2 Etiology of Parasitic Diseases

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2.1 Definition of Parasite and Host

The pathogen of parasitic disease is a type of organisms that live by parasitizing to its host. Parasitism refers to the condition that two different natural organisms live together to form certain interrelationship. One is parasite and the other is host. The parasite, an organism that temporarily or permanently lives in or on the surface of the host. Via parasitizing, the parasite is supplied by the host and impairs the host. Therefore, the parasite usually benefits from its interrelationship with the host. However, the host does not benefit from the interrelationship but only provides nutrients and a living space for the parasite. Parasite is a pathogenic organism threatening the health of both human and animals, including virus, rickettsia, bacteria, fungi, protozoa, worm, and arthropod. Parasite refers to the animal parasites including single-cell protozoa and multicellular invertebrates that lead a parasitic life.

2.2 Classification of Parasite and Host

2.2.1 Parasite

According to duration and adaptability of the parasite-host relationship as well as specific ecological environment, parasite shows great diversity and can be categorized into the following groups.

2.2.1.1 Obligatory Parasite

The entire life circle behaves as parasite such as trichina and tapeworm. The eggs or larva of some worms may live independently, but during their infective stage, they live within the host to guarantee the development from larva into adult, such as roundworm and hookworm.

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2.2.1.2 Facultative Parasite

During larva and adult stages, a parasite can not only live its life circle independently, but also can live in the host, such as strongyloides stercoralis.

2.2.1.3 Accidental Parasite

A parasite, during its infective stage of life circle, accidentally gains its access into an organism other than its common host. For instance, fly maggot may gain its access into human organ, cavity or lumen.

2.2.1.4 Opportunistic Parasite

Some parasites show no obvious pathogenicity and their host are commonly asymptomatic. However, when the immunity of the host is compromised, such as patients with AIDS and patients receiving long-term treatment by hormone or anti-neoplastic drugs, the parasite may multiply abnormally with increased pathogenicity, causing obvious clinical symptoms and signs. In severe cases, it may lead to death. Such parasites include toxoplasma and cryptosporidium.

2.2.1.5 Ectoparasite

A parasite, such as louse, that lives permanently on the surface of its host is known as ectoparasite. Such parasite also includes mosquito, bedbug and ticks that only temporarily suck blood on the surface of their host and then leave when they are full. Ectoparasite is also referred to as temporary parasite.

2.2.1.6 Endoparasite

A parasite, such as trichomonas vaginalis, schistosome and malaria parasite, that lives in the intestinal tract, organs, tissues, blood and cells of the host is known as endoparasite.

2.2.2 Host

2.2.2.1 Definitive Host

The host that is parasitized by a parasite at its adult stage or sexual reproduction stage is known as definitive host. For

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instances, human is the definitive host of paragonimus westermani.

2.2.2.2 Intermediate Host

The host that is parasitized by a parasite during its larval stage or asexual reproduction stage is known as intermediate host. In the cases of at least two intermediate hosts, they can be classified as the first or second intermediate host according to the sequence of being parasitized. For instance, paragonimiasis is the first intermediate host of Paragonimus westermani, while stone crab is its second intermediate host.

2.2.2.3 Reservoir Host

Some animals can act as host for parasites that finally live within human body during its parasitic stage. For instance, dog and cat can be host for adult paragonimus westermani that may finally parasitize human. According to epidemiological study of parasitic disease, these animals are known as reservoir host of paragonimus westermani that parasitize humans.

2.2.2.4 Paratenic Host/Transport Host

When larva of a parasite gains its access into the body of its unusual host, it fails to develop into adult parasite but keeps its larva state for a long period of time. However, when the larva gains another opportunity into its usual definitive host, it can further develop into adult. During such a process, the unusual host is known as paratenic host/transport host. Wild boar, chicken and duck may act as paratenic host/transport host of paragonimus westermani.

2.2.3 Life Cycle of Parasite

The life cycle of parasite refers to the entire course of growth, development and reproduction of one generation. It includes access route of parasite into the host during its infective stage, migration of the parasite to the usual parasitic site in the host, way of leaving the host as well as host species and environmental conditions necessary for its development.

