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Chapter 5

Balantidium coli - A neglected zoonotic parasite from Public Health perspective

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Abstract

Balantidium coli is a neglected zoonotic protozoan and the only ciliated parasite known to infect humans. Although human balantidiasis is relatively uncommon, it remains an important public health concern in regions where pig farming, inadequate sanitation, and contaminated food and water facilitate faeco-oral transmission. Domestic pigs serve as the principal reservoir, highlighting the significance of the human–animal–environment interface in disease transmission. Most infections are asymptomatic; however, invasive disease may manifest as chronic colitis, acute dysentery, or, rarely, life-threatening complications such as intestinal perforation and extraintestinal involvement may occur, particularly in immunocompromised individuals. Laboratory diagnosis relies primarily on microscopic identification of trophozoites or cysts in stool specimens, with molecular methods increasingly contributing to epidemiological investigations. Tetracycline remains the treatment of choice, while improvements in water, sanitation, hygiene, livestock management, and public health education constitute the cornerstone of prevention. This chapter reviews the taxonomy, morphology, life cycle, pathogenesis, clinical features, epidemiology, laboratory diagnosis, treatment, and prevention of *B. coli*, with particular emphasis on its zoonotic importance and the relevance of the One Health approach in controlling this neglected parasitic infection.

Keywords: Balantidiasis , Zoonotic infection , One Health, Neglected Tropical Disease, Pig reservoir, Faeco-oral transmission.

Introduction

Among the diverse protozoan parasites infecting humans, *Balantidium coli* occupies a unique position as the only ciliated protozoan known to cause human disease and the largest protozoan parasite encountered in human stool. Despite its relatively low global prevalence, balantidiasis remains an important neglected zoonotic disease, particularly in regions where close human–animal interaction, inadequate sanitation, and unsafe water supplies facilitate transmission. Unlike many intestinal protozoa that rely primarily on human-to-human spread, *B. coli* highlights the intricate relationship between animal reservoirs, environmental contamination, and human health, with domestic pigs serving as the principal reservoir. Consequently, the epidemiology of balantidiasis extends beyond individual infection to encompass broader issues of livestock management, food and water safety, environmental hygiene, and socioeconomic conditions.

The parasite primarily colonizes the large intestine, where it usually exists as a harmless commensal but may, under favorable circumstances, invade the colonic mucosa to produce a spectrum of disease ranging from asymptomatic carriage to severe dysentery and, rarely, life-threatening complications such as intestinal perforation.

Although human infection is uncommon, sporadic outbreaks and isolated cases continue to be reported from tropical and subtropical regions, particularly among pig farmers, abattoir workers, and communities with poor sanitation. With increasing recognition of the One Health approach, which acknowledges the interconnectedness of human, animal, and environmental health, *B.coli* serves as an excellent model for understanding how zoonotic pathogens exploit ecological and behavioral interfaces to cause disease. Therefore, a comprehensive understanding of its biology, transmission dynamics, clinical manifestations, laboratory diagnosis, treatment, and preventive strategies remains essential for clinicians, microbiologists, parasitologists, and public health professionals alike.

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Public Health Importance

Although balantidiasis is considered an uncommon parasitic infection in humans, *Balantidium coli* remains a pathogen of considerable public health significance because of its zoonotic nature and its close association with environmental and socioeconomic factors. The disease is often regarded as a neglected zoonosis, receiving relatively little attention compared with other intestinal protozoan infections despite its worldwide distribution and potential to cause severe invasive colitis. Human cases are likely underdiagnosed in many endemic regions owing to limited diagnostic facilities, low clinical suspicion, and the asymptomatic nature of many infections.

Domestic pigs constitute the principal reservoir of *B.coli*, harbouring the parasite in their large intestine without manifesting clinical disease. Consequently, communities engaged in pig farming or residing in close proximity to pig-rearing facilities are at increased risk of infection. The growing intensification of livestock farming in many parts of the world further highlights the importance of implementing appropriate biosecurity measures and health awareness to reduce zoonotic transmission.

The epidemiology of balantidiasis is closely linked to water, sanitation, and hygiene (WASH) practices. Inadequate sanitation, open defecation, improper disposal of animal waste, and contamination of drinking water sources facilitate faeco-oral transmission of the parasite. Consumption of untreated water or raw vegetables irrigated with contaminated water increases the likelihood of ingesting infective cysts.

