



Tænia solium / *Cysticercus cellulosae*

Scientific names: *Tænia solium* /
metacestodes of *Tænia solium*
English name: « pork tapeworm »
Helminths, phylum Plathelminths (flatworms)
Parasite

Nature and sources of *Tænia solium*

Main microbiological characteristics



T. solium scolex anofel

Tænia solium is one of two agents responsible for human taeniasis, the other being *Tænia saginata*. It is also responsible for cysticercosis, an infection of humans by the larval stage of *T. solium* (*Cysticercus cellulosae*). *T. solium* is a flatworm (Class Cestoda, Order Cyclophyllidea, Family Taeniidae). It lives in the small intestine of humans, its only known definitive host⁽¹⁾. Its form is quite similar to that of *T. saginata*. The adult worm consists of three parts: the scolex («head»); the neck, a tapered portion joining the scolex to the rest of the body and ending with the strobila, made up of a chain of segments or rings called «proglottids». However, it has some significant differences: the size of the adult worm (2 to 8 m) is shorter than that of *T. saginata*; the scolex has a double crown of hooks in addition to the four suckers; and older, mature proglottids migrate passively through the anal margin in chain fragments emitted with faeces, thus contaminating the external environment. In the small intestine, the adult reaches maturity in 3 months.

The life cycle (Figure 1) differs from *T. saginata* by the type of intermediate hosts⁽²⁾ that are mainly swine (essentially domestic pigs), although humans can also play this role following the ingestion of oncospheres, and thus develop cysticercosis.

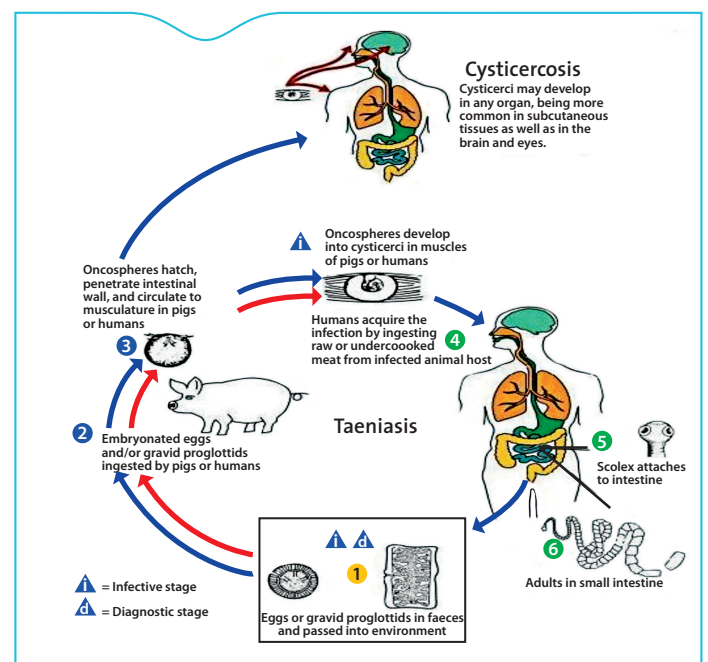


Figure 1. Biological cycle of *Tænia solium* (adapted from a diagram presented by the CDC)

In nature, the lysis of proglottids disseminates the embryophores (embryonated eggs). These, after ingestion by a pig (or by a wild boar or other swine), are lysed during the digestive process and the hexacanth embryos⁽³⁾ (oncospheres) that are released become established in the connective tissue of skeletal muscles. Here, in 3 to 4 months, they form cysticerci larvae (metacestodes) called *Cysticercus cellulosae*.

Sources of the hazard

The source of the hazard to humans comes from the cysticerci found in infected pork ("measly" meat). This hazard is particularly present when pigs wander in the environment where they can ingest embryophores from human faeces. The chains of rings released with human faeces are therefore responsible for massive infestations of coprophagous pigs.

(1) Definitive host: host that harbours the adult parasite.

(2) Intermediate host: host that harbours the larval form of the parasite.

(3) Hexacanth embryos: larvae with six hooks.

Another source of hazard to humans is the presence in the environment of human faecal matter containing *T. solium* embryophores that may be ingested (via water or raw vegetables). The environmental risk comes from defecation outside latrines and the lack or poor quality of sanitation. This phenomenon can cause a larval cestodiasis called cysticercosis, a disease in which the human harbours the larval form of *T. solium*, and not the adult worm.

The presence of *T. solium* in the digestive tract may also lead to self-infestation, either by digestion of the last rings brought back into the stomach by antiperistalsis or by accidental ingestion of ripe eggs accumulated under the nails as a result of anal itching. This self-infestation leads to a secondary cysticercosis but its frequency is rarer than that due to the ingestion of *T. solium* eggs.

