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Emerging and Neglected Zoonotic Parasites: A Review of Toxoplasma, Leishmania, Echinococcus, and Cryptosporidium

Qamar Abbas*, Abdur Rasheed, Malik Ahmad Raza Sohail, Aroosa Khalid and Chiragh Ali

Department Of Medical Laboratory Technology, The University of Chenab, Gujrat, Pakistan

*Corresponding Author: qamar17005@gmail.com

ABSTRACT

Zoonotic parasitic infection remains a major global public health challenge, posing a major public health burden worldwide. Zoonotic parasites are species capable of infecting humans with severe clinical manifestations and, in some cases high mortality rates. Various animals serve as natural reservoirs for a wide range of parasitic pathogens. Factors such as Urbanization, poor sanitation and hygiene, and close contact between reservoir hosts, intermediate hosts and humans significantly contribute to the transmission of zoonotic parasitic infections between animals and humans. This review article aims to provide a comprehensive overview of the transmission, life cycle, pathogenesis, and diagnostic approaches of clinically important zoonotic parasites including *Toxoplasma gondii, Echinococcus granulosus, Leishmania donovani* and *Cryptosporidium parvum*, with particular emphasis on their global disease burden, clinical severity and high prevalence.

Keywords: Zoonotic parasites, Toxoplasma, Leishmania, Echinococcus, Cryptosporidium

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Introduction

Zoonotic parasites are categorized into four major groups such as,

Direct zoonotic: infects humans directly from animals such as cryptosporidium parvum.

Meta-zoonotic: infects humans from intermediate invertebrate hosts.

Cyclo-zoonotic: these parasites have vertebrate hosts.

Sapro-zoonotic: infects humans via contaminated soil or water [1].

Diseases such as TB, HIV, malaria and influenza attract more attention whereas infections like parasitic zoonoses are largely neglected in public health policies as well as in literature. Immunocompromised individuals and children are at high risk of developing severe parasitic infections, which are often associated with malnutrition, diarrhea and high mortality rate [2]. The transmission patterns, life cycle and clinical features vary significantly for each parasite, based on complex life cycles, global burden of disease and highly prevalent zoonotic parasitic disease include toxoplasmosis, echinococcosis, visceral leishmaniasis, and cryptosporidiosis.

Toxoplasma gondii

Toxoplasma gondii is a protozoan parasite responsible for toxoplasmosis, found in 30% of population worldwide and is capable of infecting all endotherms [3]. T.gondii develops a persistent infection by manipulating the host immune system through alteration in gene transcription and dysregulation of host signaling pathways. These mechanisms leads to modulation of cell adhesive activity, release of cytokines, microbicidal molecules production and induction of apoptosis [4].

Life cycle

The definitive hosts of T.gondii are feline species, in which the sexual stages of parasite occurs, whereas aquatic and terrestrial mammals, as well as birds act as intermediate hosts which facilitate the asexual stages. Tachyzoites, bradyzoites and sporozoites are the three infective stages of T.gondii [5]. Definitive hosts (cats) shed the oocyst in their feces, intermediate hosts can be infected via ingestion of contaminated water, fruits and vegetables with viable oocyst. Intake of undercooked meat of intermediate hosts and consumption of contaminated fruits or vegetables cause infection transmission to humans. Toxoplasmosis can spread between individuals via blood transfusion, organ transplantation and vertical transmission from mother to offspring. T.gondii chronic infection can affect several organs including brain and heart. Major neurovirulent outcomes of T.gondii infections are toxoplasmic encephalitis (TE) and ocular toxoplasmosis (OT), congenital toxoplasmosis leads to fetal loss and neonatal death, chorioretinitis and intracranial calcification [5,6,7].

Diagnosis

For diagnosis of T.gondii following laboratory methods are used

- Bioassay
- Serological assays (DT, MAT, ELISA, ISAGA, IFAT, IHA, LAT)
- Imaging techniques (CT, MRT, ultrasonography)
- Molecular methods (conventional PCR, RT-PCR, LAMP) [8].

Echinococcus granulosus

Echinococcus granulosus is a zoonotic tapeworm parasite and is responsible for cystic echinococcosis (CE) or hydatid cyst disease in humans. E.granulosus is characterized by the formation of hydatid cysts within the liver, brain, lungs and other vital organs. People with hydatid cysts disease may have clinical symptoms like abdominal pain, vomiting and nausea, if the cyst develops within the liver. Symptoms such as chest pain, hypoxia and cough, if cysts is in lungs, whereas cerebral involvement can lead to headache, vision problems and seizures [9,10]. Cystic echinococcosis can pose a serious threat to human health depending on the cyst's location and may result in severe morbidity and fatality.

