Trichuriasis

Trichocephaliasis, Trichocephalosis, Whipworm Infestation

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Importance

Trichuriasis is caused by various species of *Trichuris*, nematode parasites also known as whipworms. Whipworms are common in the intestinal tracts of mammals, although their prevalence may be low in some host species or regions. Infections are often asymptomatic; however, some individuals develop diarrhea, and more serious effects, including dysentery, intestinal bleeding and anemia, are possible if the worm burden is high or the individual is particularly susceptible. *T. trichiura* is the species of whipworm normally found in humans. A few clinical cases have been attributed to *T. vulpis,* a whipworm of canids, and *T. suis*, which normally infects pigs. While such zoonotic infections are generally thought uncommon, recent surveys found *T. suis* or *T. vulpis* eggs in a significant number of human fecal samples in some countries. *T. suis* is also being investigated in human clinical trials as a therapeutic agent for various autoimmune and allergic diseases. The rationale for its use is the correlation between an increased incidence of these conditions and reduced levels of exposure to parasites among people in developed countries.

There is relatively little information about cross-species transmission of *Trichuris* spp. in animals. However, the eggs of *T. trichiura* have been detected in the feces of some pigs, dogs and cats in tropical areas with poor sanitation, raising the possibility of reverse zoonoses. One double-blind, placebo-controlled study investigated *T. vulpis* for therapeutic use in dogs with atopic dermatitis, but no significant effects were found.

Etiology

Trichuriasis is caused by members of the genus *Trichuris*, nematode parasites in the family Trichuridae. *Trichuris* spp. have traditionally been identified by the morphology of the adult worms, with some sources listing more than 60 species, including at least 20 in rodents alone. However, recent studies suggest that the morphology of whipworms may be influenced by the host in which they reside. Genetic studies may clarify the number of valid species in the future.

People are normally infected with *T. trichiura,* which is maintained in humans and some nonhuman primates. Several lineages of this organism, some of which may be separate species, have been recognized in nonhuman primates. Two whipworms of animals, *T. suis* and *T. vulpis,* are reported to be zoonotic. *T. suis,* a parasite of pigs, is closely related to *T. trichiura,* but *T. vulpis,* an organism found in canids, is taxonomically more distant. There are currently no reports of other zoonotic *Trichuris* species in humans; however, the identity of the parasite is not usually questioned unless the eggs in a fecal sample are of an unusual size. Because egg sizes overlap, this practice might underestimate the number of zoonotic species.

Species Affected

Whipworms seem to be widespread in mammals. Animals known to carry these organisms include cattle, sheep, goats, camels, South American camelids, pigs, dogs, cats, rabbits, rodents, and diverse species of wild animals. Some mammals seem to be infected with a single species of *Trichuris,* but others (e.g., cats) are susceptible to more than one agent.

The zoonotic species *T. suis* is a parasite of pigs and wild boars, while *T. vulpis* normally infects dogs and wild canids. *T. trichiura* is maintained in some non-human primates, as well as humans. Eggs from this organism have also been detected in the feces of pigs, dogs and cats. However, it has not yet been proven that these eggs are produced by worms in the intestines and the animals are not shedding eggs ingested from the environment. Pigs have been experimentally infected with *T. trichiura*, but how often these infections become patent is uncertain (for details, see Transmission). There do not seem to have been any attempts to infect dogs and cats with this organism, as of 2018.

Zoonotic potential

At least some lineages of *T. trichiura* are known to be shared between humans and nonhuman primates, which both act as maintenance hosts. Zoonotic transmission of this organism from wild Japanese macaques (*Macaca fuscata*) was demonstrated by

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experimental inoculation of human volunteers. *T. suis* is also known to be zoonotic. *T. vulpis* was initially identified in a few clinical cases based on the size of its eggs, which are usually almost twice as large as eggs from *T. trichiura.* Worms or worm fragments consistent with *T. vulpis* were found in a few of these cases, but most descriptions are based on the eggs alone. Some authors have questioned the validity of these reports, as *T. trichiura* occasionally produces unusually large eggs, and some reports described both large and small eggs in the same person. Two clinical cases in young children in the U.S. are suggestive, as both lived in environments that were contaminated with canine feces but seem less likely to contain *T. trichiura* eggs, and only large eggs were reported in their fecal samples. In addition, recent surveys have used genetic techniques to confirm that *T. vulpis* eggs can be shed by some humans, although the possibility that these eggs were ingested from the environment has not been completely ruled out.

