Trichinellosis: epidemiology and prevention

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Abstract

Trichinella spiralis is an obligate intracellular parasite which can infect a lot of animals and the humans. Most human cases are asymptomatic or mild and not recognized clinically; heavy exposure may lead to diarrhoea, periorbital oedema, myositis, fever, and prostration. Life-threatening or fatal cases are complicated with cardiovascular, pulmonary, and neurological symptoms. Trichinosis is an important problem for Public Health, although now there is a decline in its incidence in the US, in the Arctic and in Europe. Recently various epidemic clusters have been reported in Asian countries. Consumption of raw or undercooked meat, especially of pigs kept in close contact with the population of rats, or feed with carcasses of infected animals, is the most important cause of Trichinella infection. The health education, and an adequate animal husbandry are the most important systems for the prevention of Trichinella infections.

KEY WORDS: epidemiology, food borne diseases, human trichinellosis, parasitic diseases, prevention.

Introduction

Zoonotic parasitosis can be classified into 4 categories: direct zoonotic, meta-zoonotic, cyclo-zoonotic, and sapro-zoonotic. Direct zoonotic parasites infect humans directly from animals: Entamoeba histolytica, Cryptosporidium parvum, Toxoplasma gondii, Hymenolepis nana, Trichinella spiralis, and Sarcoptes scabiei (1). The parasitic nematode Trichinella spiralis was first identified under the microscope in 1835 by Paget and Owen (2), and outbreaks of infection occurred with great frequency in the United States and elsewhere in the world prior to the 1960s (3-5), altering the course of history, in some cases. For example, one small epidemic in 1897 resulted in the tragic deaths of three Swedish explorers (6), delaying by 12 years the discovery of the geographic North Pole.

T. spiralis is an obligate intracellular parasite (7-9) in both its larval (in the striated skeletal muscle cell) and adult form (in the small intestine), secreting some proteins, that alter the host, allowing the infection to proceed (10).

The life cycle of Trichinella is composed by three phases (11): first-stage through fourth-stage larvae and adults are responsible of the enteral phase; first-stage newborn larvae travel through the bloodstream and penetrate in the tissues during the migratory phase; first-stage larvae after their penetration in the tissues are responsible of the parenteral phase (12).

After the ingestion, the first-stage larva is freed from the surrounding tissue by the action of pepsin and hydrochloric acid in the stomach. It is then carried to the small intestine, where it invades the columnar epithelium (9, 13). Then, the larva molts four times (10 through 28 hours post ingestion), transforming into the adult worm (5, 11, 14). Mating ensues (30 to 34 h post ingestion), and 5 days later newborn larvae are shed (11). The number of produced newborn larvae depends on the immune status of the infected host (15, 16) and on the infecting species of parasite (17, 18). It is estimated that 500 to 1500 newborn larvae are shed over the life span of an adult female worm before a combination of immune responses forces their expulsion from the small intestine (15).

The newborn larvae pass to the regional nodes and thoracic duct, then to the heart, lungs, and general circulation, and finally penetrate in the striated muscle fibers, grow to full size, coil and become encapsulated again. The cyst wall may eventually calcify. The period between infection and encysting is 17-21 days (19).

Although at present the incidence and prevalence of infection due to T. spiralis are low in western Europe
and the United States, some cases are recorded yet (4, 17, 20-23), sometimes resulting in death (24, 25). However, the infection causes often not serious clinical conditions with mild signs and symptoms and thus usually goes undiagnosed (26).

A potential complication in diagnosis is represented by the several members of the genus Trichinella which may infect and cause disease in humans (27-29), and that could be easily identified through the techniques of molecular biology (30).

According to current international nomenclature, there are eight species, each of which has been assigned a number (31, 32): T. spiralis is designated T1; T. britovi, T3; T. nativa, T2; and T. nelsoni, T7. Several other species of Trichinella have number designations only: T5, T6, and T8.

T. pseudospiralis (T4) has an unusual geographic distribution and infects birds of prey (33) and mammals such as the Tasmanian devil. One human infection with T. pseudospiralis has been documented (34). Most infections arise from the consumption of insufficiently cooked pork products, less commonly of meat from bear (35, 36), walrus (37, 38), wild boar (39) or horse (40-42). Most human cases are asymptomatic or mild and not recognized clinically; heavy exposure may lead to diarrhoea, periorbital oedema, myositis, fever, and prostration. Life-threatening or fatal cases are complicated with cardiovascular, pulmonary, and neurological symptoms.

The only way for the parasite to enter into a host is by being ingested along with raw or partially cooked infected muscle tissue (except for laboratory accidents!). In the wild, the carcasses are consumed by scavengers, and thus infection is widespread within a given biome (28, 43-48) and throughout the world (49, 50). All the naturally infected animals are listed in 5 pages of the Campbell's treatise (51). Even sea mammals and herbivores have been found infected with Trichinella spp., thus redefining the dietary habits of the latter group (28, 51, 52).

