A. caninum* infections do not; only single *A. caninum* worms have ever been found in humans.

Disinfection

Aqueous iodine at 50-60 parts per million at 15-30°C can kill hookworm larvae in 15 minutes or less. They are also susceptible to sodium borate, 1% sodium hypochlorite and 2% glutaraldehyde. Sodium borate can be used to disinfect the soil. Hookworm larvae are susceptible to freezing, drying, direct sunlight and temperatures above 45°C.

Infections in Humans

Incubation Period

The incubation period for cutaneous larva migrans is short but vaguely established; according to some estimates, it is approximately 1 to 2 weeks. The incubation period for classic hookworm disease varies with the number of parasites and can be a few weeks to many months.

Clinical Signs

Cutaneous larva migrans

Cutaneous larva migrans is the most common syndrome in humans. Most of the lesions are seen on the legs, buttocks and hands, but they can be found on any part of the body that was exposed to the soil. Initially, there may be a tingling or prickling sensation where the larvae have penetrated the skin, followed by a papule at the same location.

Migration of the slow-moving larvae in the skin results in an allergic reaction where they tunnel. The lesions may include papules as well as non-specific dermatitis, vesicles, or narrow, serpiginous (snakelike), slightly elevated, erythematous lines. The lesions are intensely pruritic, especially at night, and usually advance several millimeters to a few centimeters a day. Pain is occasionally reported, usually in association with vesicles. Secondary bacterial infections can occur due to scratching. Most cases resolve spontaneously in two days to several weeks, but some lesions have been reported to last for more than a year.

Other lesions are occasionally reported, when larvae penetrate beyond the epidermis. *A. caninum* larvae occasionally migrate to the muscles, resulting in myositis with persistent swelling and tenderness. These larvae can also cause systemic signs and folliculitis. *Ancylostoma* spp. larvae have been documented in the eye.

Classic hookworm disease

Although classic hookworm disease is usually caused by human hookworms, the zoonotic species *A. ceylanicum* can also cause this syndrome. The first symptom is usually pruritus at the site of larval penetration. There may also be erythema with small papules or vesicles, which usually persists for 1 to 2 weeks. Migration of the larvae through the lungs can cause coughing and wheezing; lung signs are uncommon and are usually mild except with very heavy worm burdens.

The adult worms can cause acute intestinal symptoms such as abdominal pain, nausea, anorexia, vomiting and hemorrhagic diarrhea or melena. Chronic hookworm disease is characterized by blood loss and iron-deficiency anemia, and is associated with fatigue, pallor, tachycardia and dyspnea on exertion. Hypoproteinemia may cause edema, and there can be signs of malabsorption and malnutrition. In children, there may also be adverse effects on physical and intellectual growth. The severity of the disease varies with the worm burden and the amount of blood lost. Heavy infections can be fatal, particularly in infants.

A. ceylanicum infections tend to be milder than those caused by human hookworms. Anemia is usually the most prominent symptom but other clinical signs, similar to those caused by the human hookworms, are also reported.

Eosinophilic enteritis

Eosinophilic enteritis is caused by the zoonotic hookworm *A. caninum*. It is characterized by increasingly severe episodes of abdominal pain associated with peripheral eosinophilia, but no blood loss. Severe cases can mimic appendicitis or intestinal perforation. Some *A. caninum* infections may be asymptomatic.

Communicability

Cutaneous larva migrans and eosinophilic enteritis are not contagious. Patent *A. caninum* infections have not been reported in humans. Patients with classic hookworm disease (*A. ceylanicum*) are not directly contagious to others, as the eggs must develop for a period of time in the soil before they develop into infective third stage larvae. However, the eggs they shed can contaminate the soil.

Diagnostic Tests

Cutaneous larva migrans

The diagnosis is usually based on the clinical signs. It can be confirmed by a biopsy of the affected skin, but the larvae are rarely found and this test is not usually diagnostic.

Classic hookworm disease

Intestinal hookworm infections, including *A. ceylanicum*, are diagnosed by identifying the eggs in the feces. *Ancylostoma* eggs are 55-76 µm in length and approximately 34-50 µm in width, and have a smooth, thin outer shell. They are unembryonated when they are first shed, but develop quickly; they may contain several cells or a ball of cells. First-stage hookworm larvae may be seen in preparations from old or stored feces, especially in warm and humid conditions.

Eosinophilic enteritis

A. caninum cannot be diagnosed by examination of the feces, as only single worms have been found in human hosts and eggs are not shed. The presence of eosinophilia aids in diagnosis. Ulcerations in the ileum and colon, and occasionally hookworms, may be seen using colonoscopy. Serologic tests including ELISAs and immunoblotting (Western blotting) are used only in research.