The risk factors for contamination vary considerably according to geographical origin (see Epidemiology section).

Transmission routes

T. solium taeniasis is mainly contracted by eating raw or undercooked «measly» pork containing cysticerci.

For cysticercosis, contamination can be exogenous, from the ingestion of embryophores contained in faecal matter contaminating the environment, or endogenous, from the antiperistalsis phenomenon.

Recommendations for primary production

- Compliance with current regulations and recommendations for the treatment and spreading of sewage sludge, as well as the use of treated wastewater for irrigation and watering.
- Bear in mind the ban on the use of human fertilizers.
- Pig farms must comply with the preventive measures recommended in good farming practices, especially in tropical areas.

Human food-borne illness

Nature of the disease

Gastrointestinal parasitism by *T. solium* is usually benign (digestive disorders that may be accompanied by itching).

The gravity comes from the possible development of cysticercosis, caused by human infection by the larval stage. Cysticerci have been observed in all organs of the human body, the most common sites being the skin and subcutaneous tissue, the muscles of the tongue, neck and thorax, the ocular muscles and the eye, and the brain (neurocysticercosis). Symptoms may appear after development of the larva, i.e. at least 60 days after infection. After a varying period of time, the cysticercus calcifies (calcification takes 3 years on average). The infection is usually mild except when cerebral, when the prognosis is poor and can cause epilepsy in particular (generally late onset), or ocular, when it can cause uveitis leading to loss of vision.

There is no evidence to date to suggest that there is a susceptible population.

Dose-effect⁽⁴⁾ and dose-response relationships⁽⁵⁾

No data in humans are available.

In pigs, experimental infection cannot be achieved with doses below 500 embryophores; experimental infestations with more than 2000 embryophores give the highest rates of infection.

Epidemiology

Cysticercosis is found on all continents, except Australia, with areas of high prevalence in Central and South America, India, Africa, the Indian Ocean (Madagascar, Reunion Island) and much of Asia. Cysticercosis is a disease of underdevelopment, appearing where pigs and humans live in close proximity, in combination with poor husbandry and hygiene conditions.

Monitoring system:

There is no monitoring system in humans for *T. solium* taeniasis in France.

Prevalence:

The prevalence of *T. solium* taeniasis has evolved over time, especially with the improved level of hygiene. In mainland France, no indigenous cases have been reported, but the parasitosis is still present in some countries of the European Union (there are published data for Poland).

It is endemic in developing countries with poor hygiene levels.

• Situation in mainland France

Due to the level of hygiene of the population and French eating habits, *T. solium* taeniasis has always been extremely rare, with any cases usually being imported. The rise in the overall level of hygiene from the late 1950s, and then the widespread use of intensive pig farming, which broke the parasite cycle between the animal and the environment, played a key role in its disappearance.

• Situation in the French overseas territories (DOM)

• Guadeloupe, French Guiana and Martinique

Although domestic pig breeding is common, Creole eating habits mean that *T. solium* taeniasis is unknown in these *départements*. No cases were diagnosed by coprology between 1968 and 1995 at the Institut Pasteur in Fort-de-France, nor subsequently at the Martinique departmental hygiene laboratory. There are no reported cases of cysticercosis or neurocysticercosis in the literature, other than imported cases.

• Reunion Island

This island has been a major focus of cysticercosis. A 1985 study found a seroprevalence of 8.2% in a sample of 3388 subjects representative of the population of Reunion. In 1990, the seroprevalence was only 1.4% in a sample of 993 individuals. The microbiology laboratory for the southern hospital group in Saint-Pierre, which is the reference in cysticercosis immunodiagnosis, currently detects virtually no new seropositivity. At the same time, veterinary controls in 1993 reported no cases of porcine cysticercosis. The role of family slaughter of pigs (without veterinary supervision) should be considered.

There is a general consensus that attributes this collapse in transmission firstly to a considerable improvement in the overall level of hygiene, both individual and community (widespread sanitation), and secondly to more effective diagnosis and treatment of *T. solium* taeniasis.

(4) Relationship between the dose (the quantity of microbial cells ingested during a meal) and the effect on an individual.

(5) For a given effect, the relationship between the dose and the response, i.e., the probability of this effect appearing in the population.

Role of foods

Main foods to consider

Humans become infected by ingesting any raw or undercooked "measly" pork or delicatessen meats (smoking does not destroy cysticerci). Infestation is usually massive in contaminated pigs, affecting all muscles.

Humans can also become contaminated by ingesting water or raw vegetables soiled by human faeces containing *T. solium* embryophores.

Inactivation treatments in industrial environments

Few data are available on the inactivation of *T. solium* cysticerci but some effects of heat and cold on *T. saginata* can be combined.