Life cycle

The definitive host of E.granulosus are the dogs and other canids, intermediate hosts for this parasite are the cattle, sheep and goats. From the definitive hosts eggs enters the environment via their feces and intermediate hosts are infected through ingestion of the eggs and within their body the eggs hatch and develops into larval hydatid cysts in various organs [11]. Humans are accidental intermediate hosts, infected via ingestion of eggs, the sheep strain of E.granulosus is the most important human pathogen and when humans are infected cystic echinococcosis (CE) develops mainly in the liver and lungs. Humans can also be infected through direct close contact with definitive hosts or through consumption of contaminated vegetables, fruits and water [12].

Diagnosis

For the diagnostic purposes of cystic echinococcosis, ultrasound, computed tomography (CT), MRI and serological tests such as IgG and IgM ELISA are used [13].

Leishmania donovani

Leishmania donovani is an intracellular protozoan parasite responsible for visceral leishmaniasis (VL). It is one of the major causes of morbidity and mortality worldwide, approximately 1 million cases occur with an estimated 30000 deaths yearly [14]. Leishmaniasis is listed in Category-1 as an emerging or uncontrolled disease by the WHO. Sand flies (Phlebotomus argentipes) transmit the VL, in Anthroponotic VL parasites are transmitted to human through bites of sand flies, while the Zoonotic VL transmits to human from infected animals [15]. After the bite of sand fly the flagellated, unicellular and motile promastigote (infective) form of parasite infects the humans, within the blood circulation the parasite transforms into a non-flagellated, non-motile amastigote form and multiplies after invading the macrophages. The amastigote form divides and multiplies by binary fission within macrophages continuously till it fill the cells, which finally ruptures the cell and parasite releases and infects other macrophages [16]. Fever, dysentery, splenomegaly, hepatomegaly and asthenia are the clinical manifestation of VL.

Life cycle

The infective form of parasite (promastigote) is transmitted to humans during blood meal, in human body the promastigotes are phagocytosed by macrophages and changes into the amastigote form. This form of L. donovani enters the circulation and invades the macrophages and starts division by binary fission, multiplies rapidly and infects the other cells of reticuloendothelial system. Parasites reaches to different viceras (reticuloendothelial organs), where they cause infection. When a sandfly bites an infected individual, macrophages containing promastigote form is taken up during blood meal and within the gut of sandfly, the amastigote form changes into promastigote form, multiply and migrates to the proboscis [17,18].

Diagnosis

Diagnostic approaches of *L. donovani* includes:

- Examination of stained blood films
- Culture of peripheral blood
- Biopsy examination
- Examination of skin scrapings
- MALDI-TOF MS
- RT-PCR
- Leishmania skin test
- ELISA
- Dipstick test [19].

Cryptosporidium parvum

Cryptosporidium parvum is an intracellular parasite that is a major cause of fatality in children under 2 years of age due to diarrhoea and malnutrition in developing countries. This zoonotic parasite primarily infects the epithelial cells of the intestine, leading to villous blunting, microbial dysbiosis, and hyperplasia like abnormalities, these changes results in diarrhea, stunted growth, and nutritional deficiencies in children [20].

After infection, C. parvum invades and inhabits the surface epithelial cells but does not penetrate into the deeper layers of epithelial tissue. In immunocompromised persons, the infection may spread to epithelial cells of the pancreatic duct, stomach, biliary tract, esophagus, and respiratory tract. This can result in bile duct obstruction, diarrhea, dehydration, pancreatitis, and jaundice [21].

Life Cycle

Cryptosporidium parvum is responsible for cryptosporidiosis, a waterborne disease, this parasite undergoes a complex life cycle including both sexual and asexual stages within a single host.

The life cycle begins with the ingestion of oocysts through contaminaed water and food, within the small intestine excystation occurs and release sporozoites, which invade epithelial cells and attach to enterocytes, these sporozoites undergo mitotic division and differentiate into trophozoites.

The trophozoites further undergoes merogony and produce Type I meronts containing 6–8 merozoites, these merozoites infect other epithelial cells, while some develop into Type II meronts that produce 4 merozoites and initiate the sexual phase.

During the sexual phase, merozoites differentiate into either, Microgamonts (male) or

Macrogamonts (female), after fertilization diploid zygote is form, which further develops into two types of oocysts. Oocysts (thick-walled) are excreted in faeces and are responsible for transmission while thin-walled oocysts, remain inside the host and cause autoinfection.

Transmission mainly occurs through contaminated water and food [22,23].

Diagnosis

Laboratory diagnosis of cryptosporidiosis includes:

- Microscopic examination (Direct wet mount)
- Immunological and serological tests
- ELISA
- Rapid immunochromatographic tests
- PCR
- Histopathology [24].

Conclusion

Zoonotic parasites are species capable of transmitting infections from animals to humans. Infections caused by zoonotic parasitic pathogens including toxoplasmosis, leishmaniasis, cryptosporidiosis, and cystic echinococcosis are often associated with severe clinical manifestations and, in some cases, death. Despite their siginificant global disease impact, the zoonotic parasitic infections are highly neglected in public health policies and scientific literature worldwide, there is a need to give more attention towards these infections to minimise the global disease burden.

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