Hookworms

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Introduction

- Hookworm infection or Ancylostomiasis is an infection with one or more species of nematodes belonging to the family *Ancylostomidae*.
- The common hookworms are *Ancylostoma duodenale* and *Necator americanus*.
- In addition, the larvae of several species of hookworms infecting domesticated animals may penetrate human skin, causing pathology, even though they do not develop the adult parasites in man.
- These are very important human pathogens, infecting about 800 million to 1.25 billion people ~100 million of which causes symptomatic infections.
Introduction

- In the early part of the 20th century, hookworm disease was such a serious problem in the United States that the Rockefeller Foundation took on the task of controlling the disease, an activity that subsequently led to the creation of the World Health Organization (WHO).
Epidemiology

- Ancylostomiasis accounts for 60,000 deaths per year, mainly in children. It is estimated that 1 billion people are infected worldwide. Surveys conducted in Asia often find prevalences as high as 70 percent.
- Occurs worldwide. Both *N americanus* and *A duodenale* are endemic in warm, moist tropical areas where people defecate in the soil.
- *Necator americanus* is not confined to the Americas, being the most common species in Asia, Central and South Africa, and Central and South America.
- *Ancyclostoma duodenale* is more prominent in India, China, and North Africa.
- It is infrequent in very young children. Age prevalence gradually increases to a plateau of 80% who are older than 10 years. Infections are found equally in males and females.
Kingdom – *Animalia*
  – Phylum - *Nematoda*
    • Class - *Secernentea*
      – Order – *Strongylida*
        • Superfamily - *Strongyloidea*
        • Genus – *Ankylostoma*
        • Species - *Ankylostoma duodenale* and *Necator Americana*
Other species of hookworms

The following 5 species normally infect animals and occasionally human.

- *Ancylostoma braziliense*
- *Ancylostoma ceylanicum*
- *Ancylostoma caninum*
- *Uncinaria stenocephala*
- *Bunostomum phlebotomum*
The worms are cylindrical and grayish white. Females are approximately 1 cm long; males are smaller.

Female *A. duodenale* hookworms produce 10,000 to 20,000 eggs per day, compared to 5,000 to 10,000 for *N. americanus*. Eggs in fresh stools contain embryos in the four or eight cell stage.

The first stage (rhabditiform) larva develops within the egg and has a thick walled, long, narrow buccal cavity.

The tail is sharply pointed. The rhabditiform larvae of the two species cannot be differentiated, but the filariform larvae of *N. americanus* have dark, prominent buccal spears and a striated cuticle seen more clearly at the posterior end. These characteristics are not seen in *A. duodenale*. 
1. Eggs in feces
2. Rhabditiform larva hatches
3. Filariform larva penetrates skin
4. Filariform larva
5. Adults in small intestine

= Infective Stage
= Diagnostic Stage
Life cycle at a glance

- Life cycle stages: Adult, larva, ova
- Host: Single host, man (definitive)
- Infective form: Filariform larva
- Pathogenic form: Adults & larva
- Route of infection: Penetration through skin
- Site of localization: Small intestine
- Time required for completion of life cycle: 5-6 weeks
- Special feature of life cycle: Heart lung migration
- No. of moulting: 5 times
Hypobiosis, refers to an arrested or dormant state which larvae assume once they have entered the host but have not yet completed their development to adults. The advantage of this biological process is usually to prevent the next generation of eggs and larvae from being exposed to unfavorable environmental conditions. It may be to make sure that the next generation of infective stages is present in the environment during the period when susceptible young hosts are available.

In hookworm infections, seasonal hypobiosis serves to synchronize the parasites development with external seasonal conditions. It is such that the eggs will be produced during the wet season, when they are capable of completing their development.

Hypobiosis is characterized by reduced metabolic activity in the arrested larva, and can last up to about 8 months. During this period, the arrested larvae have a reduced susceptibility to drug treatment.
Virulence Factors

*Hook worms* has following virulence factors

- **Power of penetration by larva** - The filariform larva can penetrate through intact skin and also through capillaries and venules of lungs.

- **Sucking action** - Adult worm can suck blood from intestinal wall. *Necator* ingests 0.03 ml of blood per worm per day; *Ancylostoma* ingests 0.20 ml blood per worm per day.

- **Secretion of proteolytic enzyme** - Adult worm secrets proteolytic enzyme from dorsal pharyngeal gland, help them in digestion of blood.

- **Secretion of anticoagulant** - Adult worm posses anticoagulant which prevents clotting in punctured site of intestine.
Pathogenesis

- **Cutaneous or invasive phase**
  - Ground itch, cutaneous larval migrans

- **Pulmonary phase**
  - Pneumonitis, A mild and usually asymptomatic alveolitis with eosinophilia ensues

- **Intestinal phase**
  - The most common effect from hookworm infections is the varying degrees of anemia, depending on the level of the infection and the nutritional state of the patient.
  - Patients also can suffer from protein deficiency
  - The infection is particularly severe in children, and the development of a pot belly, as a result of the edema, is a common symptom of the infection
Quantitative pathogenesis

- As already stated, Necator ingests 0.03 ml of blood per worm per day; Ancylostoma ingests 0.20 ml blood per worm per day. Subsequent host anemia is proportional to diet, iron reserves, and worm burden.

- Threshold worm loads for anemia differ nationally, with as few as 40 worms producing anaemia in countries with low iron consumption.