Table 1. Inactivation treatments in industrial environments

Heat	Cold
Cysticerci are killed by heating meat to an internal temperature of at least 60°C for several minutes.	Cysticerci are inactivated by freezing, at least equivalent to freezing to an internal temperature of -15°C for 75 min or -18°C for 30 min.
Ionisation	Other processes
No proven efficacy with 0,2 to 0,6 kGy.	Salting for 12 to 24 hours with a pH of 5.3 to 6 inhibits the infectivity of cysticerci.

Monitoring in foods

In accordance with Regulation (EC) No 854/2004⁽⁶⁾, during the *post-mortem* inspection of carcasses at the slaughterhouse, the minimum requirements for screening for cysticercosis in pigs are: visual examination of the tongue, oesophagus and diaphragm, visual examination of the heart before and after incision.

The Order of 18 December 2009⁽⁷⁾ stipulates that for any carcass in which a cysticercus or lesion suggestive of cysticercosis is found, a thorough examination should be carried out. If more than one lesion per square decimetre is found, in any location whatsoever, the carcass (including head, oesophagus and heart) is withdrawn from human consumption. When there are fewer lesions, the damaged part is seized and the remainder of the carcass can be sanitised by refrigeration (carcass frozen to -10°C internal temperature for a minimum of 10 days). Note, however, that in pigs, infestation is usually massive.

Recommendations to operators

- Prohibition of the sale of pork that has not been inspected at the slaughterhouse.

Domestic hygiene

Epidemiological data indicate that *T. solium* taeniasis is no longer a danger on the French mainland but may be encountered in the overseas territories (DOM-TOM) and certain other countries. In the DOM, the risk may come from imported cases from Brazil or Haiti (French Caribbean, French Guiana) or from Madagascar and Mauritius (Reunion Island).

The recommendations to consumers apply to people travelling to developing countries where there is a combination of a low level of hygiene and a lack of controls in pig farming.

Recommendations to consumers

- Cook pork until well-done.
- The prior freezing in a domestic freezer (-10°C for 10 days or -15°C for 6 days) of meat intended to be eaten raw or undercooked is a good means of prevention.

Links

Bibliographic references

- Chamouillet H., Bouteille B., Isautier H., Begue A., Lecadiu M. Séroprévalence de la cysticercose, du téniasis et de l'infestation porcine sur l'île de la Réunion. *Med Trop.* 1997; 57:41-46.
- Gamble H.R. Parasites associated with pork and pork products. *Rev. sci. tech. Off. Int. Epiz.*, 1997, 16 (2), 496-506
- InVS. Morbidité et mortalité dues aux maladies infectieuses d'origine alimentaire en France (*Morbidity and mortality due to infectious food-borne diseases in France*). 2004. (http://www.invs.sante.fr/publications/2004/inf_origine_alimentaire/inf_origine_alimentaire.pdf).
- Michault A., Duval G., Bertil G., Folio G. Etude séroépidémiologique de la cysticercose dans l'île de La Réunion. *Bull Soc Pathol Exot.* 1990; 83:82-92.
- Michault A., Rivière B., Fressy P., Laporte J-P., Bertil G., Mignard C. Contribution de l'enzyme-linked immunoelectrotransfert blot (EITB) au diagnostic de la neurocysticercose humaine. *Pathol Biol.* 1990; 38:119-125
- Rodriguez-Canul R., Argaez-Rodriguez F., Pacheco de la Gala D., Villegas-Perez S., Fraser A., Craig P.S., Cob-Galera L., Dominguez-Alpizar J.L. *Taenia solium* metacestode viability in infected pork after preparation with salt pickling or cooking methods common in Yucatán, México. *Jour of Food Protect.* Volume 65, Issue 4, 2002, Pages 666-669
- Verastegui M, Gonzales A, Gilman RH, Gavidia C, Falcon N, Bernal T, Garcia HH. Experimental infection model for *Taenia solium* cysticercosis in swine. *Vet Parasitol.* 2000; 94:33-44.
- WHO/FAO/OIE. Guidelines for the Surveillance, Prevention and Control of Taeniosis/Cysticercosis. 2005. (<http://www.oie.int/doc/ged/D11245.pdf>).

Useful links

- EU Reference Laboratory for parasites: Istituto Superiore di Sanità (ISS) I-00161, Rome – Italy (<http://www.iss.it/crlp/index.php>)
- National Reference Laboratory (NRL) for food-borne parasites, excluding *Echinococcus* sp.: Maisons-Alfort Laboratory for Animal Health

(6) Regulation (EC) No 854/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption (<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:226:0083:0127:EN:PDF>).

(7) Order of 18 December 2009 on the health rules applicable to animal products and foods containing them (<http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000021533994>).