

Giardiasis: Aqua-borne Ailment

AUTHORS DETAIL

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INTRODUCTION

Giardia is a genus of flagellate protozoan parasites. It is one of the most common parasitic agents affecting the GIT tract in both animals and humans. It is a cause of waterborne diarrhea worldwide. The disease caused by *Giardia* is known as Giardiasis or lamblia. Giardiasis may manifest as asymptomatic colonial growth of protozoa and acute or chronic diarrhea. The common model organism of *Giardia* observed for studies is *Giardia lamblia* (Leung 2011). It is also the protozoal pathogen most commonly isolated from intestines, worldwide (Eisenstein et al. 2006; Daly et al. 2010). *Giardia* species like *Giardia (G.) duodenalis* inhabit portions of several mammals' small intestines like the duodenum and jejunum. This species has 8 genetic groups ranging from A to H. These groups are separated by host distribution and specificity (Cacciò and Lalle 2015; Kirk et al. 2015). *G. duodenalis* is another name used for the same organism called *G. lamblia* and *G. intestinalis* (Boutrid et al. 2018; Vivancos et al. 2018; Horton et al. 2019). A characteristic lesion manifested by the *Giardia* infection is atrophy of intestinal villi (Dawson 2005; Huang and White 2006; Halliez and Buret 2013; Robaei et al. 2014; Liu et al. 2018; Bartelt and Kaplan 2018). This leads to the characteristic sign of giardiasis i.e., diarrhea (Naz et al. 2018).

Etiology

The causative agent of Giardiasis in humans is *Giardia (G.) lamblia*. It has two forms in terms of morphology. These forms include trophozoite and cyst. The trophozoite has a median body with two symmetric nuclei placed at the anterior end of the body. It has four pairs of flagella. The surfaces of the median body of trophozoite are dorsally convex and ventrally flat. The ventral surface of trophozoite also contains an adhesive disc also known as a spiral organelle (Einarsson et al. 2016). The trophozoite has a pear-like shape. It is 5 to 10 µm wide and 12 to 20 µm long. The *Giardia* cyst is a smooth-walled structure with an ovoid shape. The width of the cysts ranges from 7 to 10 µm while its length is about 8 to 12 µm (Leung 2011).

Out of eight genotypes of *G. lamblia* ranging from A to H (Fink and Singer 2017; Burnett 2018; Leder and Weller 2019) the first two (A and B) parasitize both animals and humans, While the last six genotypes (from C to H) are only found in animals. Animals affected by A and B genotypes include pets like cats and dogs, livestock animals, and wild animals too. Similarly, the genotypes from C to H are a cause of Giardiasis in livestock cattle, beavers, and pet animals like cats and dogs (Cama and Mathison 2015; Minetti et al. 2016; Fink and Singer 2017; Burnett 2018; Leder and Weller 2019).

Life Cycle

Depending upon its morphological forms (Fig. 2) the life cycle of giardia is also divided into two distinct phases (Fig. 1). These two phases include a proliferating stage of the trophozoite phase and an infectious stage of the cyst (Fink and Singer 2017).

1. The hosts ingest the cysts of giardia either through contaminated faeces, food, water, or any other edible.
2. These cysts then hatch into trophozoites in the small intestine followed by its replication
3. The life cycle of giardia completes when these trophozoites mature into cysts and are shed through feces to be taken up by another animal (Adam 2001).

Pathogenesis

The pathogenic potential of *Giardia* cysts is too high that even with ingestion of a small number of cysts, the clinical disease may occur (Kucik et al. 2004; Burnett 2018). Once the cyst is ingested its excystation happens in the duodenum section of the small intestine (Lebwohl et al. 2003; Kucik et al. 2004; Kalyoussef and Goldman 2010) possibly due to its