Rare cases of visceral larva migrans caused by *T. vulpis* have also been proposed, although the evidence in most cases is circumstantial. Visceral larva migrans would be an unusual finding for whipworms, as both the larvae and adults are normally found only in the intestines and do not undergo tissue migration.

Whether other species of *Trichuris* might be zoonotic is not known.

Geographic Distribution

Trichuris spp. can be found worldwide, but they are most prevalent in warm, humid climates. These parasites are rare or nonexistent in arid, very hot or very cold regions where the eggs are unlikely to develop to the infective stage in the soil.

Transmission and life cycle

Hosts become infected with whipworms when they ingest embryonated eggs from the environment, often in food or water. The adult worms are embedded in the mucosa of the cecum and adjacent portions of the large intestine, and shed their eggs in the feces. Some individuals shed much larger numbers of eggs than others. Experiments in mice suggest that resistant individuals might expel the worms before the infection becomes patent, and that immunosuppression might abrogate this resistance. *T. vulpis* begins to produce eggs in approximately 10-13 weeks in dogs, while *T. suis* infections become patent in 6-8 weeks in pigs, and *T. trichiura* in 1-3 months in humans. Pigs are thought to expel most *T. suis* from the intestines after approximately 9-11 weeks, limiting the period of egg production to a few weeks. How long whipworms survive in other species is less clear. In humans, *T. trichiura* is generally described as persisting for several years, although the basis for this estimate is unclear. One dog that was shedding *T. vulpis* eggs on entry to a research facility continued to excrete eggs for 13 months, then stopped. A previous report had suggested that dogs might shed eggs for less than 6 months.

Trichuris eggs are unembryonated when they are excreted. Development to the infectious stage, an egg containing the first-stage larva, takes 2 weeks or longer, depending on the temperature, with most eggs embryonating in a few weeks to a few months. Whipworm eggs are resistant to inactivation, though they survive best in moist, shady areas. Under ideal conditions, they can remain viable for up to 11 years. However, studies in experimental outdoor plots suggest that most eggs die within a few months, and only a small percentage survive for a year or more. *Trichuris* eggs can persist in sludge during anaerobic and aerobic digestion of wastes.

The development of Trichuris species in aberrant hosts

There is relatively little information on the development of *Trichuris* spp. in species other than their natural hosts.

In one study, two people who ingested *T. suis* as part of an experiment shed eggs after either 40 or 60 days. The eggs were produced for 16 days or less in both cases. Fewer of these eggs embryonated than expected, compared to *T .suis* eggs shed by pigs; however, those eggs that did embryonate were infectious for pigs and matured to adults in that species. A laboratory technician who became infected by accident during this experiment shed grossly abnormal eggs. In other early studies, *T. suis* eggs were not detected in two people, and the evidence cited for a patent infection in the third person (shedding embryonated eggs and hatched larvae) is questionable. More recently, a patent infection was documented in one person who received *T. suis* therapy. However, most clinical trials with this organism either did not find eggs or did not examine fecal samples.

One study that inoculated pigs with *T. trichiura* found that the eggs hatched but did not mature past the early larval stages in young nursing pigs. In the same experiment, a very small number of whipworms matured to adults in pigs inoculated at 9 weeks of age. These adult worms were still immature at 10 weeks when the pigs were necropsied, and eggs were not detected. *T. suis* did not develop past the larval stage in some other studies in pigs.

The prepatent period was similar in human volunteers and Japanese macaques inoculated with *T. trichiura* eggs from Japanese macaques.

Disinfection

There is little information on the susceptibility of *Trichuris* eggs to disinfectants; however, *T. muris* can be inactivated with 30% (v/v) ammonia at temperatures greater than 30°C (86°F). *Trichuris* eggs can also be destroyed eventually by dehydration and sunlight. Temperatures above 52ºC (126°F) or below -9ºC (-16°F) are fatal to *T. trichiura*. Thermophilic composting can inactivate eggs, which are reported to survive for a few hours at 50ºC (122°F) or a few minutes at 55ºC (131°F). Composting at lower temperatures (mesophilic composting) might be effective over longer periods.

Infections in Animals

Incubation Period

Clinical signs can occur in animals during the prepatent period. The incubation period is often 2-3 weeks in experimentally infected pigs.

Clinical Signs

Many infected animals do not have any clinical signs. Heavy parasite burdens can cause diarrhea, which may be mucoid or occasionally hemorrhagic. The diarrhea is often intermittent in dogs. Heavy worm burdens may also result in weight loss, unthriftiness and/or anemia. Outbreaks of severe mucohemorrhagic diarrhea, with anorexia, depression, anemia, weight loss and deaths, occur occasionally in young pigs. Pigs carrying *T. suis* are also more susceptible to intestinal illnesses caused by some bacterial agents.

