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An overview on human helminthic parasitology I. Nematodes, the roundworms

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Abstract

This is perhaps one of the wonders of science that currently we have certain effective anthelmintics to cure more than 300 types of parasitic worm infections found in the human body. Therefore, we have never paid the due attention in some lethal consequences caused by them. The present paper is first in the series of human helminthic parasitology and an attempt to discuss certain roundworms causing various ailments and diseases in human in the light of recent researches done so far in the same field.

Keywords: Parasitology, Helminths, Nematodes, Roundworms, Diseases in human.

INTRODUCTION

Human helminthic parasitology is the study of parasitic worms parasitizing in human. They have mainly been categorized as nematodes, cestodes and trematodes. These helminths are distributed worldwide especially pervaded in sub-Saharan Africa, Central and South America, Middle East, the Caribbean and most of the Asian countries. And, they are continuously being spread unhygienically in the society. Further, as the human intestines are the good reservoir of these parasitic worms, they are attached in the intestinal mucosa absorbing the digested foods with the help of especially designed oral sucking organs comprising of lips, teeth and hooks [1-4]. Nematodes, the roundworms are further classified as either pinworms, hookworms or whipworms. Some of the medically important roundworms found in humans are *Ascaris lumbricoides*, an intestinal worm causing ascariasis; *Wuchereria bancrofti* (causing lymphatic filariasis); *Ancylostoma duadenale*, an intestinal hookworm causing ancylostomiasis; *Necator americanus*, an intestinal hookworm causing gastrointestinal disorder; *Strongyloides stercoralis*, an intestinal thread or pinworm causing strongyloidiasis; *Enterobius vermicularis*, a gastrointestinal thread, pin or seatworm causing enterobiasis; *Trichuris trichuria*, an intestinal whipworm causing trichuriasis and Trichinella spiralis and intestinal porkworm causing trichinellosis [5-12]. These above-mentioned roundworms are important as they cause various ailments, diseases and malignancies in human. Therefore, they are being discussed in the same review in the light of recent researches done so far in the same field of helminthology.

DISCUSSION

Several types of helminths are found in nature such as roundworms, flatworms and flukes and the tapeworms. The worms are characterized as natural parasite eventually united to form a kind of parasitism in human. They harm us in some way or other living in different organs of the body, however, then most preferred places are intestine, urinary tract and bladder, liver, lymph, blood and brains developing various ailments and diseases like bowel obstruction, Jaundice and malignancies in human [9, 12-21].

Roundworms cause a variety of diseases and malignancies in human. Some of them are discussed in the light of recent researches done so far in the field of helminthic parasitology.

Ascaris lumbricoides (Ascariasis)

Ascaris lumbricoides causes ascariasis in human. This is widespread in developing countries devoid of good hygiene and sanitation. Ascariasis is a most common roundworm infestation in children. This is soil transmitted small intestinal infection in human. Sometimes, the worms are visible in stool. While females

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are larger than males, they are usually 15 to 35 cm long [3, 14, 22].

A female worm produces 2 lac eggs per day. These eggs are easily passed with human feces. When these infective eggs are swallowed they penetrate the intestinal wall to reach the lung via blood circulation where hatching took place to form larvae. The larvae mature further in lungs. A patient when coughs up the larvae expelled out and reswallowed in the intestine. Upon reaching in the intestine, they develop into adult worms. The entire cycle is completed within 2-3 years [7, 13, 23, 24].

An adult worm can live in the human intestine for a couple of years. Many people do not experience them until their numbers are large. Severe infection may cause abdominal discomfort, loss of apetite, nausea and vomiting, shortness of breath, diarrhoea, gaggy cough and bloody muscus, wheezing and fever. Further, the condition, if left untreated certain complications may occur as bowel obstruction, pancreatitis, biliary and gall bladder ascariasis. Rarely, it may cause aspiration pneumonia causing chest discomfort. Mebendazole and albendazole are the first choice of drugs used by the physicians to expell out the worms from the human body [2, 4, 25-28]. Sometimes, piperazine has also been used to paralyse the muscles of *Ascaris* [29].