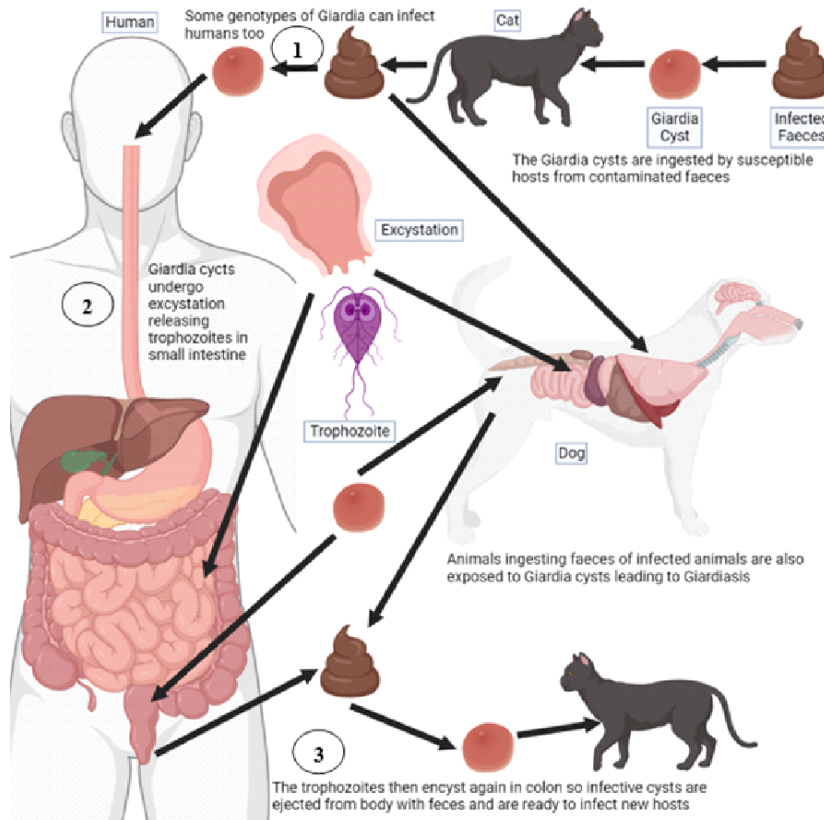


Fig. 1: Life cycle of *Giardia* and its transmission among hosts of different species.

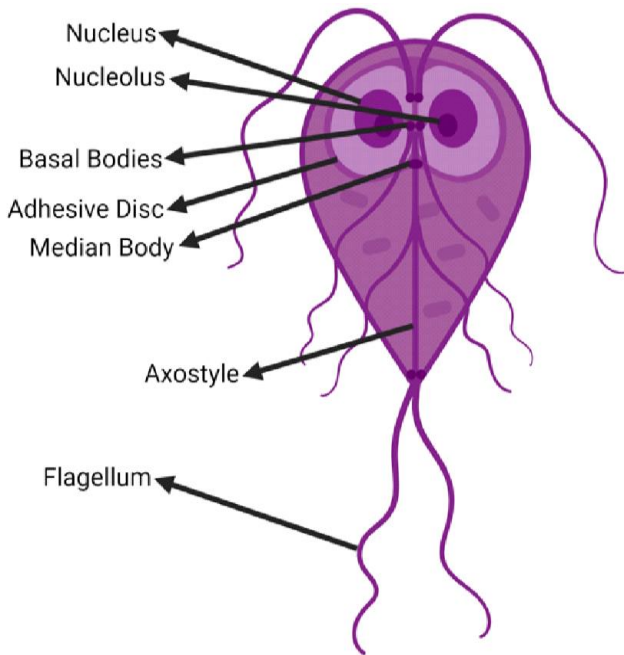


Fig. 2: Morphology of *Giardia* Trophozoite.

exposure to the strong gastric acid from the stomach, bile, and proteases from the pancreas (Lebwohl et al. 2003; Robaei et al. 2014). A nuclear division already happened during the

maturation of the cyst before excystation, so excystation results in the production of two motile trophozoites (Halliez and Buret 2013; Bartelt and Kaplan 2018).

The main predilection site for these trophozoites is the proximal part of the intestine so they are found in the duodenum and jejunum (Fig. 3). Usually, these trophozoites attach themselves to the enterocytes with the help adhesive discs found on the ventral surface of their bodies (Romero et al. 2015). Although uncommon but presence of trophozoites in the terminal portion of the intestine, the ileum, has also been reported (Heagley and Jakate 2012).