Treatment

Intestinal disease

Hookworms in the intestines can be treated with anthelmintics including pyrantel pamoate, albendazole, mebendazole and thiabendazole. Iron therapy or blood transfusions may also be needed.

Cutaneous larva migrans

Cutaneous larva migrans can be treated with topical or oral anthelmintics including thiabendazole, albendazole, mebendazole and ivermectin. The larvae may also be frozen if they are few in number. Patients with minimal symptoms may not require treatment, as the infection is self-limiting. Pruritus usually decreases within 24 to 48 hours after the initial treatment, and the lesions usually resolve in a week.

Prevention

Zoonotic hookworm disease is best prevented by eliminating the parasites from dogs and cats to decrease contamination of the soil. Dogs and cats should also be kept off beaches and other places where children play in the sand. Sandboxes should be covered when not in use. Sodium borate can be used to sterilize lawns, kennels or other areas. Removing canine feces at least twice a week also decreases soil contamination. The larvae do not survive well in dry, bare soil in direct sunlight.

Prolonged skin contact with contaminated soil should be avoided. Wearing footwear (or gloves when gardening) can decrease the risk of infection. A waterproof sheet may be spread over damp work areas, when working under houses or in other potentially contaminated areas.

Hookworms can be acquired by ingestion as well as skin contact; therefore, unsafe water should be boiled, and potentially contaminated foods avoided. The hands should also be washed before eating and after contact with soil or other sources of hookworms.

Morbidity and Mortality

Cutaneous larva migrans is particularly common in children. The prevalence is also high in adults who have close contact with the soil, including gardeners, farmers, miners, exterminators and others whose occupations require crawling under houses. Some infections are acquired at the beach. Cutaneous larva migrans is the most common travel-related skin infection in tourists to tropical areas. Infections are self-limiting and the lesions resolve within a few weeks to a few months. Rare cases have lasted up to a year. Deaths are not seen.

Intestinal infections with *A. caninum* are uncommon except in Australia. *A. ceylanicum* is also rare in humans. Classic hookworm disease can result in anemia, malnutrition, and, in severe cases, congestive heart failure, severe blood loss or death, especially in young children. Zoonotic *A. ceylanicum* infections are usually milder than classic human hookworm infections.

Infections in Animals

Species Affected

The natural (definitive) hosts of hookworms are: *Ancylostoma braziliense* is a hookworm of dogs, cats and other carnivores. *A. caninum* is found in dogs. *A. ceylanicum* and *A. tubaeforme* infect cats and other felids. *Uncinaria stenocephala* infects dogs and occasionally cats. *Bunostomum phlebotomum* is a hookworm of cattle. Rodents can be paratenic hosts for hookworms including *A. braziliense*, *A. tubaeforme*, and *U. stenocephala*.

Incubation Period

The incubation period varies with the number of parasites. Puppies can become symptomatic in the first week of life, before the infection becomes patent.

Clinical Signs

Dogs and cats

The symptoms caused by adult hookworms vary with the parasite burden and the age of the animal. They are generally more severe in young animals.

A. caninum can cause intestinal blood loss and anemia in dogs. The symptoms may include weakness, anorexia, dark reddish-brown to black hemorrhagic diarrhea, dehydration, malabsorption and wasting. Deaths may occur due to blood loss. The worms can also cause protein and fluid losses and malabsorption, resulting in decreased growth and performance. Older animals can carry a few worms without clinical signs.

A. tubaeforme can cause intestinal blood loss, anemia and weight loss in kittens. Large numbers of worms can be fatal.

U. stenocephala and *A. braziliense* are not heavy blood-feeders and do not cause anemia or bloody diarrhea. However, they can cause enteric disease, including diarrhea and protein-losing enteropathy.

Larval hookworms may also cause symptoms during their migration. Dermatitis may be seen where the larva penetrate the skin. The lesions, which can include erythema, pruritus and papules, are usually limited to the feet and often to the interdigital spaces. Some infections can be severe and result in self-inflicted trauma. In most cases, these lesions disappear approximately five days after they appear. Large numbers of larvae in puppies can cause pneumonia during their migration through the lungs.

A rare aberrant *A. caninum* adult larva was also found in the spinal cord of a puppy. It was associated with neurological signs including incoordination, ataxia, posterior paresis progressing to tetraplegia, torticollis and cervical pain.

