The Worms of Humans: Intestinal Nematodes

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Lecture Overview

1. General Facts about Intestinal Nematodes
2. 4 major intestinal nematodes: Ascaris, Trichuris, hookworm and Strongyloides
   • Public Health Implications
   • Lifecycle
   • Clinical presentation
   • Treatment
3. Trends in Intestinal Parasitism among Refugees
Introduction: Context & Environment

• Natural disasters introduce new infectious risks & re-introduce old ones.
Haiti’s worst natural disaster

- January 12, 2010 is a day that will always be remembered.
- Conditions remain hazardous, with extensive damage to buildings, roads, sanitation systems, and other infrastructure.
Purpose

• To provide guidance for health care providers:
  • Understand how natural disasters affect the types of infections present –
    • Here specifically the type of intestinal worm infections encountered
  • Learn to recognize, diagnose, and treat these infections
  • Understand how to reduce their incidence
  • Improve morbidity & mortality
Parasitic Helminths

• Trematodes (flukes)
  • Venous system: *Schistosoma*
  • Biliary tract: *Clonorchis, Fasciola*
  • Lung: *Paragonimus*

• Cestodes (tapeworms)
  • *Taenia saginata, Taenia solium, H. nana*

• Nematodes (roundworm)
  • Intestinal
  • Blood, lymphatic, subcutaneous
Nematode subtypes in humans:

- *Ascaris lumbricoides* (roundworm),
- *Ancylostoma duodenale* (hookworm),
- *Necator americanus* (hookworm), and
- *Trichuris trichiura* (whipworm)
- *Enterobius vermicularis* (pinworm) and
- parasites of the genus *Schistosoma*
Then

- Pre and Post Environmental Disaster – changes in nematode types
And Now

• Still highly linked to poor sanitation & living conditions
Water & Sewage
Challenges to attaining & maintaining potable water -
Given the impressive challenge pictured....
Let’s 1st Learn Some General Facts about Intestinal Nematodes

- Frequently nonspecific symptoms
  - Often asymptomatic until worm burden becomes large
  - Weight loss, GI discomfort
  - Diarrhea or fever from nematodes is uncommon

- Polyparasitism

- Burden is greatest in children
General Facts about Intestinal Nematodes

- Tropical and subtropical predominance
- Don’t multiply in host
  - 2 exceptions
- Infection limited to life span of worm unless reinfection occurs
  - Lifespan: 2 months – 5 years
- Rare Exceptions:
  - *Strongyloides, C. philippinensis*: autoinfection
  - Pinworm: self-reinfection
Soil Transmitted Helminths (STH) = Geohelminths

- Part of development occurs in the soil
- Average 3 – 4 weeks in soil until infective
- Infection via eggs in contaminated soil (*Ascaris, Trichuris*) or skin penetration (hookworm)
Soil Transmitted Helminths (STH)

- Infection rates and burden of disease greatest among conditions of poverty, poor sanitation
Epidemiology

- Helminths are widespread
- Prevalence highest in tropical, developing countries.
- In 2002, an estimated 1.5 billion, 1.3 billion, and 1.1 billion people were infected with Ascaris, hookworm, and Trichuris, respectively.
- Risk in travelers is low.
- Sporadic exposure less likely to produce symptomatic disease.
- Because eggs must pass through a developmental phase in soil before becoming infective or releasing infective larvae, soil-transmitted helminth infections are not transmitted person to person.
General: Hookworm Transmission

- Adult female worms in the intestine of infected people:
  - Produce eggs → eggs then excreted in the stool → defecation on the ground and use of stool to fertilize crops → eggs reach soil
    - Infection with Ascaris and Trichuris occurs when eggs in soil have become infective and are ingested
Hookworm Transmission Continued

• Hookworm eggs are not infective
  • release larvae in soil that can penetrate skin
• Infection primarily from skin contact with contaminated soil - walking barefoot
  • can also occur through ingestion of larvae
• Ascaris larvae, after they have hatched from eggs in the small intestine, & hookworm larvae, after they have penetrated the skin → lungs → become adult worms in the intestine
Clinical Presentation

- Most infections asymptomatic, especially if few worms present.
- Heavy infections & complications very rare in travelers.
- But very common in locals.
Case

- 2 young Haitian boys present to a clinic in Thomonde, Haiti.
- Report a 2-month history of progressive anorexia, fatigue, shortness of breath on exertion.
- No diarrhea.
- Each appears fatigued, but non-toxic.
- Vitals within normal limits except tachycardia.
- Weight not available.
- Lungs clear.
- Abdomen distended but not tender.
- No rashes.
What do you think is going on?
What do you think is the causative organism?
How would you diagnose it?
How would you treat them?
Concepts to Consider

