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PARASITOLOGY - CHAPTER FIVE CESTODES (TAPE WORMS)

Dr Gregory Brower
Professor
University of South Carolina School of Medicine

Dr Abdul Ghaffar
Professor Emeritus
University of South Carolina School of Medicine

Clinically important cestodes pathogenic to man are *Tenia solium* (pork tapeworm), *T. saginata* (beef tapeworm), *Diphyllobothrium latum* (fish or broad tapeworm), *Hymenolepis nana* (dwarf tapeworm) and *Echinococcus granulosus* and *E. multilocularis* (hydatid).

TEACHING OBJECTIVES

Epidemiology, morbidity and mortality

Morphology of the organism

Life cycle, hosts and vectors

Disease, symptoms, pathogenesis and site

Diagnosis

Prevention and control

TENIA SOLIUM T. SAGINATA (TENIASIS)

Epidemiology

These cestodes have a worldwide distribution but incidence is higher in developing countries. Infection rate is as low as 1 per 1000 in most of North America and as high as 10% in the third world. Pork tapeworm shows a higher incidence but this is dependent on dietary habits.

Morphology

T. saginata can be up to 4 to 6 meters long and 12 mm broad; it has a pear-shaped head (scolex) with four suckers but no hooks or neck. It has a long flat body with several hundred segments (proglottids). Each segment is about 18 x 6 mm with a branched uterus (15-30 branches). The egg is 35 x 45 micrometers, roundish and yellow-brown. It has peripheral radial striations and contains an embryo with 3 hooklets (figure 2).

T. solium is slightly smaller than *T. saginata*. It has a globular scolex with four suckers and a circular row of hooks (rostellum) that gives it a solar appearance. There is a neck and it has a long flat body (0.1 meter in length). The proglottids are 5 x 10 mm with a 7-12 branch uterus. The eggs of *T. solium* and *T. saginata* are indistinguishable (figure 2).

Life cycle

A tapeworm larval cyst (cysticercus) is ingested with poorly cooked infected meat; the larva escapes the cyst and passes to the small intestine where it attaches to the mucosa by the scolex suckers. The proglottids develop as the worm matures in 3 to 4 months. The adult may live in the small intestine as long as 25 years and pass gravid proglottids with the feces. Eggs extruded from the proglottid contaminate and persist on vegetation for several days and are consumed by cattle or pigs in which they hatch and form cysticerci (Figure 1).

Symptoms

Light infections remain asymptomatic, but heavier infections may produce abdominal discomfort, epigastric pain, vomiting and diarrhea.

Cysticercosis

T. solium eggs can also infect humans and cause cysticercosis (larval cysts in lung, liver, eye and brain) resulting in blindness and neurological disorders. The incidence of cerebral cysticercosis can be as high 1 per 1000 population and may account for up to 20% of neurological case in some countries (e.g., Mexico); cysticercosis ocular involvement occurs in about 2.5% of patients and muscular involvement is as high as 10% (India).

Pathology and Immunology

Gastrointestinal symptoms are due to the presence of the tape worm. Cysticercosis symptoms are a result of inflammatory/immune responses. Antibodies are produced in cysticercosis and are useful epidemiological tools.

Diagnosis

Diagnosis is based on the recovery of eggs or proglottids in stool or from the perianal area. Cysticercosis is confirmed by the presence of antibodies.

Treatment and control

Praziquantel is the drug of choice. Expulsion of scolex must be assured to assume a satisfactory treatment. A thorough inspection of beef and pork, adequate cooking or freezing of meat are effective precautions, since cysticerci do not survive temperatures below -10°C and above 50°C .

Figure 1

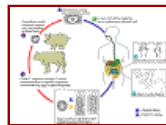


Figure 1

Life cycle of *Taenia saginata* and *Taenia solium*

Humans are the only definitive hosts for *Taenia saginata* and *Taenia solium*. Eggs or gravid proglottids are passed with feces **1**; the eggs can survive for days to months in the environment. Cattle (*T. saginata*) and pigs (*T. solium*) become infected by ingesting vegetation contaminated with eggs or gravid proglottids **2**. In the animal's intestine, the oncospheres hatch **3**, invade the intestinal wall, and migrate to the striated muscles, where they develop into cysticerci. A cysticercus can survive for several years in the animal. Humans become infected by ingesting raw or undercooked infected meat **4**. In the human intestine, the cysticercus develops over 2 months into an adult tapeworm, which can survive for years. The adult tapeworms attach to the small intestine by their scolex **5** and reside in the small intestine **6**. Length of adult worms is usually 5 m or less for *T. saginata* (however it may reach up to 25 m) and 2 to 7 m for *T. solium*. The adults produce proglottids which mature, become gravid, detach from the tapeworm, and migrate to the anus or are passed in the stool (approximately 6 per day). *T. saginata* adults usually have 1,000 to 2,000 proglottids, while *T. solium* adults have an average of 1,000 proglottids. The eggs contained in the gravid proglottids are released after the proglottids are passed with the feces. *T. saginata* may produce up to 100,000 and *T. solium* may produce 50,000 eggs per proglottid respectively. CDC DPDx Parasite Image Library