***Wuchereria bancrofti* (Filariasis)**

Wuchereria bancrofti is a major cause of filariasis or elephantiasis in human. This is a kind of disease having nocturnal periodicity of lymphatic system developing inguinal or axillary lymphadenopathy in human. Two other worms named as *Brugia malayi* and *B. timori* also cause the same disease. However, the *W. bancrofti* is responsible for 90% of all lymphatic filariasis [17, 30-32].

The disease is transmitted by a variety of infectious mosquitoes. While in Africa and America, this is transmitted by *Anopheles* and *Culex* respectively, in Pacific and in Asia, this is transmitted by *Aedes* and *Mansonia* mosquitoes. Further, humans are the only known natural definitive host of the disease appearing the infected mosquitoes have a preference for human blood. In India, *Wuchereria bancrofti* is mainly responsible for the lymphatic filariasis in human. However, very rarely *Brugia malayi* is also found to cause the same disease. According to an estimate more than 31 million people are harbouring microfilariae in India [16, 32, 33].

The sign and symptoms of the disease are fever, skin exfoliation, testicular or inguinal pain, elephantiasis of legs, swelling in arms, scrotum, vulva and mammary glands. The mosquito bite enters the juvenile larvae in the human blood. These juveniles are transformed in adults after reaching the nearest possible lymph nodes. Adults attaining the sexual maturity after mating release thousands of sheathed microfilariae in the human blood. The cycle is repeated when mosquitoes bite the infected human host. The disease if left untreated it causes chronic lymphatic filariasis with tropical eosinophilia, an asthmatic disease [17, 30, 31, 33, 34].

Currently, the disease is diagnosed by an ELISA and PCR test. Active infection is also identified by the microscopic examination of blood smear. Similarly, a rapid method for the isolation of viable microfilariae has already been developed [10, 35-37]. Ultrasonography is done to detect the noise caused by the movement of adult worms. Similarly, the dead worms can also be detected by X ray techniques.

The drugs of choice for physicians are diethylcarbamazine, albendazole and ivermectin. Polytherapy with either of the two drugs mentioned above has been found more effective than any of the drugs alone. In 2015, William Campbell and Omura Satoshi got Nobel prize for physiology or medicine for the discovery of the same drug ivermectin. It has really played a significant role in decreasing the incidence of filariasis in human worldwide [34, 38-44].

Further, *Mansonella streptocerca* is an arthropod borne filarial worm causing streptocerciasis in human in the rain forest of africa. It Causes subcutaneous filariasis in human. Similarly, the other two filarial worms are *Loa loa* and *Onchocerca volvulus* developing the African eye worm and river blindness diseases respectively. The use of diethylcarbamazine (DEC) is found effective against the microfilarial and adult stage *M. Streptocerca* [32, 45-48].

***Ancylostoma duadenale* (Ancylostomiasis)**

Ancylostoma duadenale is found in Mediterranean region, southeast Asia and southern America [49, 50]. This is an intestinal dog and cat soil transmitted hookworm developing a disease “ancylostoma” in human. *A. duadenale* has been a most common zoonotic disease in human classifying as one of the most neglected tropical diseases of the world. The disease is also popularly known as the tunnel disease miner’s anemia, brickmans anemia, Egyptian chlorosis and old-world hookworms [51].

The disease is generally caused by the infective larvae found in soil where dogs and cats freely defecate. The penetrative larvae enter in human via the exposed skin as barefoot. In most of the times they cause only “cutaneous larva migrans” and the hookworms do not reach the adulthood. This is characterized by the itching, erythematous, serpiginous, snake like marking under the skin formed. But in other cases, if the larvae enter in blood circulation, they are carried to the lungs. When a patient coughs up the larvae swallowed back in the intestine where they mature and mate freely. They are dioecious and a female can lay 10000 to 30000 eggs per day in feces. These eggs are transferred into the infective third stage larvae within 5 to 10 days [18, 52-54].

