ANCYLOSTOMA DUODENALE INFECTION IN CHILDREN: EPIDEMIOLOGY, CLINICAL MANIFESTATIONS, DIAGNOSIS AND PREVENTION

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***ABSTRACT**: This article examines the epidemiology, pathogenesis, clinical manifestations, modern diagnostic methods, and prevention strategies of hookworm disease caused by Ancylostoma duodenale in children. Hookworm infection remains one of the most prevalent soil-transmitted helminthiases globally, with an estimated 700 million people affected worldwide, predominantly in tropical and subtropical regions with poor sanitation. The parasite causes significant iron-deficiency anemia, protein malnutrition, and impaired physical and cognitive development, particularly in school-age children. This paper reviews the life cycle of A. duodenale, its pathogenic mechanisms, the spectrum of clinical presentations ranging from cutaneous larva migrans to severe chronic anemia, available diagnostic tools, and evidence-based treatment protocols. The importance of integrated control programs combining mass drug administration, improved sanitation, and health education is highlighted as the most effective approach to reducing the burden of ancylostomiasis in endemic communities.*

***Keywords:** Ancylostoma duodenale, hookworm, ancylostomiasis, iron-deficiency anemia, soil-transmitted helminths, children, diagnosis, prevention, nematoda.*

INTRODUCTION

Soil-transmitted helminthiases (STH) represent a major global public health problem, affecting more than 1.5 billion people in 102 countries [1]. Among the four main STH species, *Ancylostoma duodenale* and *Necator americanus* — the two

primary hookworm species — are responsible for an estimated 700 million infections worldwide [2]. *A. duodenale*, commonly known as the Old World hookworm, is predominantly distributed across South and East Asia, the Mediterranean region, and parts of Central Asia, including Uzbekistan [3].

Children are disproportionately affected by hookworm infection due to behavioral factors such as playing barefoot in contaminated soil and inadequate hand hygiene. The consequences of chronic infection in children are profound: iron-deficiency anemia, growth stunting, impaired cognitive development, and reduced school attendance and performance [4]. According to the World Health Organization (WHO), hookworm disease accounts for the loss of approximately 22.1 million disability-adjusted life years (DALYs) annually [1].

Despite its global significance, ancylostomiasis remains underdiagnosed in many regions due to the non-specific nature of its symptoms and limited laboratory resources. This review aims to consolidate current knowledge on the epidemiology, pathogenesis, clinical features, diagnostic approaches, and preventive strategies for *A. duodenale* infection in children.

LITERATURE REVIEW

Hookworm infection has been recognized as a disease of poverty for over a century. Early studies by Looss in the early 20th century established the percutaneous route of infection as the primary mode of transmission for *A. duodenale* [5]. Subsequent research has expanded our understanding of the parasite's biology, immunology, and the host-parasite relationship.

Bethony et al. (2006) provided a comprehensive review of STH infections, confirming that hookworm causes the most significant disease burden among nematode infections due to chronic blood loss from the intestinal mucosa [2]. Studies conducted in endemic regions, including parts of Asia and Africa, report prevalence rates ranging from 20% to 80% in school-age children, depending on environmental conditions and socioeconomic factors [6].

Research on the immunological response to *A. duodenale* has revealed that the parasite actively modulates the host immune response through the secretion of

immunosuppressive molecules, promoting its long-term survival in the intestine [7]. This immune evasion mechanism contributes to chronic infection and the associated morbidity. Recent molecular studies have also identified significant genetic diversity among hookworm populations, with implications for vaccine development [8].

In terms of control strategies, the WHO recommends periodic preventive chemotherapy (PC) with benzimidazole drugs — albendazole or mebendazole — targeting pre-school and school-age children in endemic areas [1]. However, evidence suggests that drug treatment alone, without concurrent improvements in water, sanitation, and hygiene (WASH), leads to rapid reinfection within months of treatment [9].

MAIN BODY

Etiology and Life Cycle

Ancylostoma duodenale is a roundworm belonging to the class Nematoda, family Ancylostomatidae. Adult worms are small (females 10–13 mm, males 8–11 mm) and attach firmly to the intestinal mucosa of the proximal small intestine using their buccal capsule, which is equipped with two pairs of ventral teeth — a key distinguishing feature from *Necator americanus*, which possesses cutting plates instead [5]. The female produces approximately 25,000–30,000 eggs per day, which are passed in the feces.

The life cycle of *A. duodenale* involves both free-living stages in the soil and parasitic stages in the human host. Eggs hatch in warm, moist soil within 24–48 hours, developing through two rhabditiform (non-infective) larval stages into the filariform (L3, infective) stage within 5–10 days under optimal conditions (24–30°C) [3]. Infection occurs primarily through skin penetration when a person walks barefoot on contaminated soil. Notably, *A. duodenale* can also infect humans via the oral route through ingestion of L3 larvae, distinguishing it from *N. americanus* [5]. Following skin penetration, larvae migrate through the bloodstream to the lungs, ascend the trachea, are swallowed, and reach the small intestine where they mature into adult worms within 6–8 weeks [10].

Pathogenesis and Clinical Manifestations

The pathogenesis of ancylostomiasis involves three principal mechanisms: larval migration causing tissue damage, intestinal mucosal injury due to worm attachment, and chronic blood loss. Each adult worm ingests approximately 0.04–0.26 mL of blood per day; a moderate infection with 100 worms results in a daily blood loss of 4–26 mL, sufficient to cause clinically significant iron-deficiency anemia [4].

