

An Overview on Human Helminthic Parasitology III. Cestodes, the Tapeworms

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ABSTRACT

Helminths developed a variety of diseases in humans. They are invertebrate animals usually found in the intestines of the hosts. Cestodes in association with normal ailments and diseases caused by them, they infrequently produce some other specific diseases like cysticercosis, neurocysticercosis and hydatid diseases in humans. The present review is third in the series of helminthic parasitology discussing some of the Cestodes in the light of recent researches done so far in the same field.

Keywords : Parasitology, Helminths, Cestodes, Tapeworms, Diseases and malignancies in human.

INTRODUCTION

Helminths are popularly known as the worms. They basically divided into Nematelminths (Nematoda, the roundworms) and Platyhelminthes (Trematoda, the flatworms and flukes) and (Cestodes, the tapeworms). Cestodes are tape or ribbon like bilaterally symmetrical and dorsiventral, intestinal, triploblastic, hermaphroditic, oviparous and segmented metazoans whose body parts are divided into scolex, neck and strobila. While they have suckers and hooks in their heads, the strobila is made of proglottids. The neck acts like a growing region. This is actively engaged in producing the proglottids one by one. And, the last gravid proglottid is often detached to disseminate the eggs. Sometimes, they are very big in their lengths. These are generally found in mammals like dogs, sheep, beef including humans and fishes causing diseases as cysticercosis, neurocysticercosis and hydatid diseases in humans. The present review discusses as under some of the Cestodes causing diseases in humans like *Taenia solium*, a pork tapeworm as neurocysticercosis; *Diphyllobothrium latum*, a fish tapeworm as

diphyllobothriasis; *Echinococcus granulosus*, a dog tapeworm as echinococcosis and *Hymenolepis nana*, an insect tapeworm as hymenolepiasis causing nasal and anal pruritus in the light of recent researches done so far in the field of human parasitology (Chai *et al.* 2005, Schantz 2006, Keiser and Utzinger 2009, Moro and Schantz 2009, Harhay *et al.* 2010, Ziegelbauer *et al.* 2012, Carpio *et al.* 2018, Garcia *et al.* 2018, Durrani *et al.* 2021)^[1-9].

Taenia solium (Taeniasis, Neurocysticercosis)

Taenia solium is a most common pork tapeworm found in human distributed globally where the pork is eaten abundantly. Humans and pigs are their definitive and intermediate hosts respectively. Similarly, the *Taenia* infections are also common in dogs, sheep, beef and other ruminants with their different species concerned. It causes a disease known as taeniasis in human. The larval stage of the same genus is known as cysticercus causing cysticercosis in human. In fact, the tissue infection is called as the cysticercosis. And, if it infects the brain, this is called as the neurocysticercosis. This is noted that nearly one – third of all epileptic cases are due to the neurocysticercosis. Further, as the larva looks like a bladder, the name bladder worm is also applied to them (Carpio *et al.* 2018, Garcia *et al.* 2018, Melki *et al.* 2018) ^[5,8,10].

Taenia solium is an hermaphroditic triploblastic, acoelomate, white in color tapeworm measuring about 2 to 8 meters long having flat ribbon- like body. The entire body is divided into scolex having suckers and rostellum, the organs of attachment, short neck and the main segmented body made of proglottids. Each mature proglottid is a set of male and female reproductive systems containing numerous testes and a bilobed ovary respectively opening into a common genital pore. A detached gravid proglottid is full of fertilized eggs. This is transmitted to pigs through human containing the eggs and to humans via the consumption of under- cooked pork having cysts. In pigs, the eggs developed into larvae, oncospheres and ultimately into tapeworm cysts. The ingestion of pork cysts in human grew into adult tapeworms in human intestine (Rabiela *et al.* 1989, Willms 2008, Jang *et al.* 2010, Garcia *et al.* 2014, Carpio *et al.* 2018)^[5,11-14].