Further, ancylostomiasis causes gastrointestinal bleeding. Chronic heavy intestinal infection may also cause iron deficiency and anemia, pallor, dyspnea, weakness, tachycardia, lassitude and peripheral edema. Sometimes, it may also cause Loffler syndrome with cough, wheezing, eosinophilia, hemoptysis, colic epigastric pain, flatulence, diarrhea and weight loss. The most preferable drug is mebendazole which is very effective requiring only a single dose to remove the worms [8, 19].

Similarly, the other hookworm named as *Necator americanus*, popularly known as the “new world hookworms” is also an intestinal hookworm casuing a zoonotic disease in human necatoriasis whose *modus operendi* of infection is more or less similar to that of *Ancylostoma duadenale* [5].

***Strongyloides stercoralis* (Strongyloidiasis)**

Strongyloides stercoralis is a zoonotic human intestinal pin-threadworm causing strongyloidiasis in human. This is usually found in mammals like dogs and cats. The infection is most common in places where contamination of feces are found in water and soil. The infected larvae enters in the human body when a person came in contact with the infected soil. These larvae then first reach the lungs via blood and when coughed up are swallowed back to the intestine. After molting twice they mature into an adult female worms. It has also been observed that only female worms reach the reproductive adulthood in intestine and the eggs are produced parthenogenetically [11, 55-58].

The usual sign and symptoms of the disease are at the site of penetrance the local etching with red colored rashes developed. The other symptoms are the tracheal irritation with dry cough, constipation, abdominal pain and anorexia. Rarely, in chronic infections, the patients may show arthritis, arrhythmia, duodenal obstruction, nephritic, syndrome and recurrent asthma [59, 60].

Life threatening complications as hyperinfection syndrome and disseminated infection may occur in case of immunocompromised host and the *Strongyloides* infection. In hyperinfection syndrome the

extensive larvae proliferation may lead to systemic sepsis, respiratory and multiple organ failure. As the clinical symptoms of hyperinfection is similar to that of classical strongyloidiasis in most of the cases this is diagnosed very late [21, 61, 62].

Further, the autoinfections are also observed in strongyloidiasis. This is derived that the infections are remained in the human body for quite an indefinite period of time if not treated timely. Similarly, an immunocompromised patient, if infected develops hyperinfective syndrome also called as disseminated strongyloidiasis. This is quite lethal and has got a mortality rate close to 90%. The patients receiving high dose of corticosteroids lead to accelerated autoinfection and migratory larvae invading various organs of the body. Hives are seen due to repeated autoinfections on thighs and buttocks. The rashes are usually advanced very rapidly within hours as 10 cm per hour. A distinctive variant of cutaneous larva migrans due to *Strongyloides stercoralis* has already been reported. Sometimes, peritoneal ascites with swollen belly syndrome due to malnutrition are also observed in infants and children. Gastric and colorectal adenocarcinoma cancer associated with chronic *Strongyloides stercoralis* colitis has already been reported [21, 61, 63-65].

Stool samples are observed for the detection of parasite in direct fecal smears and culture agar plates. Serodiagnosis through ELISA is also conducted. Currently, ivermectin is a first choice of drug for physicians in strongyloidiasis [67-73].

***Enterobius vermicularis* (Enterobiasis)**

Enterobius vermicularis is a common parasitic pinworm nematode found in human intestine. This is also called as thread or seatworm. It causes enterobiasis or pinworm infection as oxyuriasis in human. This is worldwide in occurrence especially in children. The eggs initially occur around the anus. As the anal itching is actively involved in the disease progression, thumb sucking and nail biting in children have played the key roles in transmission of the disease. The unbearable nocturnal seatworm anal etching is found due to the migration of females laying eggs in and around the anus. This is quite irritating in children making their nights sleepless [74-77].