In dogs, chronic bowel irritation may cause intussusception. However, unlike *T. trichiura* in humans, *T. vulpis* is not associated with rectal prolapse. Secondary pseudohypoadrenocorticism, with waxing and waning weakness, dehydration, hyponatremia, hyperkalemia and metabolic acidosis, has been reported in a few dogs. This condition can be cured by anthelmintic treatment.

Post Mortem Lesions

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Adult whipworms are found in the cecum and adjacent parts of the large intestine, with their anterior ends embedded in the mucosa. The adults of *T. vulpis* are approximately 4.5-7.5 cm long in dogs, while *T. suis* and *T. trichiura* are reported to be 3-8 cm and 2-5 cm, respectively, in their natural hosts. All species of *Trichuris* are much thinner at the head than the tail.

Some infected animals have minimal gross lesions, although inflammatory nodules may surround adult worms where they penetrate the mucosa. Similar nodules may be detected where embedded larvae have not yet become visible. In some cases, there may be catarrhal or mucohemorrhagic enteritis in the large intestine, with mucus, fresh blood and/or necrotic debris in the lumen. The intestinal wall may be thickened, inflamed or edematous. Necrotic pseudomembranes have been found in some severely affected pigs.

Diagnostic Tests

Trichuriasis is usually diagnosed by detecting *Trichuris* eggs in the feces, typically by fecal flotation or its variants (e.g., centrifugation-flotation) in animals. The density of the flotation solution influences recovery; whipworm eggs have a specific gravity of 1.15, and a solution with specific gravity > 1.20-1.35 should be used. Passive fecal flotation is reported to be less effective than centrifugal flotation (FLOTAC). The use of either a McMaster chamber or mini-FLOTAC, which does not require centrifugation, was promising in some studies. *Trichuris* eggs can be shed intermittently.

Trichuris eggs are oval, yellowish-brown and thick-shelled, with two polar plugs. Each species tends to produce eggs of a particular size. *T. vulpis* eggs are usually about 72-90 µm by 32-40 µm, while *T. suis* eggs are visibly smaller at 50-68 µm by 21-31 µm. *T. suis* and *T. trichiura* eggs are very similar, and subtle differences in their average size and morphology are not apparent with routine laboratory diagnostic procedures. Some species of *Trichuris*, including *T. trichiura* and *T. vulpis*, can occasionally produce eggs that are unusually large or small and resemble the eggs of other species. While some authors report that *T. vulpis* eggs tend to be wider and more barrel-shaped, compared to large *T. trichiura* eggs, this may be difficult to see. *Trichuris* eggs must also be distinguished from those of some other parasites such as *Capillaria* spp.

Trichuriasis can affect animals before the infection becomes patent. In pigs, examination of the intestines may reveal immature adults or larvae at necropsy. Mucosal scrapings can be helpful for detecting larvae. Other techniques, such as proctoscopy, may occasionally be employed in live animals. At least one antigen detection test to detect *T. vulpis* is now commercially available for dogs.

The organisms found in a host are generally assumed to be the whipworms of that species, provided the egg size is consistent. Species identification is uncommonly pursued except in research or in cases thought to be caused by an unexpected species of *Trichuris*. Whipworms are traditionally identified to the species level by examining the morphology of adult worms of both sexes. Overlapping characteristics, as well as the influence of the host species on morphology, may make it difficult to distinguish some species. Genetic techniques such as PCR are also being investigated, and have been used in research laboratories to identify eggs to the species level. These techniques are not yet widely available in diagnostic laboratories.

Treatment

Trichuriasis can be treated with anthelmintics including some benzimidazoles and pro-benzimidazoles (e.g., fenbendazole, febantel, mebendazole), macrocyclic lactones (e.g., moxidectin, milbemycin oxime), levamisole, dichlorvos, emodepside and other drugs. Some agents are effective against adult whipworms but have poor efficacy against larvae, and treatment may need to be repeated to eliminate all of the worms.

Control

Disease reporting

Veterinarians who encounter or suspect trichuriasis should follow their national and/or local guidelines for disease reporting. In the absence of specific control or surveillance programs, ubiquitous organisms such as whipworms are not usually reportable.