Taeniasis is an adult tapeworm infection in human intestine which is mild or usually asymptomatic. The clinical symptoms are developed in about two months later the ingestion of pork and other meat containing cysticerci. The symptoms may include constipation, diarrhea, abdominal pain, nausea and vomiting. These symptoms may last for years until the tapeworms die from the course of treatment. If untreated for a longer period of time cysticercosis and finally the neurocysticercosis may result. Cysticercosis and neurocysticercosis are expressed clinically as body aches, inflammation of the voluntary muscles, headache, blindness, convulsions, dizziness, dementia, hypertension, seizures, epilepsy, lesions in the brain, hydrocephalus, paraplegy, meningitis, eosinophilia and even death. Sometimes, the subcutaneous, firm and mobile nodules are also formed on the trunk and in extremities (Gonzales *et al.* 2016, Carpio *et al.* 2018, Garcia *et al.* 2018, Melki *et al.* 2018)^[5,8,10,15]. An increased translocation frequency of chromosomes 7,11 and 14 in lymphocytes from patients with neurocysticercosis caused by the infection of *Taenia solium* has also been reported (Herrera *et al.* 2001)^[16].

Stool test is generally conducted to determine the quality and quantity of eggs. Proglottids found in a stool sample diagnose the taeniasis preliminary. Some other specific tests like

immunoblot, ELISA and PCR are also available to confirm the infection. In addition, while X rays are used to detect the dead and calcified larvae in the subcutaneous and muscle tissue, the CT scans and MRIs are conducted to find out the larvae and lesions in the brain (Richards and Schantz 1991, Guezala *et al.* 2009, Hernandez *et al.* 2017) [17-19].

Further, the infection can be prevented with proper disposal of human fecal matter and by avoiding the ingestion of undercooked meat and vegetables contaminated with cysts and eggs. While niclosamide is a drug of choice for simple taeniasis, praziquantel is used for cysticercosis. In neurocysticercosis, albendazole and praziquantel are used. Albendazole with corticosteroids is given to reduce the inflammation. Sometimes, the surgical removal of cysts is also performed with proper medications provided (Gonzalez *et al.* 2003, white 2009, Gilman *et al.* 2012, Garcia *et al.* 2016, Mc Clugage *et al.* 2017) [20-24]. Lastly, the development of S3Pvac vaccine is developed for the control of cysticercosis caused by the *Taenia solium* (Sciutto *et al.* 2013) [25].

Diphyllobothrium latum (Diphyllobothriasis)

Diphyllobothrium latum is a broad fish tapeworm causing diphyllobothriasis in human. This is mostly found in places where raw fishes are eaten regularly (Tomas *et al.* 2009) [26]. This is native to Scandinavia, western Russia and Baltics. Currently, it has also been reported from east Asian countries like Japan, Korea, China and Taiwan and some other places like north and south America, Uganda, Peru, Chile and Serbia (Tomas *et al.* 2009) [26]. In India, the only case was reported from south India in 2011 (Ramana *et al.* 2011) [27]. The definitive hosts of *Diphyllobothrium latum* are piscivorous mammals including human and some birds representing the significant zoonotic reservoirs. The intermediate hosts are some crustaceans and fishes (Durrani *et al.* 2021) [9].

D. latum is an hermaphroditic animal measuring about 4 to 15 meters long. The entire body is divided into scolex, neck and the lower body. In scolex, on each side, the device bothrium attaches to the intestine. The neck is a proliferative region of proglottids. Each proglottid is wider enough to contain a set of both reproductive organs opening midventrally into a genital pore. The adults are developed inside the small intestine. These proglottids are detached and the immature unembryonated eggs are released in feces contaminating the freshwater to start the cycle. These eggs are matured and being eaten by the crustaceans and then fishes. Finally, when these infected fishes are consumed by the humans, the larvae thus developed reach the small intestine where they mature to repeat the cycle again. An adult worm produces approximately 1 million eggs per day. And, the incubation period of the disease is about 4 to 6 weeks (Sampaio *et al.* 2005, Durrani *et al.* 2021) [9, 28].

As the symptoms are either mild or asymptomatic, the disease has never been taken seriously and if untreated the infections may be long lasting persisting for up to even 25 years. Some of the clinical manifestations are abdominal distension, pain and discomfort, constipation, diarrhea, nausea, vomiting, weight loss, fatigue, headache, myalgia and dizziness. Sometimes, the *D. latum* infection is mimicking as the subacute appendicitis. Similarly, the parasite is thought to cause changes as immunomodulators developing some structural changes in GI tract modulating some endocrine responses to enhance the gut secretions and motility. The worm also causes the mast cell and eosinophil degradation leading to the release of proinflammatory

cytokines. (Sampaio *et al.* 2005, Scholz *et al.* 2009, Sharma *et al.* 2018, Durrani *et al.* 2021)^[9, 28-30].