Figure 2A

Taeniid eggs. The eggs of *Taenia saginata* and *T. solium* are undistinguishable morphologically (morphologic species identification will have to rely on the proglottids or scolices). The eggs are rounded or subspherical, diameter 31 - 43 μm , with a thick radially striated brown shell. Inside each shell is an embryonated oncosphere with 6 hooks. The egg in B still has the primary membrane that surrounds eggs in the proglottids. CDC



Figure 2B

Gravid proglottids of (left) *Taenia saginata* and (right) *T. solium*. Injection of India ink in the uterus allows visualization of the primary lateral branches. Their number allows differentiation between the two species: *T. saginata* has 15 - 20 branches on each side, while *T. solium* has 7 - 13. Note the genital pores in mid-lateral position. CDC



Figure 2C

Taenia saginata gravid proglottid © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission

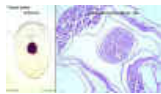


Figure 2D

Taenia solium cysticercus, whole and in section of muscle (H&E) © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission



Figure 2E

Taenia sp. egg © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission

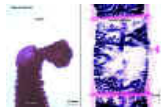


Figure 2F

Taenia solium scolex and gravid proglottid © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission



Figure 2G

Scolex of *Taenia solium*.
CDC/Dr. Mae Melvin



Figure 2G

Histopathology of *Taenia saginata* in appendix. CDC

DIPHYLLOBOTHRIUM LATUM (FISH OR BROAD TAPEWORM)

Epidemiology

Fish tapeworm infection is distributed worldwide, in the subarctic and temperate regions; it is associated with eating of raw or improperly cooked fresh water fish.

Morphology

This is the longest tapeworm found in man, ranging from 3-10 meters with more than 3000 proglottids. The scolex resembles two almond-shaped leaves and the proglottids are broader than they are long, a morphology reflected in the organism's name. Eggs are 30 x 50 micrometers in size and contain an embryo with 3 pairs of hooklets (figure 4).

Life cycle

Man and other animals are infected by eating uncooked fish that contains plerocercoid larvae (15 x 2 mm) which attach to the small intestinal wall and mature into adult worms in 3 to 5 weeks. Eggs discharged from gravid proglottids in the small intestine are passed in the feces. The egg hatches in fresh water to produce a ciliated coracidium which needs to be ingested by a water flea (*Cyclops*) where it develops into a proceroid larva. When infected *Cyclops* are ingested by the freshwater fish, the proceroid larva penetrates the intestinal wall and develops into a plerocercoid larva, infectious to man (figure 3).

Symptoms

Clinical symptoms may be mild, depending on the number of worms. They include abdominal discomfort, loss of weight, loss of appetite and some malnutrition. Anemia and neurological problems associated with vitamin B12 deficiency are seen in heavily infected individuals.

Diagnosis

Diagnosis is based on finding many typical eggs and empty proglottids in feces (Figure 3). A history of raw fish consumption and residence in an endemic locality is helpful.

Treatment and control

Praziquantel is the drug of choice. Freezing for 24 hours, thorough cooking or pickling of fish kills the larvae. Fish reservoirs should be kept free of raw sewage.