2.2.3.1 Route of Parasitic Infection

Parasite must develop into its infective stage before its invasion into human or other vertebrates as its host. Only in such a way, the parasite can continue its survival, development and reproduction in its host. Different parasites have varied infective stage and their routes of access into host are also diverse. The common routes of access include the following:

Infection via Mouth

Parasite in its infective stage can gain its access into human body via mouth along with food, water, contaminated fingers or other utensils, which is the most common route of infection. For instances, by intake of infective eggs, intake of undercooked freshwater fish with metacercaria of clonorchis sinensis and intake of pork with cysticercus can cause parasitism by roundworm, enterobius vermicularis, liver fluke, taenia solium and toxoplasma.

Infection via Skin

Contacts to soil contaminated by filariform larva of hookworm or water contaminated by schistosoma japonicum cercariae may cause their direct and active access to human via skin.

Infection via Skin by Vector Insect

Parasite develops into its infective stage in vector insects. When the insect bites, stings or sucks blood on the skin, the parasite gains its access into the body of host via skin. For instance, sporozoites of malaria parasite and filariform larva can gain their access into human body via skin when mosquitoes carrying such parasites bite.

Contact Infection

In its infective stage, parasite in oral cavity, vagina or body surface of human body can infect other person via direct or indirect contact, such as entamoeba gingivalis, trichomonas vaginalis and sarcoptes mites.

Inhalational Infection

The infective eggs of enterobius vermicularis in dust can be inhaled and then swallowed to cause parasitism.

Infection via Blood Transfusion

Human malaria parasite in its intraerythrocytic asexual form can cause parasitism via blood transfusion.

Retrograde Infection

Enterobius vermicularis lay eggs around the anus of the host where larva may develop within several hours. Subsequently, larva may gain its access into the intestinal tract and further develop into adult.

2.2.3.2 Parasitic Site of Parasite

After parasite gains its access into its host, in some cases, it directly arrives to its parasitic site. For instances, the infective eggs of enterobius vermicularis with larva and cysticercus of taenia solium may directly develop into adult in the intestinal tract of the host and then parasitize the host there after being swallowed. However, in some other cases, the parasites may follow certain procedures to migrate in the host before reaching its usual parasitic site. For instance, larvae of roundworm and hookworm migrate from one organ to another in the host before reaching their usual parasitic site. The parasitic sites in human body can be roughly categorized into intravascular, intralymphatic, within blood or body fluid, intracellular, within tissues, respiratory tract, gastrointestinal tract and within other organs. Some parasites are rather exclusive in terms of parasitic site in the host, while others can live in multiple organs and tissues. Certain parasitic site that different parasites need in the host is the result of long-term inter-adaptation between parasite and its host after an evolving process.

2.2.3.3 Reproductive Pattern of Parasite

When parasite reaches its parasitic site and continues its development into its mature stage, it begins to reproduce its offsprings. Different species of parasites show varied reproductive patterns.

Asexual Reproduction

Asexual reproduction is a common reproductive pattern of parasite protozoa, including binary division such as amoeba trophozoite and leishmanial; multiple fission such as schizogony of plasmodium; gemmation such as endodygony by trophozoites of toxoplasma gondii. Polyembryony often occurs in some worms in their larva stage. That is to say, asexual reproduction, also known as larva reproduction, is a reproductive pattern of parasite in its larva stage.

Sexual Reproduction

Sexual reproduction is a common reproductive pattern of worm, with a female adult worm and a male adult worm to mate and the female adult worm to lay eggs or deliver larva. Most of the eggs or larvae develop into their mature stage in an external environment such as soil or intermediate host before they gain access into the host to develop into adult.

Alternation Generation

Some parasites have to experience both asexual and sexual reproductive pattern to complete a full life circle of one generation. That is to say, an asexually reproduced generation alternates with a sexually reproduced generation, which is known as alternation generation, such as plasmodium, toxoplasma gondii and fluke.