Prevention

Destroying *Trichuris* eggs in the environment is usually difficult and/or impractical, although it may be accomplished on solid surfaces by methods such as heat treatment. The most practical ways to reduce the risk of infection are to treat infected animals, prevent the environment from becoming contaminated with feces, and avoid placing animals in contaminated areas. The number of eggs in contaminated soil is expected to decrease with time. *Trichuris* eggs are less likely to survive and develop in drier, sunnier locations, and promoting these conditions can be helpful. For instance, lawns where dogs defecate should not be overwatered. It may also be helpful to keep the lawn short to reduce shade on the soil.

Pigs

Confinement rearing on slatted floors or concrete, in conjunction with good sanitation, reduces the risk of infection. Pens should be cleaned often to remove feces, and thoroughly cleaned and disinfected between occupants. Well-drained outdoor lots and pastures are expected to have lower egg burdens than moist areas. Land rotation may be helpful in reducing the number of eggs in the environment, so that infections are more likely to be subclinical.

Dogs

Dogs should be tested or treated regularly for intestinal parasites, and feces should be removed frequently from the environment to reduce the burden of eggs. Some combination flea control products and/or heartworm preventatives contain agents that can kill whipworms. Cement runs, which can be cleaned, or gravel or sand runs, which promote better drainage, are preferable to dirt runs in kennels. Cement runs should be cleaned daily and disinfected often.

Morbidity and Mortality

Trichuris spp. are common parasites in animals. Most studies have assumed that all whipworm eggs found in dogs and pigs are *T. vulpis* or *T. suis*, respectively. However, this might not be the case in all regions, particularly where sanitation is poor and animals are regularly exposed to human feces. A recent study in Thailand found that more than half of the *Trichuris*-positive fecal samples from dogs contained the human parasite *T. trichiura*, as identified by PCR. Likewise, more than half of the fecal samples from dogs and cats in Malaysia were found to contain eggs identified genetically as *T. trichiura*. Whether these animals were infected with adult worms or simply shedding eggs acquired from the environment is currently unclear.

The prevalence of *T. vulpis* in owned dogs is reported to range from < 5% to 10-30% in various regions, although higher rates have sometimes been reported in kennels and among strays. While any age can be affected, one study found that the prevalence of patent infections in dogs peaked before a year of age, then gradually declined with age. Eggs were more likely to be found in dogs older than 6 months than puppies, probably due to the long prepatent period. The prevalence of *T. suis* is influenced by management. This organism occurs sporadically and at low levels among pigs raised indoors under controlled conditions, but it is relatively common in animals raised outdoors. It is most prevalent in young pigs. In pigs, the worm burden is known to be influenced by genetic background and possibly diet.

Most animals infected with *Trichuris* spp. are asymptomatic or have only mild gastrointestinal signs. However, more severe illnesses are possible. In pigs, trichuriasis is particularly significant in animals less than 3 months of age. This disease had a mortality rate of 10-12%, shortly after weaning, during outbreaks in parts of Australia.

Infections in Humans

Incubation Period

The incubation period in humans does not appear to be published.

Clinical Signs

T. trichiura is often carried subclinically in humans, but heavy worm burdens can cause watery, mucoid or bloody diarrhea. Abdominal pain or discomfort, nausea, vomiting and/or flatulence may also be seen in some patients. A decreased appetite, weight loss, malnutrition and anemia are possible. Anemia is most likely to occur in individuals who are particularly susceptible to this condition, such as pregnant women. Urticaria has also been reported. Untreated severe infections in children can lead to clubbing of the fingers, through an unknown mechanism. Complications may include rectal prolapse (particularly in children), appendicitis, colitis and proctitis.

Gastrointestinal signs have been reported in some people infected by *T. suis*. In one study, some individuals who ate *T. suis* eggs reported abdominal pain, flatulence and watery diarrhea. These symptoms resolved spontaneously, and were milder or subclinical with repeated exposure. Similar transient clinical signs were also documented in some other reports. No adverse effects were seen in some clinical trials where *T. suis* eggs were administered for therapeutic purposes. However, the participants in some of these trials were already suffering from gastrointestinal conditions that could have masked mild symptoms.

Most clinical cases attributed to *T. vulpis* have been characterized by mucoid diarrhea, sometimes with intermittent abdominal pain or discomfort. Other signs, such as poor appetite and easy fatigability, were also seen in some children. Some infections with this organism were reported as incidental findings, when eggs were detected during surveillance, or, in one case, when adult worms were found at necropsy in the appendix.

Visceral larva migrans attributed to *T. vulpis* has been reported rarely in humans, and this condition is still controversial. In one report, two children in a household had symptoms of fatigue with eosinophilia, together with serological reactivity to *T vulpis*. The symptoms resolved with anthelmintic treatment. In another case, a mass in the lung was found to contain whipworms and the patient was seropositive for *T. vulpis*. Visceral larva migrans was also considered to be a possible explanation for rhinitis and epistaxis in a child with intestinal signs and eggs in the feces. Both the rhinitis and intestinal signs resolved with anthelmintic treatment.