WEB RESOURCES

Diphyllobothriasis - CDC

Figure 4

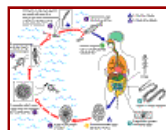


Figure 3

Immature eggs are passed in feces ¹. Under appropriate conditions, the eggs mature (approximately 18 to 20 days) ² and yield oncospheres which develop into a coracidia ³. After ingestion by a suitable freshwater crustacean (the copepod first intermediate host) the coracidia develop into proceroid larvae ⁴. Following ingestion of the copepod by a suitable second intermediate host, typically minnows and other small freshwater fish, the proceroid larvae are released from the crustacean and migrate into the fish flesh where they develop into a plerocercoid larvae (sparganum) ⁵. The plerocercoid larvae are the infective stage for humans. Because humans do not generally eat undercooked minnows and similar small freshwater fish, these do not represent an important source of infection. Nevertheless, these small second intermediate hosts can be eaten by larger predator species, e.g., trout, perch, walleyed pike ⁶. In this case, the sparganum can migrate to the musculature of the larger predator fish and humans can acquire the disease by eating these later intermediate infected host fish raw or undercooked ⁷. After ingestion of the infected fish, the plerocercoid develop into immature adults and then into mature adult tapeworms which will reside in the small intestine. The adults of *D. latum* attach to the intestinal mucosa by means of the two bilateral grooves (bothria) of their scolex ⁸. The adults can reach more than 10 m in length, with more than 3,000 proglottids. Immature eggs are discharged from the proglottids (up to 1,000,000 eggs per day per worm) ⁹ and are passed in the feces ¹. Eggs appear in the feces 5 to 6 weeks after infection. In addition to humans, many other mammals can also serve as definitive hosts for *D. latum*. CDC [DPDx Parasite Image Library](#)



Figure 4A

Eggs of *Diphylobothrium latum*. These eggs are oval or ellipsoidal, with at one end an operculum (arrows) that can be inconspicuous (right). At the opposite (abopercular) end is a small knob that can be barely discernible (left). The eggs are passed in the stool unembryonated. Size range: 58 to 76 μm by 40 to 51 μm . CDC. Image A contributed by Georgia Division of Public Health



Figure 4B

Gravid proglottids of *Diphylobothrium latum*. CDC/Dr. Mae Melvin

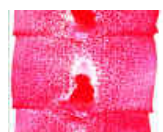


Figure 4C

Proglottids of *Diphylobothrium latum*. The species characteristics are: the proglottid is broader than it is long; size 2 to 4 mm long by 10 to 12 mm wide; uterus coiled in rosette appearance; genital pore at the center of the proglottid. CDC

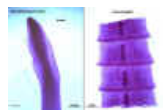


Figure 4E

Diphylobothrium latum scolex and gravid proglottids © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission



Figure 4D

Proglottids of *Diphylobothrium latum*. These proglottids tend to be passed in strands of variable length in the stool. The proglottids tend to be broader than long. CDC. Image contributed by Georgia Division of Public Health.

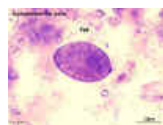


Figure 4F

Diphylobothrium latum egg © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission

***HYMENOLEPIS NANA* (DWARF TAPEWORM)**

This is a small tapeworm (20 x 0.7 mm) which infects children. Rodents are the reservoir. Infection is by the oro-fecal mode and, hence, cross infection and auto infection by eggs in feces in normal (figure 6). The worm develops from ingested eggs into an adult in the small intestine and resides there for several weeks (figure 5). Light infections produce vague abdominal disturbances but heavier infections may cause enteritis. Diagnosis is based on finding eggs in the feces. Praziquantel is the drug of choice. Hygiene is the best control.

WEB RESOURCES

[Hymenolepiasis - CDC](#)



Figure 5

Eggs of *Hymenolepis nana* are immediately infective when passed with the stool and cannot survive more than 10 days in the external environment ¹. When eggs are ingested by an arthropod intermediate host ² (various species of beetles and fleas may serve as intermediate hosts), they develop into cysticercoids, which can infect humans or rodents upon ingestion ³ and develop into adults in the small intestine. A morphologically identical variant, *H. nana* var. *fraterna*, infects rodents and uses arthropods as intermediate hosts. When eggs are ingested ⁴ (in contaminated food or water or from hands contaminated with feces), the oncospheres contained in the eggs are released. The oncospheres (hexacanth larvae) penetrate the intestinal villus and develop into cysticercoid larvae ⁵. Upon rupture of the villus, the cysticercoids return to the intestinal lumen, evaginate their scoleces ⁶, attach to the intestinal mucosa and develop into adults that reside in the ileal portion of the small intestine producing gravid proglottids ⁷. Eggs are passed in the stool when released from proglottids through its genital atrium or when proglottids disintegrate in the small intestine ⁸. An alternate mode of infection consists of internal autoinfection, where the eggs release their hexacanth embryo, which penetrates the villus continuing the infective cycle without passage through the external environment ⁹. The life span of adult worms is 4 to 6 weeks, but internal autoinfection allows the infection to persist for years. CDC [DPDx Parasite Image Library](#)

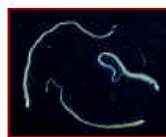


Figure 6A

Three adult *Hymenolepis nana* tapeworms. Each tapeworm (length: 15-40 mm) has a small, rounded scolex at the anterior end, and proglottids can be distinguished at the posterior, wider end. CDC. Image contributed by the Georgia Division of Public Health.



