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EPIDEMIOLOGY, DIAGNOSIS, TREATMENT, CONTROL AND ECONOMIC IMPACT OF TRICHINOSIS

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Abstract

Trichinosis is a disease caused by a nematode parasite of the genus Trichinella spp. This zoonosis has been a major public health problem in many countries. The main source of infection in our country is the domestic pig. It is contaminated by eating food scraps containing raw meat infested with Trichinella spp., eating rats, mice or their droppings or by contact with wild animals. Secondary sources of infection are wild boar and bear. Humans get sick after eating meat infested with larvae enclosed in muscle tissue, insufficiently cooked, curd, roast or smoked. The difficulty in establishing the diagnosis is due to the fact that this disease does not manifest itself clinically and does not present pathognomonic signs and the parasite and its larvae are not visible to the naked eye. The main diagnostic method is represented by the trichinelloscopic examination performed by the veterinarian from a sample of meat collected from certain areas, mainly from the diaphragmatic pillars. In humans, the clinical manifestations are represented by fever, diarrhea, muscle pain, facial edema, eye hemorrhages - retinal and subconjunctival and subungual. All organs, meat and by-products obtained from pigs infected with Trichinella spp. are forbidden to be consumed and are destroyed by burning.

Key words: *disease, pig, trichinosis, Trichinella spp.*

INTRODUCTION

Trichinellosis is a serious parasitozoonosis affecting both wild and domestic animals. While in animals this disease evolves subclinically, only microscopic lesions being evident, in humans the evolution is serious, sometimes deadly. The most common species of trichinella that can cause human disease is *Trichinella spiralis*, although other species of *Trichinella* implicated in human disease are: *T. nativa, T. nelson, T. britovi, T. pseudospiralis, T. murelli, T. papuae*. The most important source of human infection worldwide is the domestic pig. In the last three decades, in Europe it has been proven that horse or wild boar meat is also an important reservoir of infection for humans (Mitrea, 2011; Zarlenga et al., 2016).

The biological cycle is of the autoheterogenous type, it is carried out without passing into the external environment. In the case of *Trichinella* spp. parasites, the definitive host is also the intermediate host. Raw or insufficiently cooked meat, which contains trichinella larva, reaches the stomach and is subject to digestion. The digestive enzymes dissolve the capsule, thus releasing the larva that invades the small intestine, sinking into the columnar tissue. The larvae initially migrate through the lymphatic system, then through the blood system, and reach the general circulation, from here in the organs and muscles. Only the larva that have reached the striated muscles will develop further. Larva can survive months to years, sometimes being viable for the entire life of the host animal. The transition to a new host is made by the ingestion of the parasitized muscles by a receptive animal (Mitrea, 2011; Zarlenga et al., 2016; Şuler et al., 2019).

The evolution of the disease includes several stages (Mitrea, 2011; Furhad & Bokhari, 2023), namely:

- an incubation period lasting between 2 and 28 days;

- an asymptomatic period in which the ingested larva mature into adults, in the small intestine;
- an intestinal stage, manifested by diarrhea with or without fever, abdominal pain, anorexia;
- a stage of muscle invasion that captures the migration of the newly formed larva in the circulatory system, towards the striated muscles; at this stage, the predominant symptomatology is represented by myalgias, swelling of the muscle masses, periorbital or facial edema, urticarial eruptions, fever 38-40°C, neuropsychiatric disorders (headache, up to delirium, coma), respiratory disorders, cardiac disorders (myocarditis with tachycardia, arrhythmia);
- a period of convalescence, corresponding to the confinement of the larva in the muscles.

MATERIALS AND METHODS

Bibliographic sources from the specialized literature, relevant to the topic, were used for the creation of this article. The main aspects followed were related to the epidemiology, diagnosis, treatment, control and economic impact of trichinellosis.

RESULTS AND DISCUSSIONS

Epidemiology. Trichinellosis is a disease present on all continents, in humans it is more frequent in North America and Europe and very rare in Asia, Africa and Australia. Around 10,000 human infestations occur worldwide each year. Cultural factors such as traditional meat-based gastronomy or products derived from raw or insufficiently cooked meat have an important role in the epidemiology of the disease (Franssen et al., 2017).