The entire cycle of infection and disease development is completed within 4 to 8 weeks. The disease transmission is by eggs. The eggs hatch larvae in the duodenum. These larvae grow rapidly and migrated towards the small intestine and colon. During the course of migration they mate in the ileum and after moulting twice transform into adults. The male worms usually die after mating and are released with stool. The gravid females are then attached to ileum, caecum, appendix and the ascending colon. A gravid female with full of eggs migrated to the anus through rectum where the eggs are deposited. After depositing the eggs female also dies [12, 78, 79].

Despite itching around the anus other clinical symptoms are the disturbed sleep, restlessness, irritability, loss of appetite, abdominal pain, diarrhoea, emotional instability and bed wetting. *E. vermicularis* infestation masquerading as cervical carcinoma. Sometimes, chronic infections if not treated well within time, it may cause vulvar and vaginal inflammations and urinogenital infections as the pathogens may migrate to the uterine cavity, fallopian tubes, peritoneal cavity and the surface of appendix carrying sufficient load of bacterial and other infections. The young girls with UTI and prolonged irritative voiding symptoms of bladder infestation have also been found with the pinworm infection. Similarly, a pelvic mass was also observed due to the infestation of the fellowpian tube with the *E. vermicularis* [74, 76, 77, 80-89].

Diagnosis is mainly based on the detection of eggs or light yellow thread like adult pinworms. The adhesive tape applied around the anal area may also detect the eggs. The drugs of choice for the elimination of pinworms are benzimidazole, albendazole and mebendazole. The drugs work on inhibiting the microtubules causing glycogen depletion making the parasite starved. However, the other drug like pyrantel pamoate kills the adult worms by developing neuromuscular blockage is also being usedup as a second line medication. Similarly, the drugs used as piparazine and parvinium pamoate causing paralysis and oxygen deprivation in pinworms respectively are in practice by the physicians as the circumstantial alternative medicines. Since, all these drugs as mentioned above are only effective on adult worms, the long term medications are required in a repeated intervals to obtain the better results [20, 81, 90-92].

***Trichuris trichiura* (Trichuriasis)**

Trichuris trichiura or *Trichocephalus trichiuris* is a third most common nematode infecting human. This is a large intestinal parasite whipworm causing trichuriasis or trichocephaliasis in human. This is whiplike posteriorly. Humans are the main reservoir of this parasite. The eggs of *T. trichiura* are released in soil via the human feces. And, where untreated human feces is used as fertilizer, there vegetables, foods and drinks are contaminated enormously. The children playing in such a soil are also infected very easily. The ingested eggs hatch larvae inside the small intestine. The fully formed dioecious worms are inhabited in the human colon. The average total life span of *T. trichiura* is about a year [9, 93].

Further, most of the individuals are asymptomatic however, heavy infections may develop the clinical symptoms as abdominal pain, nocturnal loose motions, diarrhoea, bleeding in stool, loss of appetite, weight loss following rectal prolapse and anemia. Trichuria dysentery syndrome (TDS) in children are also noted with mucoid diarrhoea, rectal bleeding and rectal prolapse [94, 95].

Stool test reveals the presence of typical whipworm eggs. Kato-Katz thick smear technique is specifically used to detect the eggs. Colonoscopy is also found useful to detect the adult worms. The high clearance rate is achieved with the use of mebendazole, albendazole, or ivermectin [96-98].

***Trichinella spiralis* (Trichinosis)**

Trichinella spiralis or *Trichinia spiralis* is a popular pork worm nematode parasite causing a disease known as trichinosis in human. This is generally caused by the domestic pigs in several countries of eastern Europe and Asia. This is quite a different organism and must not be baffled with the *Taenia solium*. This is the smallest nematode distributed globally parasitizing in human, yet the largest of all intracellular parasites. A pig becomes infected when it eats infectious raw meat containing cysts. After being eaten, the cysts are released in stomach of a pig with the help of protein digesting enzymes like pepsin and HCl. Then, they migrated to the small intestine where they develop into the adult worms. Females are quite larger than males, just double in size. They copulated to produce the new larvae which are then migrated to the striated muscles to form the cysts again. As this is not a soil transmitting disease, the parasite does not lay eggs and even an adult cannot survive long outside of the body [15, 99-103].