Figure 6B

Egg of *Hymenolepis diminuta*. These eggs are round or slightly oval, size 70 - 86 μm X 60 - 80 μm , with a striated outer membrane and a thin inner membrane. The space between the membranes is smooth or faintly granular. The oncosphere has six hooks (of which at least four are visible at this level of focus). CDC. Image contributed by Georgia Department of Public Health.



Figure 6C

Egg of *Hymenolepis nana*. These eggs are oval or subspherical and smaller than those of *H. diminuta*, their size being 40 - 60 μm X 30 - 50 μm . On the inner membrane are two poles, from which 4-8 polar filaments spread out between the two membranes. The oncosphere has six hooks (seen as dark lines at 8 o'clock). CDC. Image contributed by Georgia Department of Public Health.



Figure 6D

Hymenolepis nana egg © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission



Figure 6E

Hymenolepis nana cysticercoid © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission



Figure 6F

Hymenolepis nana adult © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission

WEB RESOURCES

[Echinococcosis - CDC](#)

ECHINOCOCCOSIS (HYDATID)

Echinococcus granulosus and *E. multilocularis* are causative agents of hydatid cysts.

ECHINOCOCCUS GRANULOSUS

Epidemiology

The organism is common in Asia, Australia, Eastern Africa, southern Spain, southern parts of South America and northern parts of North America. The incidence of human infection about 1 to 2 per 1000 population and may be higher in rural areas of affected regions.

Morphology

This is the smallest of all tapeworms (3 to 9 mm long) with only 3 proglottids.

Life cycle

The adult worm lives in domestic and wild carnivorous animals. Eggs, passed by infected animals, are ingested by the grazing farm animals or man, localize in different organs and develop into hydatid cysts containing many larvae (proto-scolices or hydatid sand) (Figure 8). When other animals consume infected organs of these animals, proto-scolices escape the cyst, enter the small intestine and develop into adult worms (Figure 7). Echinococcus eggs, when swallowed by man, produce embryos that penetrate the small intestine, enter the circulation and form cysts in liver, lung, bones, and sometimes, brain. The cyst is round and measures 1 to 7 cm in diameter, although it may grow to be 30 cm. The cyst consists of an outer anuclear hyaline cuticula and an inner nucleated germinal layer containing clear yellow fluid. Daughter cysts attach to the germinal layer, although some cysts, known as brood cysts, may have only larvae (hydatid sand). Man is a dead end host.

Symptoms

The symptoms, comparable to those of a slowly growing tumor, depend upon the location of the cyst. Large abdominal cysts produce increasing discomfort. Liver cysts cause obstructive jaundice. Peribronchial cysts may produce pulmonary abscesses. Brain cysts produce intracranial pressure and Jacksonian epilepsy. Kidney cysts cause renal dysfunction. The contents of a cyst may produce anaphylactic responses.

Diagnosis

Clinical symptoms of a slow-growing tumor accompanied by eosinophilia are suggestive. Intradermal (Casoni) test with hydatid fluid is useful. Pulmonary cysts and calcified cysts can be visualized using x-rays. Antibodies against hydatid fluid antigens have been detected in a sizable population of infected individuals by ELISA or indirect hemagglutination test.

Treatment and control

Treatment involves surgical removal of cyst or inactivation of hydatid sand by injecting the cyst with 10% formalin and its removal within few (4-5) minutes. Praziquantel has been shown to be effective in many cases. Albendazole, in high doses, is an alternative. Preventive measures involve avoiding contact with infected dogs and cats and elimination of their infection.