It has a focal character, with two main outbreaks being known (Mitrea, 2011):

- Synanthropic or domestic outbreak: represented by pig, rat, dog, cat, nutria and lately equine.
- The sylvatic outbreak: represented by wild boar, bear, wolf, fox, etc.

The two outbreaks can be interconnected, mainly through rats, which represent the main core of *Trichinella* that ensure the passage of parasitosis to domestic pigs, the latter being the major source of human infestation (Furhad & Bokhari, 2023).

Contamination is carried out orally, by ingesting the muscles with *Trichinella* larvae. In humans, this can be achieved by consuming meat or meat products from infested animals. In animals, the contamination is similar, in addition, it can be achieved by consuming slaughterhouse by-products or corpses containing cysts or infesting larva. It has been proven that the infestation can also be carried out through the placenta - if it occurs during pregnancy or galactogen pec (Ribicich et al., 2007; Şuler et al., 2019).

The favoring factors are primarily represented by the carnivorous diet. In the case of domestic pigs, the infestation occurs as a result of feeding them with raw or improperly processed slaughterhouse remains, as well as the presence of rats in the breeding area (Ribicich et al., 2007; Mitrea, 2011).

Parasite resistance is reduced in the case of adult helminths; males die after fertilization, but females last 5-6 weeks in animals and approximately 4 months in humans. However, the larva show greater resistance, surviving for many years in the muscles of living animals, and *Trichinella* larvae can remain viable for up to 25 years in humans. In bodies and carcasses, the larva can survive for up to 3 weeks, even in rotten conditions, and when boiled, they are highly sensitive. Cold resistance differs depending on the species of *Trichinella, T. nelsoni* being very sensitive, compared to *T. nativa* which can withstand up to 38 months at -18°C in the meat of white bear or *T. spiralis* whose larva were found live in muskrat corpses, preserved for 35 days at -34°C. Larva eliminated through feces last on the soil for only a few days (Ribicich et al., 2007; Mitrea, 2011).

Diagnostic. In living animals, trichinellosis is impossible to diagnose following a clinical examination because this disease has no pathognomonic signs. Serological tests can be performed, in this case leukocytosis and eosinophilia being correlated with the number of nematodes causing the infection. Serology confirms the suspicion of trichinosis infection when anti-Trichinella IgG antibodies are detected. Creatinekinase, lactate dehydro-

genase, aldolase and aminotransferases may be elevated due to parasitic invasion of skeletal muscle causing destruction. At the same time, infested animals can present hypokalemia, hypoalbuminemia and increased serum levels of IgE, but all these tests are non-specific, as they can be observed in other parasitic and autoimmune diseases (Muluken et al., 2020).

The postmortem diagnosis is the one that shows the importance in veterinary medicine, being a mandatory examination for food animals. The trichinelloscopic examination and the artificial digestion method are the two tests used to detect the larvae of *Trichinella* spp. (dspcluj.ro, 2024).

Examination of the fields is done field by field in ascending or descending order noting the integrity of the tissue and the areas of expressed meat juice around the compressed fragments (Savu, 2009; Savu et al., 2012).

In case of trichinellosis, fertile cysts with characteristic structure and shape are found in the interfibrillar spaces and even free larva both interfibrillarly and especially in the peripheral juice. Cysts can be captured in different stages such as spiraling, encapsulation, degeneration or calcification. If the result is positive or uncertain, the diagnosis is carried out by artificial digestion, and the examination is repeated, by collecting other samples; the analysis takes place in an authorized and accredited laboratory (Savu et al., 2012; Mitrea, 2011).

The differential diagnosis in animals is made against cysticercosis, echinococcosis, sarcoccystosis, microascariasis or against tyrosine accumulations in muscles, fat drops, lymphatic filariasis, whipworm (Mitrea, 2011).