Environmental and climatic factors like heavy rainfall, flooding, and natural disasters can contaminate surface water with human and animal faeces, increasing opportunities for water-borne outbreaks. Seasonal variations in rainfall and agricultural practices may therefore alter the environmental persistence and dissemination of infective cysts, particularly in endemic regions.

The public health importance of *B. coli* extends beyond human infection and exemplifies the principles of the One Health approach, which recognizes the interconnectedness of human, animal, and environmental health. Effective prevention requires coordinated efforts involving veterinary surveillance, safe livestock management, improved sanitation, access to clean drinking water, food safety, health education, and early diagnosis and treatment of infected individuals. By integrating medical, veterinary, and environmental interventions, the burden of this neglected zoonotic infection can be substantially reduced.

Habitat

The ecological success of *B. coli* depends on two habitats: the large intestine of mammals, particularly pigs, and moist environmental conditions that allow cyst survival. The colon provides an anaerobic environment rich in bacteria that constitute the parasite's primary food source.

In humans, *Balantidium coli* resides primarily in the large intestine i.e.

- Caecum
- Ascending colon
- Sigmoid colon
- Rectum

Occasionally, trophozoites invade the intestinal mucosa, producing ulceration. Rarely, dissemination occurs to extraintestinal sites such as:

- Liver
- Lungs
- Peritoneum
- Genitourinary tract

The principal reservoir host is the domestic pig, where the parasite usually exists as a harmless commensal in the large intestine.

Taxonomic Status

Table 1: Taxonomical classification of *Balantidium coli*

Taxonomic rank	Classification
Domain	Eukaryota
Kingdom	Protista
Phylum	Ciliophora
Class	Litostomatea
Order	Vestibuliferida
Family	Balantidiidae
Genus	*Balantidium*
Species	*Balantidium coli*

Note:
Recent molecular phylogenetic studies have suggested reclassification of *Balantidium coli* into the genus *Neobalantidium*, and the accepted scientific name in some taxonomic databases is *Neobalantidium coli*. However, the traditional name *Balantidium coli* continues to be widely used in medical literature and clinical practice.

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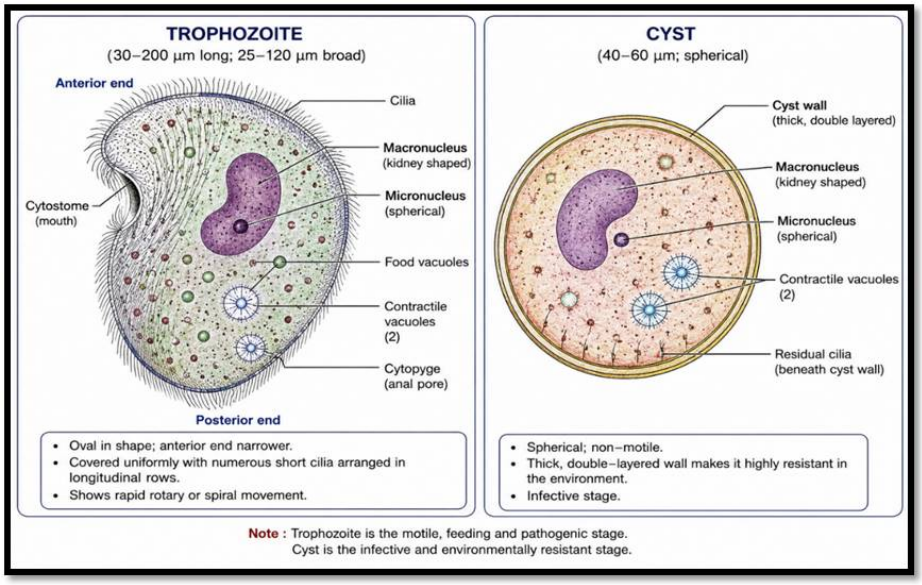
Morphology

Balantidium coli exists in two developmental stages:

1. Trophozoite
2. Cyst

Figure 1: Morphology of Trophozoite and Cyst stages of *Balantidium coli* (Source-Internet)



Trophozoite

The trophozoite is the actively motile and feeding stage.

Size

- Length: 30–200 µm
- Width: 25–120 µm

The average size may have a broad range:

- 50–100 µm long
- 40–70 µm broad

It is the largest protozoan parasite found in human stool.