Figure 8



Figure 7

The adult *Echinococcus granulosus* (3 to 6 mm long) (1) resides in the small bowel of the definitive hosts, dogs or other canids. Gravid proglottids release eggs (2) that are passed in the feces. After ingestion by a suitable intermediate host (under natural conditions: sheep, goat, swine, cattle, horses, camel), the egg hatches in the small bowel and releases an oncosphere (3) that penetrates the intestinal wall and migrates through the circulatory system into various organs, especially the liver and lungs. In these organs, the oncosphere develops into a cyst (4) that enlarges gradually, producing protoscolices and daughter cysts that fill the cyst interior. The definitive host becomes infected by ingesting the cyst-containing organs of the infected intermediate host. After ingestion, the protoscolices (5) evaginate, attach to the intestinal mucosa (6), and develop into adult stages (1) in 32 to 80 days. The same life cycle occurs with *E. multilocularis* (1.2 to 3.7 mm), with the following differences: the definitive hosts are foxes, and to a lesser extent dogs, cats, coyotes and wolves; the intermediate host are small rodents; and larval growth (in the liver) remains indefinitely in the proliferative stage, resulting in invasion of the surrounding tissues. With *E. vogeli* (up to 5.6 mm long), the definitive hosts are bush dogs and dogs; the intermediate hosts are rodents; and the larval stage (in the liver, lungs and other organs) develops both externally and internally, resulting in multiple vesicles. *E. oligarthrus* (up to 2.9 mm long) has a life cycle that involves wild felids as definitive hosts and rodents as intermediate hosts. Humans become infected by ingesting eggs (2), with resulting release of oncospheres (3) in the intestine and the development of cysts (4) in various organs. CDC DPDx Parasite Image Library



Figure 8A

"Hydatid sand". Fluid aspirated from a hydatid cyst will show multiple protoscolices (size approximately 100 μ m), each of which has typical hooklets. The protoscolices are normally invaginated (left), and evaginate (middle, then right) when put in saline. CDC Image contributed by Georgia Division of Public Health

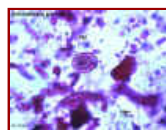


Figure 8B

Echinococcus granulosus egg © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission



Figure 8C

Echinococcus granulosus adult © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission



Figure 8D

Echinococcus granulosus hydatid cysts in section of lung (H&E) © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission



Figure 8E

Echinococcus granulosus hydatid sand © Dr Peter Darben, Queensland University of Technology clinical parasitology collection. Used with permission



Figure 8F

Histopathology of hydatid cyst. *Echinococcus*, echinococcosis, CDC/Dr. Mae Melvin



Figure 8G

Hydatid cysts



Figure 8F

Gross pathology of cotton rat infected with *Echinococcus multilocularis*. First *E. locularis* isolated in the United States proper. CDC/Dr. I. Kagan



Figure 8G

Histopathology of *Echinococcus granulosus* hydatid cyst in a sheep. Thick fibrous pericyst, hyaline ectocyst, and brood capsules filled with protoscolices are visible. CDC/Dr. Peter Schantz

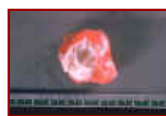


Figure 8H

Gross pathology of membrane and hydatid daughter cysts from human lung CDC/Dr. I. Kagan



Figure 8I

Man's arm showing positive skin test for hydatid disease (echinococcosis) CDC/Dr. I. Kagan

ECHINOCOCCUS MULTILOCULARIS

This is a tapeworm, similar to *E. granulosus*, that also causes hydatid in northern parts of Asia and North America. It has a very similar morphology and life cycle except that rodents are its intermediate host. Humans, when infected with this worm, also develop hydatid cysts which produce symptoms similar to those caused by *E. granulosus*. However, the cysts are multilocular (many chambers). The organism is resistant to praziquantel; high doses of Albendazole has some anti-parasitic effect. Surgery is the means of removing the cyst. Rodent control is the means of prevention.

Summary

Cestodes

Organism	Transmission	Symptoms	Diagnosis	Treatment
<i>Tenia saginata</i>	Cyst in beef	Epigastric pain, vomiting, diarrhea	Proglottids or eggs in stool or perianal area	Praziquantel
<i>Tenia solium</i>	Cyst in pork	Epigastric pain, vomiting, diarrhea	Proglottids or eggs in stool or perianal area	Praziquantel
<i>T. solium</i> Cysticercosis	Oro-fecal	Muscle pain and weakness, ocular and neurologic problems	Roentgenography, anti-cysticercal antibody (EIA)	Praziquantel
<i>D. latum</i>	Cyst in fish	Abdominal pain, loss of weight, anorexia, malnutrition and B12 deficiency problems	Proglottids or eggs in stool or perianal area	Praziquantel
<i>E. granulosus</i>	Oro-fecal	Large cysts produce various symptoms depending on the location of the organism.	Roentgenography, anti-hydatid fluid antibody (EIA), Casoni skin test	Surgery, formalin injection and drainage, Praziquantel
<i>E. multilocularis</i>	Oro-fecal	As above	As above	Surgery, Albendazole



Return to the Parasitology Section of Microbiology and Immunology On-line

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