Cattle

Larval penetration of the lower limbs can cause uneasiness and stamping, and there may be local skin lesions, edema and scabs. The adult worms can cause anemia, rapid weight loss, and alternating diarrhea and constipation. Hypoproteinemia may be seen, but bottle jaw is usually mild. Deaths can occur, especially in calves.

Communicability

Hookworm eggs shed in the feces are not immediately infective. They become infective after developing to the third stage larvae in the soil.

Canine and feline hookworms usually become patent after 13-27 days. This period varies with the route of exposure. In dogs, *A. caninum* infections can become patent in

14 days. *A. caninum* infections transmitted in colostrum or *in utero* can become patent during the second week of life. In cats, the prepatent period for *A. braziliense* is 14 to 16 days if the larvae are ingested, and 13 to 27 days if they enter the body through the skin. The prepatent period for *A. tubaeforme* in cats is 18 to 28 days after ingestion and 19-25 days after skin penetration. For *U. stenocephala*, the prepatent period is 13 to 21 days after ingestion and 15 to 17 days after skin penetration. The prepatent period for *B. phlebotomum* in cattle is approximately two months.

Diagnostic Tests

Hookworm infections are diagnosed by fecal flotation and detection of the eggs. Typical *Ancylostoma* eggs are 55-76 μm in length and approximately 34-50 μm in width, and have a smooth, thin outer shell. They are unembryonated when they are first shed, but develop quickly; at the time of diagnosis, they may contain several cells or a ball of cells. *Uncinaria* spp. eggs are very similar but slightly larger (70-90 μm x 40-50 μm); they cannot be easily distinguished from *Ancylostoma* spp. except in mixed infections. First-stage hookworm larvae may appear in preparations from old or stored feces, especially in warm and humid conditions. Eggs are not shed constantly, and repeated sampling may be necessary to detect infections.

The larvae can be identified by fecal culture, if identification to the species level is important. Adult worms can be differentiated by their morphology, using published keys.

Treatment

Hookworms are treated with anthelmintics including mebendazole, albendazole, fenbendazole, thiabendazole, ivermectin, febantel, dichlorvos, pyrantel pamoate, nitroscanate, levamisole and others. Anthelmintics appear to be less effective for *U. stenocephala* than *Ancylostoma* spp. Supportive care such as supplemental iron, blood transfusions or a high protein diet may also be necessary in some cases.

Prevention

Anthelmintics can be used in ruminants to decrease parasite burdens and pasture contamination. Pasture rotation and other management techniques can also be important components in preventing disease.

Some heartworm preventatives aid in the prevention of hookworm disease in dogs. Concrete runways, washed at least twice a week in warm weather, should be used for dogs housed in kennels. Clay or sandy runways, as well as soil and lawns, can be decontaminated with sodium borate. To prevent *A. caninum* infections in puppies, bitches should be free of hookworms and should be kept out of contaminated areas during their pregnancy. The dam and puppies should also be housed separately from other animals.

Infections in cats can be decreased by keeping cats indoors and preventing them from eating rodents. Keeping the litter box clean decreases reinfection.

Morbidity and Mortality

Hookworms are a common parasite of cats and dogs; up to 96% of the dogs and 80% of the cats in some countries may be infected. *A. tubaeforme* has been found in 75% of the cats in Illinois and Kentucky, 77% of the cats examined in Arkansas, and 27% of the cats in Alabama.

A. caninum and *A. tubaeforme* infections are generally more serious than *U. stenocephala* and *A. braziliense*. Some *A. caninum* and *A. tubaeforme* infections may be fatal, particularly in young animals, due to blood loss. *B. phlebotomum* can cause deaths in calves.

Post-Mortem Lesions

Small, grayish-white to reddish-white, cylindrical nematodes (approximately 5-20 mm long) are found in the intestines. The intestinal mucosa may be congested and swollen, with many tiny hemorrhagic points, red marks or ulcers. With many hookworm species, the intestinal contents are bloodstained. In animals with anemia, the liver and other organs may appear pale.

Pneumonia and lung consolidation can be seen with large numbers of larvae in puppies. Skin lesions may be found on the feet, particularly between the toes, where the larvae penetrated. Larvae in aberrant sites may be associated with necrotic and hemorrhagic tracks in the tissues, as well as hemorrhages and other signs of tissue damage.