Further, in rare cases, gastrointestinal obstruction may also occur. Vitamin B12 and iron deficiencies are very common with the same infection developing megaloblastic and pernicious anemia resulting into the subacute combined degeneration of the spinal cord and cognitive decline. The diagnosis is made by the detection of proglottids and eggs in feces. A different diagnostic tool is also applied in which the gastrografen contrast medium is introduced in the duodenum for the visualization as well as detachment and passing of the whole parasite. The choice of drugs is praziquantel and niclosamide. In addition, patients with prolonged infection must also undergo with vitamin B12 and iron supplements as the worms absorb nearly 80% of dietary B12. (Ohnishi and Murata 1994, Loukas and Hotez 2006, Ko 2008, Jimenez *et al.* 2012, Briani *et al.* 2013, Sharma *et al.* 2018, Durrani *et al.* 2021) ^[9, 30-35].

Echinococcus granulosus (Echinococcosis)

Echinococcus granulosus is a dog tapeworm, hydatid worm or hyper- tapeworm inhabiting in the intestine of canids, the members of dog family and wild carnivores causing echinococcosis in human. This is worldwide in occurrence but mostly found in places where sheep farming are in practice. However, the disease is prevalent in some endemic areas of Argentina, Peru, east Africa, central Asia and China. Similarly, in some areas of Africa, South America and Asia, this is estimated that more than 10% of the certain populations are affected (Mc Manus *et al.* 2003. Eckert and Deplazes 2004, Singh *et al.* 2020) ^[36-38].

There are two main types of echinococcosis named as hydatid disease, hydatidosis or cystic echinococcosis and alveolar echinococcosis caused by the *E. granulosus* and *E. multilocularis* respectively. However, two other less common forms are also found as polycystic and unicystic echinococcosis caused by the *E. vogeli* and *E. oligarthrus* respectively. Further, while dogs, foxes, wolves, Jackals, hyenas and cats have been the definitive hosts of the disease, their intermediate hosts are sheep, goat, cattle, pigs, yak and other farm animals. Humans have always been the accidental intermediate host of the disease. They are infected either by the feces containing eggs or after coming in contact with the contaminated fur of a carnivore especially the pet dogs and other farm animals. (Kemp and Roberts 2001, Canda *et al.* 2003, Torgerson and Heath 2003, Kemp and Tappe 2008, Brunetti *et al.* 2010, John *et al.* 2017, Bonelli *et al.* 2018) ^[39-45].

An adult tapeworm is about 3 to 6 mm in length having scolex and neck with only three typical segments as immature, mature and gravid proglottids. The scolex is laced with four suckers and a rostellum having 25 to 50 hooks. The mature proglottid is full of eggs. Similarly, a hydatid cyst is a condition of a larval cyst that usually occurs as a fluid- filled sac having daughter cysts in which the scolices develop. Further, cystic echinococcosis is generally followed by the dog-ship- dog cycle. Dogs are infected when they consume the offal or organ or variety meat containing cysts. The cysts develop in adults in intestines. They produce eggs that are passed out via feces. The eggs again develop into cysts in some intermediate hosts and the cycle is repeated continuously (Kemp and Roberts 2001, Mc Manus *et al.* 2003, Moro and Shantz 2009) ^[7, 36, 39].

The cysts in general initially do not develop any symptoms and may last for several years. This is harmless in dogs but might be problematic in humans. Similarly, the type of disease that occurs in human depends upon the type of species of *Echinococcus* causing the infection. Also, the clinical symptoms depend upon the location of cysts in the body. Alveolar echinococcosis generally begins with the liver but can spread other parts of the body as well such as lungs, spleen, kidneys, heart and brain. In case of liver infection, the clinical symptoms are abdominal tenderness, pain and discomfort, weight loss, jaundice and sometimes anaphylactic shock. Similarly, the lung infection may develop chest pain, dyspnea and coughing (Bitton *et al.* 1992, Kemp and Roberts 2001, Eckert and Deplazes 2004) [37-39, 46].

In addition, the cysts while in body if macerated either during the course of surgical excision or by trauma, a person is most likely to experience the anaphylactic shock suffering from high fever, pruritus, edema of the lips and eye lids, dyspnea, stridor and rhinorrhea. However, in recent years, new methods like cyst puncture, liquid aspiration, injection of chemicals and then respiration have been developed. Benzimidazole based chemotherapy is a newer option for the same in combination with albendazole and mebendazole medication. Similarly, if the cysts are located in risk position PAIR (puncture- aspiration- injection- respiration) is applied (Bitton *et al.* 1992, Kemp and Roberts 2001, Eckert and Deplazes 2004, Park *et al.* 2009, Brunetti *et al.* 2010) [37,39,44,46,47].