Shape

- Oval / Ovoid
- Slightly elongated

The anterior end is narrower than the posterior end.

Surface

The entire body is covered by numerous short cilia arranged in longitudinal rows. Cilia near mouth are longer, and called “adoral cilia”. Unlike amoebae and flagellates, *B. coli* possesses numerous cilia covering its entire surface. These coordinated ciliary movements enable rapid, spiral, rotatory motility (“Boring motility”)

Functions of cilia include:

- Locomotion
- Feeding through cytostome
- Rotation during movement to navigate through the intestinal lumen

Pellicle

A firm but elastic pellicle maintains body shape while permitting flexibility.

Cytoplasm

Differentiated into an outer clear ectoplasm and an inner granular endoplasm.

The endoplasm contains two nuclei – Large kidney-shaped macronucleus in the centre, and small micronucleus lies in the concavity of the macronucleus. It also contains two contractile vacuoles and multiple food vacuoles.

Macronucleus -Controls metabolic activities

Micronucleus -Functions during conjugation

Cytostome
Located at the anterior end.
It serves as the mouth through which bacteria, starch granules, cellular debris and food particles are ingested.
Cytopyge
Located near the posterior end.
Responsible for elimination of undigested food.
Vacuoles
Numerous food vacuoles are present.
Two contractile vacuoles regulate osmotic balance.

Cyst

The cyst is the infective stage.
Size - 40–60 μm
Shape- Spherical, surrounded by a thick and transparent cyst wall
Cyst Wall - Thick, double-layered, highly resistant to environmental conditions
Internal structures - Contains:

- Macronucleus
- Micronucleus
- Contractile vacuoles
- Residual cilia beneath the cyst wall

The cyst is non-motile.

Life Cycle

The life cycle of *B. coli* revolves around transmission between pigs, the environment, and humans. Infection begins when mature cysts are ingested through contaminated food or water. After surviving gastric passage, excystation occurs in the small intestine, releasing trophozoites that migrate to the caecum and colon. Most trophozoites remain confined to the lumen, feeding on bacteria and multiplying by transverse binary fission. Under favourable conditions they encyst before leaving the host in formed stool, completing the transmission cycle.

The life cycle is direct (monoxenous), requiring only one host.
Natural Host – Pig (Acts as Reservoir, remains asymptomatic)
Accidental Host – Humans
Infective form – Mature Cysts
Mode of transmission – Humans get infection from consuming food and water infected with cysts / contact with pig faeces / faeco-oral transmission
Development in Large Intestine
Excystation
Occurs in the small intestine. The cyst wall ruptures, releasing trophozoites. Trophozoites are the feeding stage of the parasite.
Colonization
The trophozoites migrate to the caecum and colon. They multiply by:

- Transverse binary fission (most common)
- Conjugation is rare. It is also called “Syngamy”

Pathogenic Phase
Most trophozoites remain in the intestinal lumen. Some invade the intestinal mucosa by secreting:

- Hyaluronidase
- Proteolytic enzymes

These enzymes facilitate tissue invasion.
Encystation
Occurs in the distal colon.
Exit
Mature cysts are passed in formed stool. These are resistant and serve as the the infective stage.
Trophozoites may be passed in diarrheal stool but rapidly disintegrate outside the host.

Pathogenesis

Most infections remain asymptomatic.
Disease develops when trophozoites invade the colonic mucosa.
The pathogenesis involves:
Mechanical damage - Ciliary movement produces irritation of the mucosa.
Enzymatic destruction - Hyaluronidase promotes penetration into the intestinal wall. Proteolytic enzymes digest surrounding tissue.
Inflammatory response - Neutrophils, macrophages and lymphocytes infiltrate affected areas.
Ulcer formation - Ulcers are irregular, round or oval, variable in depth. Unlike amoebic ulcers, balantidial ulcers generally have broad bases and lack the classic flask-shaped appearance.

Severe infections may result in:

- Necrosis
- Hemorrhage
- Perforation
- Peritonitis

Rarely, extraintestinal manuifestations may occur:

- Hepatic abscess
- Pulmonary infection
- Genitourinary involvement

Clinical Features

The severity ranges from asymptomatic infection to fulminant colitis.

Asymptomatic Carrier State

Most common presentation. Patients remain healthy while passing cysts intermittently.