Internet Resources

- Centers for Disease Control and Prevention (CDC)
http://www.cdc.gov/ncidod/diseases/submenus/sub_hookworm.htm
- CDC Guidelines for Veterinarians: Prevention of Zoonotic Transmission of Ascarids and Hookworms of Dogs and Cats
<http://www.cdc.gov/ncidod/dpd/parasites/ascaris/prevention.htm>
- Material Safety Data Sheets –Canadian Laboratory Center for Disease Control
<http://www.hc-sc.gc.ca/pphb-dgsp/MSDS-ftss/index.html#menu>
- Medical Microbiology
<http://www.gsb.utsouthwestern.edu/microbook>
- The Merck Manual
<http://www.merck.com/pubs/mmanual/>
- The Merck Veterinary Manual
<http://www.merckvetmanual.com/mvm/index.jsp>

References

- Acha PN, Szyfres B (Pan American Health Organization [PAHO]). Zoonoses and communicable diseases common to man and animals. Volume 3. Parasitoses. 3rd ed. Washington DC: PAHO; 2003. Scientific and Technical Publication No. 580. Cutaneous larva migrans; p. 249-252.
- Acha PN, Szyfres B (Pan American Health Organization [PAHO]). Zoonoses and communicable diseases common to man and animals. Volume 3. Parasitoses. 3rd ed. Washington DC: PAHO; 2003. Scientific and Technical Publication No. 580. Zoonotic ancylostomiasis; p. 312-317.
- Aiello SE, Mays A, editors. The Merck veterinary manual. 8th ed. Whitehouse Station, NJ: Merck and Co; 1998. Gastrointestinal parasites of small animals. Hookworms; p 318-319.
- Aiello SE, Mays A, editors. The Merck veterinary manual. 8th ed. Whitehouse Station, NJ: Merck and Co; 1998. Gastrointestinal parasites of ruminants; p 208-219.
- Braund KG, editor. Clinical neurology in small animals - localization, diagnosis and treatment. Ithaca, NY: International Veterinary Information Service (IVIS); 2003 Feb. Inflammatory diseases of the central nervous system. Available at: http://www.ivis.org/special_books/Braund/braund27/ivis.pdf. Accessed 20 Dec 2004.
- Beaver PC, Jung RC, Cupp EW. Clinical parasitology. 9th ed. Philadelphia: Lea & Febiger; 1984. The Strongylida: Hookworms and other bursate nematodes; p. 269-301.
- Blagburn BL. Problems associated with intestinal parasites in cats and their potential zoonotic importance in humans. Available at: <http://www.mvma.org/Proceedings/parasitology/parasite.html>. Accessed 11 Dec 2004.
- Bowman DD, Barr SC, Hendrix CM, Lindsay DS. Gastrointestinal parasites of cats. In: Bowman DD, editor. Companion and exotic animal parasitology. Ithaca, NY: International Veterinary Information Service [IVIS]; 2003. Available at: http://www.ivis.org/advances/Parasit_Bowman/ddb_GL/chapter_frm.asp?LA=1. Accessed 13 Dec 2004.
- Canadian Laboratory Centre for Disease Control. Material Safety Data Sheet – *Ancylostoma duodenale* (and *Ancylostoma caninum*). Office of Laboratory Security; 1999 Nov. Available at: <http://www.hc-sc.gc.ca/pphb-dgsp/MSDS-ftss/index.html#menu>. Accessed 8 Dec 2004.

- Carter GR, editor. A concise guide to infectious and parasitic diseases of dogs and cats. Ithaca, NY: International Veterinary Information Service [IVIS]; 2001 Jul. Internal parasitic diseases of dogs and cats. Available at: http://www.ivis.org/special_books/carter/toc.asp. Accessed 11 Dec 2004.
- Douglass MC, Juzych LA. Cutaneous larva migrans. eMedicine.com; 2004 Aug. Available at: <http://www.emedicine.com/derm/topic91.htm>. Accessed 13 Dec 2004.
- Garekar S, Asmar B. *Ancylostoma* infection. eMedicine.com; 2002 Oct. Available at: <http://www.emedicine.com/ped/topic96.htm>. Accessed 13 Dec 2004.
- Kelsey DS. Enteric nematodes of lower animals transmitted to humans: zoonoses [monograph online]. In Baron S, editor. *Medical Microbiology*. 4th ed. New York: Churchill Livingstone; 1996. Available at: <http://www.gsbs.utmb.edu/microbook/>. Accessed 28 July 2004.
- Landmann JK, Prociv P. Experimental human infection with the dog hookworm, *Ancylostoma caninum*. *Med J Aust*. 2003;178:69-71.
- Velho PE, Faria AV, Cintra ML, de Souza EM, de Moraes AM. Larva migrans: a case report and review. *Rev Inst Med trop S Paulo*. 2003;45: 167-71.
- Williams JF, Zajac A. Diagnosis of gastrointestinal parasitism in dogs and cats. St. Louis, MO: Ralston Purina; 1980. Nematodes; p. 16-28.