The presence or absence of clinical signs was not mentioned in the report describing the inoculation of human volunteers with *T. trichiura* eggs from Japanese macaques.

Diagnostic Tests

As in animals, trichuriasis is usually diagnosed by detecting *Trichuris* eggs in the feces. The diagnostic methods used in humans include various concentration techniques (e.g., formol-ether concentration) followed by microscopy. A McMaster chamber can also be employed, and direct fecal smears may be used in some resource-poor environments. Flotation techniques are not usually used in human laboratories, as passive flotation cannot detect some other helminth eggs that may occur in human feces. However, FLOTAC and mini-FLOTAC are being investigated. Any whipworm eggs in human fecal samples are generally assumed to be *T. trichiura*, unless the size is inconsistent with this species. Variations in the number of eggs shed each day, and the uneven distribution of eggs in the feces can result in false negatives, especially when the number of worms is small. Other techniques, such as colonoscopy, may occasionally be employed in these cases.

There is no standard diagnostic procedure for larva migrans. In two pediatric cases, a tentative diagnosis was based on serology and the recovery of *T. vulpis* eggs from the family dog and environmental samples. In one adult case, the diagnosis was by serology combined with histology of a pulmonary mass.

Treatment

Trichuriasis in humans is treated with anthelmintics, most often mebendazole or albendazole. A single dose is sometimes employed if the worm burden is light, but 3 daily doses are generally recommended in clinical cases. The efficacy of albendazole against *T. trichiura* has decreased over the last 2 decades in some regions. Combination therapies (e.g., ivermectin with albendazole or mebendazole; albendazole with oxantel pamoate) were promising against *T. trichiura* in some clinical trials. Some veterinary drugs are being evaluated for use in humans.

Prevention

Prevention of zoonotic trichuriasis depends on preventing *Trichuris* infections in animals and reducing environmental contamination from their feces, together with good hygiene. Hands and raw foods should be washed before eating, and unsafe drinking water should be boiled or filtered. Children should be taught not to eat soil, and to wash their hands after playing outdoors or with pets. Contamination of public areas can be decreased by restrictions on uncontrolled dogs, collection of feces by dog owners, and prevention of animal access to areas such as children's playgrounds.

Morbidity and Mortality

Human trichuriasis is usually caused by *T. trichiura*. This parasite is still very common in some parts of the world, although control programs and improved sanitation have decreased the number of infections in many locations. Individuals differ in their susceptibility to *T. trichiura*: a small percentage of the population is thought to host the majority of the infections and account for most environmental contamination. The clinical signs vary with the host's age, general health and nutritional status, but the prognosis is good if the infection is light or if it is treated. Untreated heavy infections can be serious, particularly in malnourished patients.

The prevalence of zoonotic trichuriasis is uncertain. Until recently, *T. vulpis* was thought to be uncommon in humans; however, genetic techniques recently identified the eggs of this organism in 1-11% of *Trichuris*-containing fecal samples in some areas. Most of these studies were done in impoverished areas where dogs roam freely and sanitation is poor. Earlier studies based on egg morphology also reported a significant number of eggs thought to be *T. vulpis* in kennel workers and institutionalized mental patients with pica. One estimate for *T. vulpis* trichuriasis based on egg size suggested a prevalence of 12% in Vietnam and 0.2% in the U.S. state of New York.

The eggs of *T. suis* and *T. trichiura* appear identical in routine diagnostic testing, and naturally-occurring infections with *T. suis* could easily be missed. One of 42 people shedding *Trichuris* eggs in Lao PDR, Myanmar, and Thailand was found to be shedding *T. suis*, using genetic techniques. Genetic identification of eggs also suggests that *T. suis* infects some people who live in close proximity to pigs in Uganda. No expelled worms from people who had contact with pigs in Ecuador were found to be *T. suis*. The worms from ten people were tested in this study, including 4 by genetic techniques.

A few *T. trichiura* infections might be acquired from eggs shed by nonhuman primates. One study detected *T. trichiura* eggs in 7% of zoo caretakers in Belgium and the Netherlands. All of the positive individuals cared for nonhuman primates.

Internet Resources

Centers for Disease Control and Prevention (CDC)

International Veterinary Information Service (IVIS)

Public Health Agency of Canada. Pathogen Safety Data Sheets

The Merck Manual

The Merck Veterinary Manual

World Health Organization

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