Chronic Balantidial Colitis

Symptoms include:

- Intermittent diarrhoea
- Abdominal discomfort
- Mild abdominal pain
- Flatulence
- Weight loss
- Nausea
- Constipation alternating with diarrhoea

Patients may experience recurrent episodes over several months.

Acute Balantidial Dysentery

Clinical features resemble amoebic dysentery, but invasion is limited to muscularis mucosa i.e. Severity is less. Trophozoites form tiny superficial ulcers upon invasion of the gut submucosa. On microscopic examination, cluster of trophozoites and inflammatory cells can be seen in the submucosa.
Symptoms include:

- Frequent and profuse loose stools (resembling Cholera)
- Blood and mucus in stool (resembling bacillary dysentery)
- Severe abdominal cramps
- Tenesmus
- Fever (occasionally)
- Nausea and vomitting
- Severe Dehydration

Fulminant Disease

Occurs mainly in immunocompromised patients, malnourished individuals, alcoholics, patients receiving corticosteroids
Complications include:

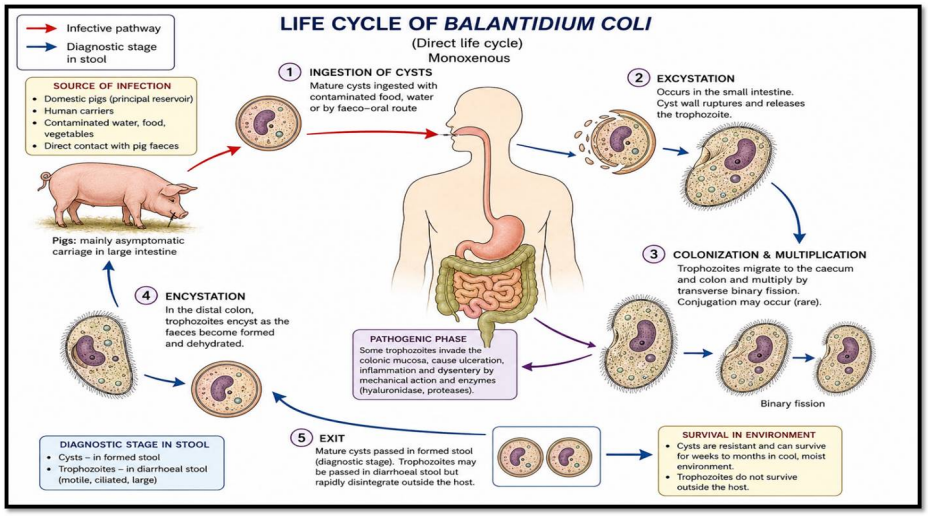
- Toxic megacolon
- Intestinal perforation
- Massive hemorrhage
- Septicemia
- Peritonitis

Extraintestinal Disease

Very uncommon. Reported manifestations include:

- Pulmonary balantidiasis (Pleuritis and pneumonia)
- Liver abscess
- Peritoneal infection
- Genitourinary infection

Figure 2: Life cycle of *Balantidium coli* (Source-Internet)



Epidemiology

Balantidiasis has a worldwide distribution but remains quite an uncommon parasitic infection.

Geographic distribution

Found mostly in tropical and subtropical countries , in rural agricultural / animal husbandry communities where pig rearing is common. Human cases are reported from:

- Latin America
- Southeast Asia
- India
- Philippines
- Papua New Guinea
- Parts of Africa

Highest prevalence reported from Indonesia. In our country, it is quite rare.
Identified Risk Factors include-

- Pig farming
- Poor sanitation
- Open defecation
- Contaminated water supply
- Immunosuppression
- Malnutrition

Laboratory Diagnosis

Laboratory diagnosis aims to demonstrate either trophozoites during active diarrhoeal illness or cysts in formed stool during asymptomatic infection.

Specimens

- Fresh stool
- Concentrated stool samples
- Rectal scrapings
- Colonoscopic biopsy

Macroscopic Stool Examination may reveal blood and mucus in stool
Microscopy – Repeated stool examination must be done as the parasite is shed intermittently.
Saline wet mount
Fresh trophozoites are easy to identify as they exhibit: Rapid rotary movement, Uniform ciliation, Large kidney-shaped macronucleus (sometimes visible)
Iodine preparation
Better demonstrates Cysts and Nuclear structures, Cysts are found in chronic cases and carriers. They are round and surrounded by thick cyst wall.