The clinical presentation of *A. duodenale* infection progresses through distinct phases. At the site of larval entry, a pruritic, erythematous papulovesicular rash known as 'ground itch' or cutaneous larva migrans appears within hours, most commonly on the feet and lower legs [6]. During pulmonary migration, patients may develop a transient syndrome characterized by cough, wheezing, dyspnea, and eosinophilia, resembling Löffler's syndrome [10].

In the established intestinal phase, clinical features include epigastric and periumbilical pain, nausea, vomiting, diarrhea alternating with constipation, and fatigue. In children with heavy or prolonged infection, iron-deficiency anemia is the most serious consequence, presenting as pallor, weakness, tachycardia, and in severe cases, cardiac decompensation. Protein malnutrition (hypoalbuminemia) due to intestinal protein loss can lead to edema [4]. Cognitive impairment, decreased school performance, and growth retardation are well-documented long-term effects of chronic hookworm infection in children [9].

Diagnostic Methods

Diagnosis of ancylostomiasis relies on the following approaches:

1. Stool examination — the Kato-Katz thick smear technique is the standard WHO-recommended method for detecting and quantifying hookworm eggs in feces. It allows estimation of infection intensity (eggs per gram of feces), which correlates with clinical severity. The method is simple, inexpensive, and widely applicable in field settings [1].

2. Complete blood count — peripheral blood eosinophilia (5–15%) is characteristic of the migratory phase. In chronic infection, a hypochromic microcytic

anemia pattern with reduced serum iron and ferritin levels confirms iron-deficiency anemia due to chronic blood loss [4].

3. Biochemical tests — serum albumin levels may be reduced in heavy infections due to intestinal protein loss. Serum ferritin is a sensitive marker for assessing iron stores in affected children [7].

4. Molecular diagnostics — PCR-based methods offer high sensitivity and specificity for species-level identification of hookworm, differentiation between A. duodenale and N. americanus, and detection in low-intensity infections where microscopy may yield false negatives [8].

5. Serological methods — ELISA-based detection of specific IgG antibodies against hookworm antigens is primarily used in epidemiological research rather than routine clinical diagnosis [7].

Treatment

The WHO recommends benzimidazole anthelmintics as first-line treatment. Albendazole (400 mg single dose) achieves cure rates of 72–95% against *A. duodenale*, while mebendazole (500 mg single dose or 100 mg twice daily for 3 days) is an alternative with slightly lower efficacy [1]. Pyrantel pamoate (11 mg/kg, maximum 1 g) is an option in cases of benzimidazole contraindication. Iron supplementation is essential alongside anthelmintic therapy to correct established anemia; oral ferrous sulfate (3–6 mg/kg/day of elemental iron) is standard in children [4]. Follow-up stool examination is recommended 3–4 weeks after treatment to assess cure. Reinfection is common in endemic areas without environmental improvements, necessitating periodic retreatment.

Prevention and Control

Effective prevention of ancylostomiasis requires a multi-component approach. Personal preventive measures include wearing footwear in areas where soil contamination is likely, regular hand washing with soap before meals and after outdoor activities, and avoiding consumption of unwashed raw vegetables. Environmental control focuses on safe disposal of human feces, improvement of sanitation infrastructure, and treatment of agricultural water supplies [9].

At the community level, the WHO recommends periodic preventive chemotherapy (PC) — also known as mass drug administration (MDA) — targeting pre-school children (aged 1–5 years) and school-age children (6–15 years) in areas where hookworm prevalence exceeds 20% [1]. MDA programs have demonstrated significant reductions in infection prevalence and anemia in endemic communities. Health education campaigns promoting hygiene behaviors are a cost-effective complement to chemotherapy. Integrated WASH interventions addressing water quality, sanitation access, and hygiene promotion are essential for sustainable control and prevention of reinfection [9].

CONCLUSIONS

Ancylostomiasis caused by *Ancylostoma duodenale* remains a significant public health challenge in endemic regions, with children bearing the greatest burden of disease. Based on the reviewed evidence, the following conclusions are drawn:

1. Ancylostoma duodenale infection is primarily transmitted through skin penetration by infective larvae in contaminated soil, with the oral route also possible — a feature unique among major hookworm species. Warm, moist environmental conditions favor larval development and transmission.

2. The clinical spectrum ranges from mild skin and pulmonary manifestations during larval migration to severe iron-deficiency anemia and protein malnutrition in chronic intestinal infection. Children are particularly vulnerable due to higher nutritional demands and behavioral exposure factors.

3. The Kato-Katz technique remains the gold standard for field diagnosis, while molecular methods offer superior sensitivity and species discrimination for research settings. Hematological and biochemical tests are essential to assess the severity of anemia and nutritional deficiency.

4. Albendazole and mebendazole are highly effective anthelmintic agents. Treatment must be combined with iron supplementation in children with established anemia and followed by stool examination to confirm cure.

5. Sustainable control of ancylostomiasis requires integrated strategies that combine periodic preventive chemotherapy, WASH improvements, and health

education — as drug treatment alone without environmental improvements results in rapid reinfection.

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