Humans become infected by *T. spiralis* when they ate undercooked raw pork meat containing cysts. In stomach, the cysts are released after the digestion of meat with the help of pepsin and HCl. The larvae then migrated to the small intestinal burrow where they mature and mate to reproduce the new larvae. These larvae entered in lymphatic vessels and blood stream to scatter in various organs of the body like myocardium, lymph nodes, retina, kidney and the skeletal muscles. But, it has been observed that only the larvae migrated to the skeletal muscles survive and encyst to form nurse cells [6, 99, 101, 104].

The sign of initial infection appears within 12 hours after ingestion of infected pork meat in the form of nausea, vomiting, abdominal pain and diarrhea. They after 5 to 7 days, if not treated well within time facial edema with puffiness of the eyes especially inflammation in whites of the eyes, fever, splinter hemorrhage and rashes may occur.

In total, after 10 days following ingestion other symptoms also occur as intense muscular swelling and pain, myalgia, asthenia, lung inflammation with difficult breating, pneumonia, drowning of pulse and blood pressure, myocardial, nervous and kidney disorders due to the migration of larvae in organs concerned. In a very rare case meningitis and encephalitis may also occur [105-108].

Trichinosis is often diagnosed in humans where the larvae of the same parasite once invaded the muscle tissue. Muscle biopsy is usually carried on detect the cysts. Meat testing is also done for the same purposes. However, an immuno test like ELISA is also available. The patients are usually treated with mebendazole, albendazole, orthiabandazole. Currently, no vaccines are available for trichinosis [104, 109-112].

PREVENTION AND CONTROL

Helminthiasis is a worm infection. Soil transmitted helminths are essentially an intestinal worms transmitted usually through eggs. They are the most important groups of infections agents causing serious global health problems. Prevention of infection can largely be achieved by applying good hygiene, fresh water and proper sanitation. There should be no open defecation and the excreta must never be recycled as fertilizer. Similarly, the other preventive measures include the practice of wearing shoes and deworming of pets with proper disposal of their feces should be acquired amongst us. Scientists are also trying to develop vaccines against helminths [113- 115].

Further, mass deworming or preventive chemotherapy is also done for school children. This is usually being carried out by administering mebendazole or albendazole. It has always been cheaper, popular and widely accepted programme in the society [116-118].

CONCLUSION

Helminthology is the study of worms. They are distributed wroldwide in humans and animals. They are zoologically classified into nematodes, trematodes and cystodes commonly called as roundworms, flatworms or flukes and tapeworms respectively. These helminths are eukaryotic macroparasites laced with specific attachment organs with suckers and teeth. They absorb the food and excreted some toxic substances in the human body. Since most of these worm infections are asymptomatic living with the harmony of host individuals causing no apparent harm, it becomes very difficult to diagnose and treat them within time, until and unless they are in large numbers to cause diseases like bowl obstruction, Jaundice and malignancies in human.As most of the nematode infections are soil transmitted through eggs; fresh water, good hygiene and sanitations are required to keep us away from a variety of roundworm infections such as *Ascaris lumbricoides, Ancylostoma duadenale, Necator americanus Strongyloides stercoralis, Enterobius vermicularis, Trichuris trichiura* and *Trichinella spiralis.* Further, if these infections are left untreated certain lethal complications may occur as bowel obstruction, pancreatitis, biliary and gall bladder ascariasis, tropical eosinophilia, Loffler hyperinfection and autoinfection syndrome, ectopic enterobiasis, gastrointestinal and rectal bleeding, cutaneous larva migrans, muscular disorder and organ failure. Lastly, the physicians first choice of drugs to treat the roundworm infections are either mebendazole or albendazole. However, some other drugs like ivermectin, benzinidazole, orthiabandazole have also been used in some specific infections. Diethylcarbamazine is used for lymphatic filariasis.

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