Concentration Techniques
Useful in chronic infection with low cyst output:

- Formalin–ethyl acetate concentration
- Zinc sulfate flotation (less commonly used)

Permanent Stains

- Trichrome stain
- Iron hematoxylin stain

Staining provides better visualization of internal structures, including the macronucleus, micronucleus, and cilia.
Histopathology - Staining of biopsy material or scraping of ulcers taken by sigmoidoscopy, reveals trophozoites , cysts and lymphocyte infiltration of submucosa
Culture - Rarely performed for routine diagnosis. Boeck Drbohlav egg serum media and Balamuth's media may be used for cultivation of *Balantidium coli*. Culture is rarely required as the parasite is easily identifiable by stool microscopy or histopathological examination of biopsy samples.
Molecular Methods - PCR assays targeting ribosomal RNA genes have been developed and are mainly used in research and epidemiological investigations. They offer higher sensitivity and facilitate molecular typing but are not routinely available in most diagnostic laboratories.

Differential Diagnosis

- Amoebic dysentery (*Entamoeba histolytica*)
- Inflammatory bowel disease (IBD)
- Bacillary dysentery (*Shigella spp.*)
- Colorectal carcinoma
- Other protozoal colitis

Treatment

Because humans act as a source of environmental contamination, treatment is recommended for both symptomatic patients and asymptomatic carriers.

First-line therapy - Tetracycline is considered the drug of choice for most adults. Typical adult regimen: 500 mg orally four times daily for 10 days.

Alternative drugs – Metronidazole (750mg thrice a day, for 5-7 days) , Iodoquinol
These are used when tetracycline is contraindicated or unavailable.

Special situations

- **Children and pregnant women:** Tetracyclines are generally avoided; treatment should be individualized with appropriate alternatives based on clinical judgment and current guidelines.
- Adequate fluid and electrolyte replacement is essential in patients with severe diarrhoea or dysentery.

Prevention and Control

Effective prevention relies on interrupting faeco–oral transmission and reducing exposure to infected animal reservoirs.

Personal Measures

- Hand hygiene after toilet use and animal handling (in pig sty)
- Consumption of safe drinking water.
- Thorough washing of fruits and vegetables.
- Proper cooking of food where appropriate.

Environmental Measures

- Improved sanitation and sewage disposal.
- Prevention of faecal contamination of water sources.
- Hygienic disposal of pig excreta.
- Protection of water supplies in pig-farming areas.

Public Health Measures

- Health education regarding faeco–oral transmission.
- Periodic surveillance in endemic regions.
- Early diagnosis and treatment of infected individuals.
- Veterinary management and hygienic pig-rearing practices to reduce zoonotic transmission.

How One Health Approach Can Help Control Balantidiasis ?
The epidemiology of balantidiasis highlights the close interdependence of human health, animal health, and the environment. Consequently, its prevention is best addressed through the One Health framework, which promotes collaboration among physicians, microbiologists, veterinarians, environmental scientists, public health authorities, and policymakers. Integrated surveillance of human and animal infections, improved veterinary health services, environmental sanitation, community education, and coordinated outbreak response are essential components of this multidisciplinary strategy.

Conclusion

Balantidium coli illustrates how human health is closely linked to animal reservoirs and environmental sanitation. Although clinically uncommon, its ability to cause invasive colitis, coupled with its zoonotic transmission through pigs and contaminated water, makes it an important organism in tropical medicine and public health. Improvements in sanitation, safe water, veterinary hygiene, and early diagnosis remain the cornerstone of prevention. As the global emphasis on One Health grows, *B. coli* continues to serve as an excellent example of the interconnectedness of human, animal, and environmental health.

Points To Remember

- *Balantidium coli* is the only ciliated protozoan infecting humans and the largest protozoan parasite found in human stool.
- The pig is the principal reservoir host. Humans rare the accidental host.
- The infective stage is the mature cyst.
- Humans acquire infection by the faeco–oral route, usually through contaminated food or water.
- The organism inhabits the caecum and colon, where trophozoites may invade the mucosa and produce ulcerative colitis.
- Most infections are asymptomatic, but severe dysentery resembling amoebiasis may occur.
- Direct saline wet mount examination of fresh stool demonstrating large, rapidly motile, ciliated trophozoites remains the cornerstone of diagnosis.
- Tetracycline is the preferred treatment for most adult patients, with metronidazole and iodoquinol serving as alternative therapies.

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