- In Haiti, moderate to heavy Ascaris infections can impair the nutritional status of children.
- The most serious complication is intestinal obstruction, usually of the small intestine.
- Pulmonary symptoms - in small % of patients when Ascaris larvae pass through lungs.
  - Symptoms include cough, fever, & chest discomfort.
- Hookworm infection can lead to anemia & protein deficiency due to blood loss.
- Trichuris infection can cause blood loss from dysentery & rectal prolapse.
General Diagnosis

- Identify eggs on microscopic examination of a stool specimen.
- Adult Ascaris worms may occasionally be coughed up or found in stool or vomit.
Treatment

• Soil-transmitted helminth infections are usually treated with albendazole or mebendazole (more on this in a few slides)

• Both effective and well tolerated
Back to the impact the earthquake had on worms in Haiti:

• Several reports since the late 1990’s have found an increase in the prevalence of hookworm infections - specifically in areas of Haiti where intestinal parasites are common, but not hookworm previously.

• Changing environmental conditions, specifically deforestation & subsequent silting of river, cause periodic flooding with deposition of a layer of sandy loam topsoil and increased soil moisture → increased transmission of hookworms.
How can prior studies guide our approach now? What do we know about the effectiveness of mass treatment programs?

- Study in Leogane
- Annual mass drug administration (MDA) with: DEC (6 mg/kg) and Albendazole (400 mg in a single dose)
  - 1st conducted in October 2000
  - DEC for the program was provided by the World Health Organization (WHO)
  - Albendazole was donated by GlaxoSmithKline (Middlesex, UK)
Results

• Age-specific prevalence of intestinal helminth before (A) and after (B) two rounds of mass treatment.
• The prevalence of infection (%) is plotted for the indicated age groups. Ascaris is plotted with a dotted line with diamonds, Trichuris with a solid line with squares, and hookworm with a dashed line and triangles.
Results continued

- Intestinal helminth prevalence before & after mass treatment with diethylcarbamazine and albendazole.
Various Helminth Eggs
Haitian Children With Soil–Transmitted Helminth Infections

- Stunting, anemia, loss of IQ, diminished school performance
- Many years of lost primary schooling attributable to STH
Highest Worm Burdens in School-aged Children

Mean Worm Burden vs. Mean Age (years)
Growth Curve of Child With Soil-transmitted Infection
Ascaris lumbricoides

- 1/8th the world’s population infected
- Largest of nematodes infecting humans
- Adult habitat: small intestine (jejunum)
- Obligatory extra-intestinal migration (eosinophilia)
- Lifespan: 1 – 2 years
- Intensity of infection greatest in children, ages 5 – 10 years
Ascaris infection in Haiti and Paraguay
Ascaris

Geographic prevalence highest in warm, wet climates

1 adult female = 200,000 eggs/day
Pre-patency: 2 months

Pneumonitis: 4 – 16 days after infection, short duration (~3 wks)
Löeffler Syndrome (Pneumonitis)

Transverse sections of Ascaris larvae in pulmonary alveoli
Ascaris lumbricoides

- Larval phase: eosinophilia, pneumonitis

- Adult phase:
  - Malnutrition, Impaired Physical Growth
  - Mild abdominal discomfort → → Small bowel obstruction (in children, few as 60 worms)
  - Wandering ascaris: biliary tract obstruction, cholangitis, pancreatitis, liver abscess

- Treatment: Albendazole x 1 dose
Adult *Ascaris* worms migrating in liver
Ascaris causing intestinal obstruction.
Acute G.I. Obstruction from Ascaris
Ascariis
(roundworm):
The only
dematode ever
coughed or
vomited up
Result of chronic malnutrition from lack of food and from worm or parasitic GI infections: Protein Malnutrition
Whipworm: 
*Trichuris trichiuria*

- Adult habitat: caecum, colorectum
- No extra-intestinal phase
- Lifespan: 1 - 3 years
- 90% infections are asymptomatic
- Symptoms with heavy infections
  - Intensity of infection peaks by age 10
Pre-patency: 2 months
Whipworm:  
_Trichuris trichiura_

- Clinical Features:
  - Asymptomatic
  - Physical Weakness, Anemia
  - Stunted Growth, Cognitive Deficits
  - Stool frequency (12+/day), nocturnal stooling
  - _Trichuris dysentery syndrome_
  - _Trichuris colitis_
  - _Rectal prolapse_