The incubation period of the disease may vary from months to years or even decades depending upon the size and location of the cysts and immunity of the hosts. The diagnosis of echinococcosis requires a combination of different diagnostic tools like histopathology, imaging techniques, nucleic acid detection and serology. Surgical excision of cysts, ultrasonography, CT scan, MRI are done to locate and remove the cysts. Similarly, hemagglutination, ELISA, immunoblots or latex agglutination are also carried out. PCR is also used to identify the parasite with the help of eggs found in feces (Macpherson and Milner 2003, Torgerson and Heath 2003, Eckert and Deplazes 2004, Prathiush *et al.* 2008, Park *et al.* 2009, Brunetti *et al.* 2010, Craig *et al.* 2007, Li *et al.* 2014) [37,41,44,47-51]. The researches are also being carried out in connection with the development of vaccines against the disease echinococcosis (Dang *et al.* 2009) [52].

Hymenolepis nana (Hymenolepiasis)

Hymenolepis nana is a dwarf human intestinal worm especially found in children. This is worldwide in occurrence more common in Europe, America, Russia and Asia. In Asia, this is more prevalent in India. This is 40mm long and 1mm wide hermaphroditic tapeworm. The body is divided into scolex, neck and strobila. The scolex has four suckers and one rostellum armed with a single circle of 20 to 30 hooks. There is a long neck followed by strobila containing proglottids. Each proglottid is relatively wider having a set of both male and female reproductive organs containing 3 testes and a single ovary. These proglottids are full of eggs being discharged through feces. Eggs hatch oncospheres in the duodenum. These oncospheres transformed into cysticercoids in the small intestine of human where they attach and mature giving rise eggs to repeat the cycle again. Humans are the definitive hosts. An insect as beetle have played an intermediate role in the life cycle. And, humans and rodents are infected when they ingest cysticercoids- infected arthropods (Duclos and Richardson 2000, Seung *et al.* 2004, Schauntz 2006, Watwe and Dardi 2008) [6,53-55].

H. nana develops hymenolepiasis in human. Light infections are usually asymptomatic. Heavy infections cause loss of appetite, weakness, intestinal inflammations, abdominal pain, diarrhea, nausea, vomiting, anorexia, toxemia and anal and nasal pruritus. In children, it causes headache, irritability, enteritis, anal itching, itchy buttocks and difficult sleeping. Very rarely, epileptic seizures may occur. Stool examination for eggs and proglottids confirm the diagnosis. (Schantz 2006, Chero *et al.* 2007)^[6,56].

As the transmission is by fecal- oral route, good hygiene and proper sanitation can prevent spread of the disease. The prescribed drug of choice is a single dose of praziquantel of 25mg/kg is very effective. Within 10 to 30 minutes of administration almost all *H. nana* become paralyzed and completely dislodged from the caecum. The same drug is also effective for other similar species *Hymenolepis* like *H. diminuta* and *H. microstoma* as well. Other drugs like nitazoxanide and albendazole are also being used up by the physicians as the alternative medicines for the same purposes (Chitchang *et al.* 1985, Romero *et al.* 1997, Ortiz *et al.* 2002, Chero *et al.* 2007, Chai 2013)^[56-60].

CONCLUSION

As most of the tapeworms are either food borne transmitted as pork, the *Taenia solium*; fishes, the *Diphyllbothrium latum*; sheep, the *Echinococcus granulosus* or soil transmitted, the *Hymenolepis nana*; proper cooking, fresh water, good hygiene and sanitations are always required. Further, if these infections are left untreated certain lethal complications may occur as neurocysticercosis, gastrointestinal obstruction, hydatid cysts anaphylactic shock and toxemia may occur. The tapeworm like *Taenia solium* affects muscle as cysticercosis, brain as neurocysticercosis and other tissues of the human body. While cysticercosis causes lumps under the skin, neurocysticercosis spreads into the brain and spinal cord developing severe headache and seizures. This is one of the causes of acquired epilepsy. This is spread either via contaminated food or water with undercooked pork meat. The most preferred drugs for the treatment of tapeworm infections are albendazole and mebendazole. However, other drugs like praziquantel, niclosamide and nitazoxanide have also been tried by the physicians under certain circumstances.

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