2.2.4 Nutrition and Metabolism of Parasite

Parasites live most/all of their life circle in the physiochemical environment of their host. Therefore, nutrition and metabolism of parasites depend on the host, and interactions of different degrees occur between parasite and its host.

2.2.4.1 Nutrition

The nutrients that parasite need are from substances that have been digested or semi-digested in intestines of the host. The intake of nutrients is, on one hand, via temporarily or permanently formed specific morphological structure such as pseudopod of protozoon, cytostome, cytopharynx, microcytostome or other organellae. On the other hand, the intake of nutrients can be directly via cytomembrane such as protozoon. Tapeworm, without alimentary tract, has to take in nutrients via cortex of its body wall. Most of the flukes have incomplete alimentary tract and take in the needed nutrients via integument of their body wall.

2.2.4.2 Metabolism

Energy Metabolism

The energy of parasite is mainly supplied via aerobic metabolism and anaerobic metabolism. Aerobic metabolism can completely oxidize metabolites and produce more energy. However, anaerobic metabolism, also known as glucose metabolism, produces lactic acid and pyruvic acid after anaerobic glycolysis of glucose, with less energy obtained. Lactic acid commonly can be utilized by the host to synthesize glycogen, which is subsequently oxidized into carbon dioxide and water.

Glucose Metabolism

Glucose metabolism can be achieved via three approaches: anaerobic glycolysis, aerobic metabolism of tricarboxylic acid cycle and shunt of phosphopentose metabolism. A great number of parasites, especially those parasitizing in the alimentary tract, live in an environment with no or low level of oxygen and their energy is mainly supplied via glycolysis. For instances, amylase in entamoeba histolytica can resolve starch that parasites have stored into glucose, and then produce energy via glycolysis. Some tapeworms in their larva stage can store large glycogen and obtain energy via glycolysis and tricarboxylic acid cycle. All nematoids can transform glucose or glycogen into pyruvic acid via glycolysis, which is then reduced into lactic acid or produces acetyl Co-A, followed by the metabolic process of tricarboxylic acid cycle.

Metabolism of Protein and Amino Acid

When glucose is unavailable, parasite can obtain energy from protein metabolism. Experiments have shown that most parasites produce more ammonia when glucose is insufficient, indicating active catabolism of protein. Amino acid that parasite obtains from the host enters into metabolic pool for synthesizing different tissues or participating in metabolism. Amino acids in metabolic pool commonly participate in the routine metabolic pathways of protein whose products include ammonia, urea and uric acid. Most of these products are toxic, playing significant role in the pathogenesis of parasitic disease.

Lipid Metabolism

Lipid in parasite includes glyceride, free fatty acid and phospholipid. Nonsaponifiable substance, such as sterol and related substances, can also be included. Lipid metabolism sometimes concurs with glucose metabolism, and sometimes with protein metabolism.

2.2.5 Classification of Parasite

The number of existent animal species in the world ranges from 1.5 million to 4.5 million, and more than 1 million have been described and categorized. The number of parasitic protozoa, worms and arthropods is also considerable. According to animal classification system, parasite predominantly distributes in Platyhelminthes, Nemathelminthes, Acanthocephala and Arthropoda in kingdom of animalia, and Phylum sarcomastigophora, Phylum apicomplexan and Phylum ciliata in subkingdom of gnotozoa.

Animal classification has seven levels, including Kingdom, Phylum, Class, Order, Family, Genus and Species. In addition, the animal classification system also includes some intermediate levels such as Subphylum, Subclass, Suborder, Superclass and Superorder.

Kingdom	Animalia
Subkingdom	Protozoa
Phylum	Sarcomastigophora
Class	Rhizopodea
Order	Ameoebina
Family	Entamoebidae
Genus	Entamoeba
Species	Entamoeba histolytica

Binomial system is applied for nomination of parasite. That is to say, a technical name of parasite include two parts, with the first part identifying the genus and the second part identifying its species. In some cases, the second part is followed by its subspecies. The name of species or subspecies is prior to the first name of the identifier and the year of its identification (the publication year of its identification report). And the technical name of parasite should be italicized in any printed document.