The pathogenic action of *Giardia* begins in its trophozoite stage. This happens because the trophozoite begins damaging the intestinal lumen wall. *Giardia* destroys the intestinal mucosa leading to the shortening of the brush border of microvilli. Microvilli brush border shortening may or may not be accompanied by villous atrophy during giardiasis. A deficiency of disaccharides began to appear and the host immune response is also activated. Activation of immune response results in increased permeability of intestines. An increased intestinal permeability leads to an increase in anion and fluid secretion into the intestines which in turn affects and changes the microflora of the intestine. Modified microflora serve as a stimulatory factor for enhancing the pathogenicity of *Giardia*. This results in the apoptosis of enterocytes leading to the loss of function of the intestinal barriers (Dawson 2005; Huang and White 2006; Halliez and Buret 2013; Robaei et al. 2014; Liu et al. 2018; Bartelt and

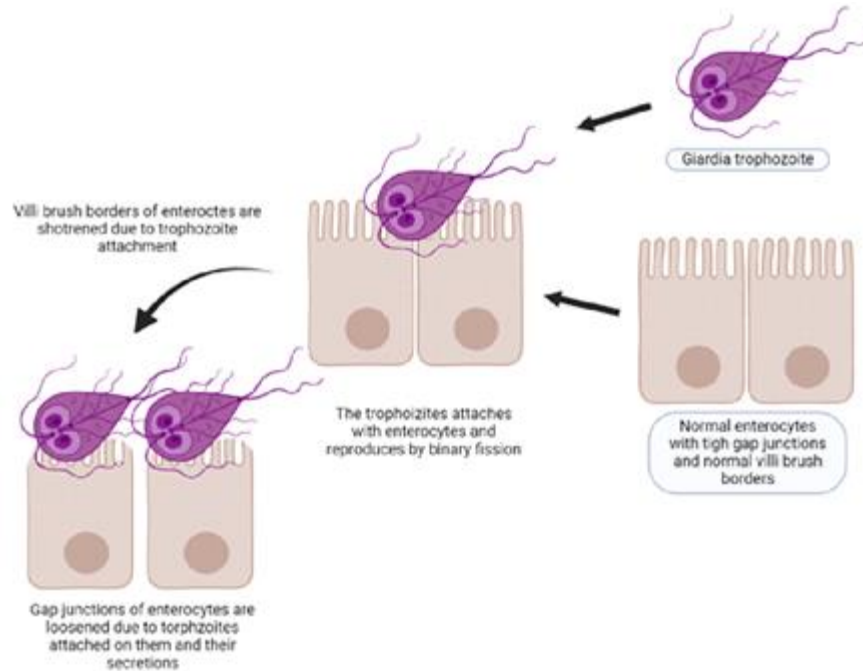


Fig. 3: Pathogenic action of *Giardia* in the host's body.

Kaplan 2018). The main agent suspected to be the cause of all this destruction is an enzyme secreted by trophozoite, the cysteine protease (Liu et al. 2018). Mainly *Giardia* trophozoites are extracellular parasites. This means they do not damage the cells lining the small intestine (Adam 2001; Halliez and Buret 2013; Einarsson et al. 2016) instead they tend to proliferate while being attached to the microvilli (Adam 2001). The trophozoites disrupt the epithelial cell junctions of the intestine altering the gastro-intestinal motility. They also release lectins and thiol proteinase enzymes that have a cytopathic effect on intestinal cells (Leung et al. 2019) In the small intestine, the trophozoites double their numbers within 9 to 12 hours by reproducing through binary fission (Lebwohl et al. 2003; Leung 2011).

After maturation, these trophozoites are passed from the small intestine to the colon along with the ingesta. In the colon, these trophozoites then encyst (Fink and Singer 2017). These cysts are then readily ejected from the body along with faeces. These are actively infective right after their ejection from the host's body. Hence, they are responsible for the further transmission of *Giardia* (Adam 2001; Naz et al. 2018). The cyst wall is a very useful structure for surviving in harsh environmental conditions outside the host's body. The cyst can survive for weeks to about a month while facing harsh conditions such as moist weather and water as cold as 4°C (Adam 2001; Naz et al. 2018).