- Treatment: Albendazole x 3 days.
Whipworm: Trichuriasis Colitis
Rectal Prolapse from Trichiuriasis
Whipworm Egg: 2 polar plugs
The Human Hookworms

_Necator americanus_
_Ancylostoma duodenale_
Hookworm: *Necator americanus & Ancylostoma duodenale*

- One – tenth the world’s population infected
  - Significant cause of anemia & protein malnutrition
- Adult habitat: small intestine
- Lifespan:
  - ~ 1 year (*A. duodenale*)
  - ~ 3 - 5 years (*N. americanus*)
- Worm burdens do not decline in adult years
Typical Age and Intensity of Infection Relationship

Mean Worm Burden (%)

Mean Age (y)

- **Trichuris**
- **Ascaris**
- **Hookworm**
Human Hookworm Infection

~600 million cases worldwide
(rural poverty >>>> urban slums)
44 million pregnant women infected
Iron-deficiency anemia: Physical & Intellectual Retardation
*Necator americanus* is the predominant hookworm species
Life Cycle of Hookworm

Pre-patency: months - year
Hookworm-Blood Loss

Adult worms injure their host by causing intestinal blood loss:

- Anticoagulants, Hemolysins, and Hemoglobinases
- 30 to 200 µL blood per day per hookworm
- Intestinal blood loss and Iron Deficiency Anemia
Adult Hookworms in Situ (1 cm)

Adult size: 0.5 – 1 cm

Daily eggs per worm: 5 – 20,000
Hookworm:

• Clinical Features:
  • Ground-itch —> Dry cough, wheezing (1-2 wks later) in primary infection
  • Abdominal discomfort
  • Progressive iron-deficiency anemia
    • 40 – 160 worms associated with Hgb < 11 g/dL
  • Failure to thrive, extreme fatigue
  • IQ loss
• Treatment: Albendazole x 1 dose
Hookworm Disease

Pallor and Facial Edema

Anasarca
At-Risk Populations for Hookworm Disease

- Women and Children: Low Iron Stores
- Children:
  - Physical growth stunting
  - Cognitive deficits and intellectual retardation
- Women of Child-bearing age
  - Puberty
  - Menstruation
  - Pregnancy
    - Increased Maternal Mortality (anemia)
    - Low Birthweight
    - Infant Mortality
School Based Deworming

- In 2001, (WHO) adopted a resolution aimed at the “deworming” of 75 percent of all at-risk school-age children by 2010,
  - Improvements in iron, Hgb status
  - Improved Cognition, Educational Achievement
  - Reduction in school absenteeism
  - Reduction in community helminth transmission of ascariasis & trichuriasis
Control

- Anti-helminthic drugs:
  - 50 million tablets of mebendazole donated per year by Johnson & Johnson
  - Albendazole available from GlaxoSmithKline for 2¢ per pill
- Currently no vaccine exists for ascariasis or trichuriasis
- Human Hookworm Vaccine Initiative (HHVI): Phase I trials
Pinworms (Enterobiasis, Oxyuriasis, Threadworm): Overview & Transmission

- Fecal-oral ingestion of egg
- Direct person-to-person contact
- Indirect contact via contaminated hands, dust, food, or objects (bedding, clothing, toys, bathwater, toilet seats)
- Incubation period from when the egg is ingested to when the adult worm migrates to the anus:
  - 1–2 months
  - Eggs can remain infective indoors for 2–3 weeks
- Humans are only known natural host
- Animal pinworms do not infect humans
Transmission Risks

- Poor hygiene (hand washing and poor toilet hygiene)
- Unsanitary or inadequate toilet facilities
- Crowded living conditions or living in same household as infected person
- Close day-to-day contact (living and working) with people, particularly institutionalized people or preschool- and school-age children

Pinworm (also known as seatworm), 150 micrometers
Clinical Presentation

- Asymptomatic, or
- Common symptoms include nocturnal perianal and perineal pruritus and restless sleep.
- Urethritis, vaginitis, salpingitis, hepatitis, or peritonitis may occur if adult worms migrate from the perineum to other sites.
Diagnosis

- Direct visualization: female worms
- Microscopic identification: worm eggs
- “scotch tape test”
- Eosinophilia is unusual (because of absence of tissue invasion)
- Serologic testing is not useful or widely available.
- Eggs and worms are rarely found in routine stool samples.
Treatment