Trichinosis is a significant but declining health problem in the US (5), in the Arctic and parts of Europe. Recently Asian countries have been recognized as foci of Trichinellosis, with several epidemics (53-55). Human trichinellosis is rare in Western Europe, and cases have not been reported in Denmark in recent years. Four cases were reported from Sweden in 1985, but acquired in Yugoslavia (56). In Greenland in 1947, an outbreak comprising 300 cases with 33 deaths occurred caused by consumption of walrus meat (57). In Germany, sporadic epidemics have occurred since World War II with a total of 2000 cases (58). Numerous outbreaks and sporadic cases of trichinellosis due to ingestion of wild boar and pork products have been reported in Southern Europe (39, 41, 42). It is a serious health and economic problem in Eastern Europe (5, 59), because of the uncontrolled growth of rat populations (5). In former Yugoslavia, the number of humans infected has been 100-200 per year over 10 years, with a peak of 1240 cases in 1985, caused by pork not subjected to veterinary control (60). In 2011, there were 363 cases of trichinellosis reported by 26 states of European Union of which 268 cases (73.8%) were reported as confirmed. The difference in the number of total cases versus confirmed cases may be because not all cases in an outbreak will be laboratory confirmed and the remaining cases are considered epidemiologically linked to the confirmed cases. The number of human trichinellosis cases increased by 20.2% in the EU in 2011 compared with 2010 but is still at a much lower level than in 2007-2009. The EU notification rate was 0.05 cases per 100,000 population and the highest notification rates in 2011 were reported in Latvia (2.24 cases per 100,000) followed by Lithuania, Romania, Bulgaria and Slovakia (0.89, 0.50, 0.36 and 0.24 cases per 100,000, respectively). These five countries accounted for 84.3% of all confirmed cases reported in 2011. On average, 74.3% of the confirmed trichinellosis cases were hospitalised. One death due to trichinellosis was reported from Spain in 2011 (only 12 states of EU provided this kind of information), so the fatality rate was of 0.49% (61).

**Perspectives**

The consumption of raw or low cooked infected meat from animals (especially pigs) raised in situations that favor the existence of rodent populations is the most frequent source of infection by any species of Trichinella (17). Infection of pig herds by T. spiralis is usually perpetrated by the animals scavenging on infected rodent populations or, less commonly, by cannibalism of sick animals (29, 51, 59, 62-64). In other countries, where the controls are less rigid, feeding the livestock with raw pork scraps may spread the infection. Less common, but with devastating consequences, the disposal of carcasses of furbearing animals by feeding the remains to farm animals has inadvertently spread T. spiralis to large communities of consumers without criminal intent by the farmers, who were unaware of the broad host range of this parasitic nematode (65). Prevention at the community level depends on proper animal husbandry and on the withholding of uncooked meat in the feed of all farm animals. Microscopic inspection of portions of pig muscle tissue (directly or by the pooled digestion test) can control infection at the level of the abattoir (66). An ELISA for swine trichinellosis is now approved for the certification of pork by the US Department of Agriculture.

The necessary temperature to kill the larvae is 77°C and is achieved when the meat is no longer pink. Freezing temperatures of -15°C for 20 to 30 days, -23°C for 10 to 20 days, and -29°C for 6 to 12 days are also effective, except for T. nativa which can infect for several days at these temperatures (32). Freezing muscle tissue from animals such as black bear, raccoon, or opossum is not effective, since it is thought that the antifreeze protein molecule common to most wild animals also protects worms in their muscle tissue from ice crystal formation and even preserves the worms in carcasses
can be consumed by another animal (67, 68). Microwave cooking is not 100% effective in killing larvae in large pieces of meat, such as a whole fresh ham, since there are unavoidable “cold spots” in the pattern of the microwave beam (69).

Non-commercial sources of pork, as from wild animals and small rural farms not using modern hog management practices, still represent a significant health problem. Health education of the general population is therefore one of the most important ways to prevent Trichinella infection (19).


The noteworthy innovations of this new legislation are:
- the possibility for a farm breeding pigs to be classified as “free from Trichinella” if some parameters are respected
- the possibility for a region, country or a territory to receive the status of “free from Trichinella” if a number of parameters is respected, and no Member State objects
- the prohibition of use of the trichinoscopic system for the detection of Trichinella larvae in abattoirs if more than 15 pigs / day or more than 75 pigs / week are slaughtered. In this case the method of artificial digestion is recommended
- the staff responsible for the examination and the detection of Trichinella must be periodically trained.

The trichinoscopic method is considered no longer suitable because it does not allow to highlight the not encapsulated larvae and has a low sensitivity towards those encapsulated.

In 2013 Gu et al. tested a vaccine against Trichinella in a murine model. The epitope 8F7 was found to induce the highest protection and was combined with two other previously identified epitopes (YX1 from Ts-Pmy and M7 from Ts-87) to formulate a multi-epitope vaccine. Mice immunized with this multi-epitope vaccine experienced a 35.0% reduction in muscle larvae burden after being challenged with T. spiralis larvae (70).

The mass spectrometry has been recently demonstrated to allow a fast verification of Trichinella larval isolates on genus level, which might be crucial for confirmatory testing after questionable findings during meat inspection and a reliable determination of the four most prevalent Trichinella species worldwide is possible by means of MALDI-TOF MS analysis. As the method is easy to handle and can be performed within 1 hour, it represents a major step forward in the use of this technique in foodborne parasitology. Future studies will focus on the expansion of the Trichinella database to increase the accuracy and precision of identification and the validation of MALDI-TOF MS for typing of Trichinella field isolates (71).

Furthermore, the database and protocol will be made available to large laboratories to test the performance of this technique under routine conditions.

References

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