Clinical Signs

After a *Giardia* cyst enters the body of the host, it takes about 3 weeks for the signs to appear (Kucik et al. 2004; Dawson

2005; Biggs et al. 2016). Usually, the *Giardia* infection progresses asymptotically. Clinical signs may appear in 25% to 50% of the infected hosts (Lebwohl et al. 2003; Biggs et al. 2016; Leder and Weller 2019). Clinical signs are usually seen in young ones infected with *Giardia*. Infection in adult hosts progresses without any clinical signs in most of the cases (Biggs et al. 2016). The asymptomatic carriers keep shedding its cyst for 6 months post-infection (Pickering et al. 1984; Romero et al. 2015). Clinically affected individuals present a typical sign of acute or chronic diarrhea. At the beginning of the infection, the stools are just loose and watery but as the disease progresses the odor of stool becomes foul and its consistency turns to greasy (Naz et al. 2018).

Some general signs of disease include;

- Fatigue (shown by lethargy)
- Anorexia
- Abdominal pain
- Flatulence
- Asthenia
- Bloating
- Weight loss (Adam 2001; Pietrzak et al. 2005; Naz et al. 2018).

The signs like abdominal aches and asthenia are more commonly observed in younger patients as compared to adult ones (Almirall et al. 2013). Symptoms like headache, chills and fever may also appear during Giardiasis although these are rarely seen (Leung 2011). The appearance of blood, mucus or leucocytes in faeces has never been observed (Leung 2011; Minetti et al. 2016). These symptoms usually subside in 2 to 4 weeks after the appearance of the first clinical signs (Lebwohl et al. 2003; Leder and Weller 2019).

Diagnosis

Giardiasis can be confirmed by a faecal examination of the suspected individual. If *Giardia* trophozoites or cysts are seen during the microscopic examination of the stool sample, infection is confirmed (Leung et al. 2019). Usually, stool examination gives 50% to 75% sensitivity because the sample is taken once while cysts are excreted at irregular intervals. This sensitivity can be increased by over 90% by taking multiple samples for 2 to 3 days (Kucik et al. 2004; Leung 2011; Minetti et al. 2016). Real-time PCR can be also used for diagnosing Giardiasis as it gives 100% specificity and 98% sensitivity (Soares and Tasca 2016; Mero et al. 2017; Parčina et al. 2018).

Treatment

For treating giardiasis, the primary effort should be to correct dehydration and imbalance of electrolytes. Actively providing symptomatic treatment against giardiasis helps in the alleviation of clinical signs and reducing their duration, which in turn prevents complications from occurring while reducing disease transmission at the same time (Leung et al. 2019). European Scientific Counsel Companion Animal Parasites reported in 2018 that a 25 mg/kg oral dose of Metronidazole twice a day for 5 days has been proven sufficient to treat giardiasis in cats and dogs (ESCCAP 2018).

Disease in Humans

Introduction

Giardiasis is one of the most common protozoal infections in humans. Its causative agent is *Giardia (G.) lamblia*. Some common conditions caused by Giardiasis include water-borne diarrhoea, food-borne diarrhea, traveler's diarrhea, and day care center outbreaks. According to the World Health Organization giardiasis is one of the most neglected diseases that are associated with unhygienic conditions and poverty (Savioli et al. 2006).

Etiology

Only two genotypes or assemblages of *G. lamblia* namely A and B are generally presumed to be culprits of giardiasis in humans (Halliez and Buret 2013). This general assumption was proved to be untrue when some recent reports proved the role of the E genotype in human giardiasis. These reports came from Australia, Brazil, and Egypt (Moein and Saeed 2016; Fantinatti et al. 2016; Zahedi et al. 2017). The assemblage C was also found in giardiasis patients in Slovakia and China (Liu et al. 2014; Štrkolcová et al. 2015). The assemblage F was reported in human infection in Slovakia (Pipiková et al. 2020). The assemblage D was also

reported in some travellers from Germany after they visited the South-eastern parts of Asia (Broglia et al. 2013).

Transmission/ Zoonosis

Giardia is usually transmitted to human via faeco-oral route and direct contact. Zoonotic transmission of disease can also happen but rare cases have been reported so far (Hlavsa et al. 2005). Giardiasis infection begins in humans when cysts are ingested from contaminated water bodies or through direct contact with an infected person. Lack of proper hygiene management and application of sufficient sanitation measures also plays a vital role in transmission. Recently it has been observed that the day cares for children are serving as shelters for *Giardia* populations to flourish and transmit into new hosts. This transmission happens when the day care nurses tend to handle babies and change their diapers without properly maintaining hygiene and handwashing protocols (Reses et al. 2018).