In humans, trichinosis is diagnosed as follows (dspcluj.ro, 2024; Muluken et al., 2020):

- On the basis of clinical signs, when at least three of the following six symptoms are present: fever, muscle aches and pains, gastrointestinal symptoms, facial edema, eosinophilia, and subconjunctival, subungual, and retinal hemorrhages.
- Following laboratory tests: demonstration of trichinella larva in tissue obtained by muscle biopsy and demonstration of *Trichinella*-specific antibody response by immunofluorescence, ELISA or Western blot.
- Based on the epidemiological investigation: consumption of infested meat or products and by-products from an animal confirmed positive in the laboratory.

The differential diagnosis in humans is done against (Office International des Epizooties, 2004):

- Salmonellosis, shigellosis and other infections, viral, bacterial or parasitic of the gastrointestinal tract.
- Influenza virus infection
- Glomerulonephritis, serum sickness, toxic-allergic reactions to drugs or allergens, polymyositis, periarteritis nodosa, dermatomyositis.
- Typhoid fever.
- Cerebrospinal meningitis, encephalitis, neuroinfections.
- Leptospirosis, bacterial endocarditis and exanthematic typhus.
- Eosinophilia-myalgia syndromes (for example, eosinophilic fasciitis)
- Fasciolosis, toxocariasis and invasive schistosomiasis.

Treatment. In time, both in humans and in animals, different treatment schemes have been tried, the most effective proving to be benzimidazoles, thiazole derivatives and avermectins. Also, three important aspects were observed, namely (Gómez-Morales et al., 2012; Owen & Reid, 2007):

- It has been proven that the best effectiveness, up to 100%, is on the adult forms of *Trichinella* spp., which are very difficult to diagnose or not at all in live animals.
- On the encapsulated larva, the effectiveness of the drugs is variable, the destruction of the cysts being only partial.
- In the larval migration phase, the effectiveness of the drugs remains high, but it is difficult to diagnose.

Figure 1. The arrangement of the meat samples between the blades for the trichinelloscopic examination

Figure 2. Placement under the microscope of slides with meat samples for the trichinelloscopic examination (Own source)

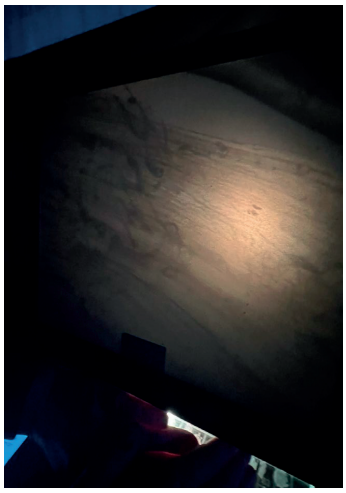

Figure 3. Muscle fiber seen under a microscope (Own source)

The tests carried out showed that increased and repeated doses of anthelmintics are needed, most of the time they are associated with anti-inflammatory and capsulolytic substances. The main anthelmintics used are albendazole and mebendazole, but satisfactory results were also observed following the administration of flubendazole, oxfendazole and avermectin. Albendazole is preferred because in most patients it reaches the required plasma levels, no monitoring is necessary, as opposed to what happens after the administration of mebendazole, whose plasma levels can vary from patient to patient, being continuous monitoring necessary (Gottstein et al., 2009).

It is important to apply an effective and early treatment, especially in the first three days after the infection. A therapy correctly applied and at an optimal time, stops a possible muscle invasion and the development of the disease. Unfortunately, most infected people are diagnosed just a few weeks after infection, when the larva have already settled in the muscles (Gottstein et al., 2009; Owen & Reid, 2007).

The vital prognosis in animals is favorable, the disease being important due to its serious zoonotic aspect, in humans it is a disease with serious symptoms, sometimes even fatal (Gamble, 2022; Office International des Epizooties, 2004).

The control of trichinellosis requires the strict observance of measures such as (Alban & Petersen, 2016; Gamble, 2022):

- The obligation to carry out the trichinelloscopic examination of pork or game meat from animals potentially carrying *Trichinella* spp.
- Confiscation and appropriate processing of carcasses, products and by-products obtained from infested animals.
- Proper sterilization of slaughterhouse products and by-products that are animal feed.
- Disposing of the carcasses of animals that can be the source of *Trichinella* and it is forbidden to feed animals with organs from game animals that have not been thermally treated or treated improperly.
- Encouraging the population to prepare the meat properly, as it is known that smoking, salting or short-term freezing do not destroy the larvae in meat, products and by-products.