- A single Necator americanus will take approximately 30 µl of blood daily, whilst the larger Ancylostoma duodenale will take up to 260 µl. The gross pathology of the disease is very dependent on the intensity of infection.

- Light infections appear asymptomatic, but in heavy infections, the continuous loss of blood leads to a chronic anemia, with down to 2gm of hemoglobin per 100ml of blood in extreme cases. This leads to permanent loss of iron and many blood proteins as well as blood cells. This in turn has consequences for further production of erythrocytes, which have been shown to contain less hemoglobin, as well as being reduced in size and smaller in numbers.

- This form of anemia may be directly fatal, but more often it induces more non-specific symptoms. The most noticeable being the severe retardation in growth and development, (both physical and mental), in infected children, and a general weakness and lassitude, often wrongly interpreted as "laziness".
Effect of anaemia

- Severe anemia affects the intellectual and physical development of children and the cardiovascular performance of adults.
  - 25 worms no symptoms
  - 25-100 worms mild symptoms, anemia
  - 100-500 worms considerable damage, moderate symptoms
  - 500-1000 worms severe symptoms, with severe pathology, often-fatal consequences.

- *A. duodenale*, on the other hand, appear to be much more pathogenic, as few as 100 adult worms can result in severe symptoms, normally associated with a much heavier worm burden in *Necator* infections.
Host Defenses

- Immunity to hookworm develops in dogs, but no strong evidence suggests that it occurs in humans. Ground itch is thought to be an allergic reaction, but the response is minimal unless accompanied by bacterial infection.

- Seasonal fluctuation in hookworm egg production in *A. duodenale* has been reported and is thought to be due to host resistance, but may also reflect arrested development of the parasite. In some persons, a self-cure or a spontaneous reduction of worms occurs and may be attributed to immediate hypersensitivity reactions in the intestinal wall. IgE antibody mediated antibody dependant cell mediated cytotoxicity (ADCC) play an important role.
Clinical manifestations of Hookworm disease

- **A. Due to larva**
  - Ground or dew itch
  - Loeffler’s syndrome

- **B. Due to adults**
  - Asymptomatic or mild symptoms
  - GI tract discomfort - dyspepsia, nausea and epigastric distress
  - Peripheral eosinophilia
  - Microcytic hypochromic anaemia
  - Dimorphic anaemia

- **Protein energy malnutrition in severe cases**
Laboratory Diagnosis

Principle:
- Diagnosis of hookworm infection is based on detection of eggs or larvae in the stool.
  - Reliable detection of the eggs in the feces usually requires the use of one of the fecal egg concentration techniques.
  - The species can be readily identified by virtue of the differences in their mouth parts.
  - The anemia seen in hookworm disease is hypochromic and microcytic and, when profound, may be accompanied by markedly hyperplastic bone marrow with increased normoblasts as well as myeloid metaplasia of the liver and spleen.
  - Serum iron is decreased and its utilization as measured with tagged radioisotopes is increased.
  - Peripheral eosinophilia is often present in the blood in hookworm infections.
Treatment

- **Mebendazole** is the drug of choice, 100 mg orally bid for 3 days alternatively 500 mg orally as single dose results in a 95.0% cure rate and a 99.9% reduction in egg counts, Albendazole is the second choice 400 mg orally as a single dose with a 77.9% cure rate and a 95.4% reduction in egg counts. Pyrantel is an alternative agent.

- Iron replacement should be part of the management strategy, and may have greater efficacy than anthelmintics in reducing morbidity. Topical treatment with thiabendazole ointment is very effective in controlling creeping eruption or larva migrnas.
Control and Prevention

- Control of this parasite should be directed against reducing the level of environmental contamination. Treatment of heavily infected individuals is one way to reduce the source of contamination.
- Other obvious methods are to improve sanitary condition, e.g. latrines, but also convincing people to use them by maintaining them in a serviceable form, making them conducive to use.
- Community control is difficult unless there is significant improvement in socioeconomic conditions, sanitation, education, and the availability of proper footwear.
- Current World Health Organization (WHO) recommendations include periodic mass therapy to lower the overall worm burden until conditions permit, a multicomponent physical and educational program.
Hookworms are intestinal nematode, possibly the most common intestinal helminthes. About 1 billion people of the world are infected by it.

Hookworms have three stages in its life cycle, ova, larva and adult of which Filariform larva are the infective stage, and larva and adults are the pathogenic stage. It is transmitted by penetration of skin.

Hookworms causes ankylostomiasis or hookworm disease which is manifested by ground itch and pneumonitis caused by larval stage, and asymptomatic to microcytic hypochromic anemia and protein energy malnutrition by adult stage.

Diagnosis of Hookworm infection is based on identification of ova or larva or adult stage of Hookworm by microscopic/macroscopic examination of stool.

Hookworm infection can be effectively treated with mebendazole and albendazole.
Study Questions

- What is the mortality and morbidity of ankylostomiasis? What is its clinical significance?
  1. Describe Life cycle of *Hookworm*.
  2. Write about the laboratory diagnosis of ankylostomiasis?
  3. Write short notes on Loeffler’s syndrome.
  4. Write about the pathogenesis of ankylostomiasis.
  5. What are the virulence factors of *Hookworms*.
  6. Discuss how anemia occurs in hookworm infection?