- Antihelminthic x 1 dose; repeat in 2 weeks.
- Drugs of choice:
  - mebendazole, albendazole, or pyrantel pamoate.
- Treat all household contacts & caretakers at the same time
- Daily morning bathing removes a large proportion of eggs
- Change underclothing & bedding frequently & launder in hot water.
- Reinfection occurs easily
- Instruction about prevention is mandatory to eliminate continued infection and spread.
Strongyloidiasis: Strongyloides stercoralis

- Worldwide prevalence: ~100 million
- Adult habitat: duodenum, jejunum
Strongyloidiasis - Clinical Presentation

- Asymptomatic eosinophilia
- Abdominal pain
- Dermatitis - larva currens
- Pulmonary infiltrates with eosinophilia
- Dissemination with sepsis
Documented length of infections in years

<table>
<thead>
<tr>
<th>Condition</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongyloides</td>
<td>&gt; 60</td>
</tr>
<tr>
<td>Schistosomiasis</td>
<td>32</td>
</tr>
<tr>
<td>Burkholderia pseudomallei (Melioidosis)</td>
<td>26</td>
</tr>
<tr>
<td>Echinococcus (hydatid disease)</td>
<td>&gt;20</td>
</tr>
<tr>
<td>Trichinella larvae in muscle</td>
<td>18</td>
</tr>
<tr>
<td>Cysticercosis (Taenia solium)</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Onchocerciasis (adult worms)</td>
<td>10-15</td>
</tr>
</tbody>
</table>

Adapted from Hospital for Tropical Disease
London, 1997
Pruritic Larva Currens from *Strongyloides*

Larva currens = autoinfection with *Strongyloides* filariform larvae.
Strongyloides Rhabditiform Larvae may transform to Filariform Larvae… penetrating perianal skin and bowel mucosa.
Strongyloidiasis Hyperinfection: *Strongyloides stercoralis*

- **Hyper-Infection:**
  - intestinal perforation
  - hemorrhagic pneumonia
  - shock, sepsis, gram-negative meningitis
  - eosinophilia may be limited
Dear Who Ever you are —
I can’t believe what I just had to do and I damn sure can’t believe what you have to do — I thought I was dedicated to my job but this is something else — I really feel for you —
Good news:
Pre-departure treatment for intestinal parasites in US bound refugees

Since 1999, CDC has implemented empiric treatment with single dose albendazole for all refugees departing from sub Saharan Africa
To Review... General Truths about Nematodes

- Polyparasitism

- Burden greatest in children
  - except hookworm, *Strongyloides*

- Don’t Multiply in Host (2 exceptions)

- Eosinophilia = tissue invasion
  - Larval stages or *Strongyloides*
What is the most likely worm to be coughed or vomited up?

- *Trichuris*
- Hookworm
- *Strongyloides*
- Tapeworm
- *Ascaris*
Which worm infection do you ALWAYS want to treat?

- Ascaris
- Trichuris
- Strongyloides
- Pinworm
- Hookworm

Haitian male, in US for 8 years, developed fever, rash and pneumonia after being placed on steroids for uveitis.
Which worm’s burden of illness increases through your late childhood and early adulthood years?

- *Strongyloides*
- *Hookworm*
- *Ascaris*
- *Trichuris*
- *Pinworm*
Which worm infection is most likely to mimic colitis?

- *Trichuris*
- *Ascaris*
- *Strongyloides*
- Pinworm
- Hookworm
Which Nematode is the most likely to be the cause of eosinophilia in an immigrant/refugee from Africa who has been in America x 9 months?

- *Trichuris*
- *Strongyloides*
- Pinworm
- Hookworm
- *Ascaris*
When is the ideal time to check Stool O & P in Returning Traveler?

- IMMEDIATELY upon landing
- Within 1 week
- 1 month
- 2 months
- 6 months
- 1 year
Recommended References

TROPICAL INFECTIOUS DISEASES
Principles, Pathogens, & Practice,
Guerrant, Walker, Weller
Churchill Livingstone

MANSON’S TROPICAL DISEASES
Cook & Zumla
W.B. Saunders

ATLAS OF TROPICAL MEDICINE & PARASITOLOGY
Peters & Pasvol
Mosby Elsevier

RED BOOK
2006 Report of the Committee on Infectious Diseases
Table 4.10. Drugs for Parasitic Infections

COMMUNITY-WIDE REDUCTION IN PREVALENCE AND INTENSITY OF INTESTINAL HELMINTHS AS A COLLATERAL BENEFIT OF LYMPHATIC FILARIASIS ELIMINATION PROGRAMS

MADSEN BEAU DE ROCHARS et al