In humans, trichinellosis can be controlled in this way (Alban & Petersen, 2016):

- - by exhorting the population to properly heat the meat, as it is known that smoking, salting or short-term freezing do not destroy the larvae in meat, products and by-products;

- carrying out a trichinellosis detection test after slaughtering or hunting;
- raising pigs in hygienic spaces and fighting rodents, which are potentially carriers.

The economic impact of trichinellosis is a significant one considering the costs required for the treatment of both humans and animals, the costs for eviscerating the bodies and for the destruction of the infested meat and products, as well as the potential profit that could be obtained from the sale of meat, products and by-products from meat if they were not affected by *Trichinella* spp. (Cuperlovic et al., 2005).
Between 2016 and 2021, the incidence of human trichinellosis cases was higher in males compared to females (Cuperlovic et al., 2005).

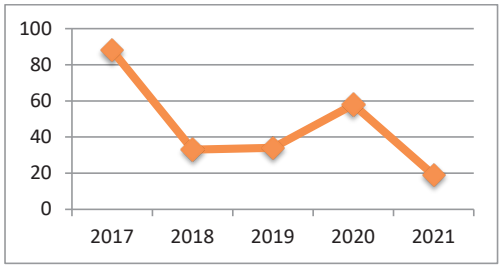

Figure 4. The evolution of human trichinellosis cases in Romania between 2016-2021 (I.N.S.P.)

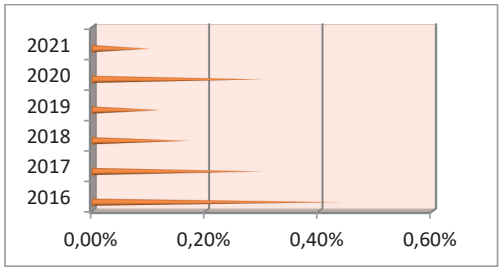

Figure 5. Incidence rate of human trichinellosis cases in Romania during 2016-2021 (I.N.S.P.)

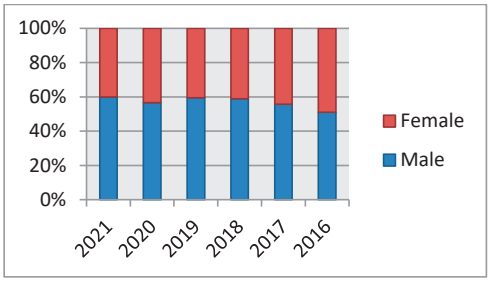

Figure 6. Incidence of human trichinellosis cases according to sex (I.N.S.P.)

CONCLUSIONS

The infection core is represented by domestic animals - pigs, wild or commensal - rats. The larvae of the nematode parasitize the muscles of mammals, and humans can become infected by ingesting raw or insufficiently cooked meat, especially pork, or game - wild boar, bear. When ingested, the muscle larva survive and enter the tissues of the small intestine, where they undergo development to the adult stage.
The disease is not transmitted between humans.
The clinical manifestation of the disease is closely related to the amount of meat ingested, the degree of meat infestation and the body's resistance.
The methods of salting, drying, smoking do not ensure the destruction of the larvae. They can be destroyed if the pork is frozen for almost three weeks at a temperature of at least -15°C. Larvae are also destroyed in the case of thermal processing of meat at a temperature above +70°C.
Romania contributes to European statistics with the most human and animal cases. The cases reported in humans in Romania mainly affect adults
Between 2019 and 2021, in our country no infections with Trichinella spp. were reported in pigs housed in controlled conditions.
In 2021, the proportion of hunted boars that tested positive was 0.07%. The proportion of positive foxes was 1.6% in 2021, higher compared to the rate of 0.9% in 2020.
Trichinellosis in humans can be monitored and controlled through a rigorous reporting and testing system, which requires good interaction between the public health sector and the appropriate veterinary sector.
Trichinellosis has been declared a disease to be monitored, and for European Union member states, this is mandatory under the European Union Zoonoses Directive, 2003/99/EC.

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