Prevalence

In developing countries, the prevalence of giardiasis is too high that about 33% population of these countries is affected by it. The prevalence of Giardiasis for different age groups is given in Table 1.

From the aspect of development status of a country, the prevalence of giardiasis is given in Table 2.

Even in well-developed countries, some specific groups of people have been identified as at-risk individuals for getting infected with *Giardia* as given in Table 3.

Clinical Signs / Symptoms

In humans, the incubation period of *Giardia* is about 2 weeks after that the clinical signs begin to appear. The severity of giardiasis is highly variable in humans and sub-clinical infection is also common. The appearance of signs in different states of infections is given in Table 4.

Treatment

Firstly, restoring the optimal hydration and electrolyte balance of the patient is important. This minimizes the severity and duration of infection. Patients of very young or very old age are less tolerant to fluid loss and electrolyte imbalance so they require extra care. One way of achieving this rehydration besides IV infusions is with oral rehydration solutions (Leung et al. 1987; Leung and Robson 1989; Issenman and Leung 1993; Chow et al. 2010).

Along with managerial protocols, a regime of drug-based treatment should also be followed to treat giardiasis. This regime includes the drugs of choice against *Giardia* as given in Table 5.

Table 1: Giardiasis prevalence according to age groups (Zajaczkowski et al. 2018)

No.	Age Group	Percentage of Giardia infected
1	Children	8%
2	Adults	2%

Table 2: Giardiasis prevalence in different economic conditionsn (Dixon et al. 2011)

No.	Type of Country	Prevalence Rate
1	Developed	2% - 7%
2	Developing	20% - 30%

Table 3: Risk of contracting giardiasis among different groups of people (Coffey et al. 2021).

No.	Group of people	Risk of getting in contact with faeces
1	People with gay sexuality	During sexual activity
2	Day care workers	While changing diapers and handling children
3	Professionals dealing with human faecal material like lab workers, prostate examiners	While performing their duties
4	Wilderness travellers	May come in contact with faeces of animals
5	International travellers	May come in contact due to unhygienic conditions during traveling

Table 4: Signs and symptoms in different states of giardiasis

No.	State of Disease	Signs and Symptoms	Reference
1	Acute	Diarrhoea, Nausea, Cramps, Vomiting, Fatigue and Weight loss	(Cacciò and Lalle 2015)
2	Chronic	With acute clinical signs Or without any clinical signs and symptoms	(Muhsen and Levine 2012; Escobedo et al. 2014)

Table 5: Dose regimen of different drugs for the treatment of giardiasis (Petri 2005; Robertson et al. 2010; Bartelt and Kaplan 2018)

No.	Drugs Generic name (Brands)	Dose	Dose Frequency	Route
1	Metronidazole (Flagyl)	15 mg/kg/day (Max 750 mg/day)	Twice a day for 5 to 10 days	Oral
2	Tinidazole (Tindamax, Fasigyn)	50 mg/kg (Max 2 g)	Single dose a day	Oral
3	Nitazoxanide (Alina, Allpar)	7.5 mg/kg	Twice a day for 3 days	Oral

Tinidazole has less side effects than other drugs on this list, so it is considered safe for use in children of age 3 years and above (Leung 2011; Biggs et al. 2016).

Control Methods

Controlling *Giardia* is not very easy because its cysts are well-built to last in harsh environmental conditions. The cysts also remain unaffected by disinfecting agents like chlorine used for cleaning water. However, Iodine can be used against cysts but it needs 8 hours to make the water safely consumable. Boiling water for 10 minutes is an easy method to eliminate the cysts. Travelers that do not have the facilities to boil water may use National Safety Foundation standard rated 53 or NSF standard-rated 58 filters to make water safe for drinking by reducing cysts in the water (Adeyemo et al. 2019).

Conclusion

Giardiasis is an important disease of both animals and humans marked by diarrhea and weight loss. Usually, it is asymptomatic in adult patients but despite showing no clinical signs the infected person can shed cysts in their faeces for several months. Such characteristics make it difficult to control the spread of Giardiasis. It is more

prevalent in developing countries where they have fewer resources to maintain proper sanitation and hygienic protocols. The control of giardiasis is very difficult because it is transmitted through edibles and develops strong cysts to survive in harsh conditions. Still, the use of simple hygienic measures like boiling water for 10 minutes before consumption can eliminate the protozoal cysts.

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