Hookworm

_Ancylostoma duodenale, Necator Americanus_

Intestinal Nematode

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Prepared as part of an education project of the Global Health Education Consortium and collaborating partners

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4.1 Epidemiology

- Common disease with at least 740 million people infected globally (estimates up to >1 billion)

- Causes more morbidity than any other geohelminth principally by consequences of iron-deficiency anemia
  - Hookworm infection is the leading cause of iron deficiency anemia worldwide

- Largely worldwide distribution, prevalent in all tropical and subtropical countries, especially sub-Saharan Africa, South China, Pacific and South-east Asia
4.2 Risk factors

- Poor sanitation
- Walking barefoot in soil contaminated with feaces
- Infection by *A. duodenale* probably also occurs by oral and transmammary route

Photo: http://www.johntyman.com/africa/a442.jpg
4.3 Biology

• Human infection caused by 2 hookworms
  o Small white-grey or reddish-brown thread like worms

• *Ancylostoma duodenale*
  o Buccal capsule containing 2 pairs of teeth for attachment to the small-intestinal mucosa
  o Male: 1 x 0.5 cm
  o Female: 1.2 x 0.6 cm
  o Maximum egg output 15-18 months after infection
  o Interval between infection and disappearance of eggs from stool with death of the worm averages 1 year
  o Female produces 25,000-35,000 eggs/day (18-54 million during its lifetime)
  o Adult worm lives 1-3 yrs (often longer)
4.3 Biology

• *Necator americanus*
  - Shorter and more slender than *A. duodenale* (1 x 0.4 cm)
  - Smaller buccal capsule than *A. duodenale*
  - Cutting plates instead of teeth
  - Eggs slightly larger than *A. duodenale* (70 x 40 μm)
  - Female produces ~20,000 eggs daily
  - Adult worm lives 3-10 yrs (3-5yrs for female worm)

• Humans are definitive host
4.3 Life cycle

- Eggs are deposited in duodenal lumen
- Leave body through feaces
- If deposited in damp shaded soil they hatch into rhabditiform larva (first stage)
  - Feeds on organic debris
  - Becomes elongated and fully developed
- Larva moult to form a filariform larva (infective stage → moves away from the feaces into soil)
- Protected from desiccation, they can live in warm damp soil for up to 2 yrs
- Filariform larva penetrates skin of host when contact initiated → receives host signal to resume development
- Enters vasculature → travels to lung → breaks through alveoli, moves up trachea, is swallowed and reaches small intestine
- During migration 3rd moult takes place, → upon arrival in intestine 4th moult
- Worm attaches to the small-intestinal mucosa where it sucks blood
- *A. duodenale* can also infect by ingestion
4.4 Pathology

• 3 stages (first two usually only seen in primary infection, during larva migration phase)

  o Invasive phase
    ▪ Vesiculation and pustulation at entry site

  o Migration via venous system through the lungs with small hemorrhages into the alveoli and eosinophilic and leucocytic infiltration
    ▪ Coughing, asthma and bronchitis (Loeffler’s Syndrome)
    ▪ Larvae moved up, either by coughing or ciliary escalator to pharynx where they are swallowed → move to intestines

  o Established infection by adult worms in intestine
    ▪ Seen in the inhabitants of endemic areas
    ▪ May be asymptomatic or, in case of severe infections, lead to anemia
4.4 Symptoms

• Initial invasive stage
  o Entry site of larva: ground itch (irritating vesicular rash)
    ▪ Limited to the area around entry points of the body (usually palms and soles, between toes)
  o Lasts up to 10 days

• Larva migration phase
  o Appear 1-2wks after the primary infection, and depend on worm burden
  o Pulmonary symptoms with dry cough, asthmatic wheezing, fever, high eosinophilia
    ▪ Wheezing less pronounced than with *A. lumbricoides*
  o Low-grade fever may be present
  o Entire episode usually of 2-3m duration – mostly self-limiting
4.4 Symptoms

- Later, established infection
  - Epigastric pain upon worm migration
    - Can be relieved by food → DDx: duodenal ulcer!
    - Symptoms peak at 30-45d after infection and gradually disappear
  - Occult blood in stools to frank melena
    - Results when hookworm detaches from one site in intestine to move to another location
  - Iron deficiency anemia
    - Occurs after iron stores are depleted
  - Protein-depleting enteropathy (hypoalbuminemia): puffiness, edema
  - Retinal hemorrhages
4.4 Symptoms

- Effects of anemia: malaise, digestive disturbance, no wasting
  - Each worm consumes .03-.6 mL of blood per day
  - Usually 40-160 worms are enough to cause anemia
  - 500-1000 = significant blood loss and anemia even in the presence of iron supplementation
  - Shortness of breath, high output heart failure

- Severe infection - persistent anemia in children may have severe long-term consequences
  - Stunting of growth and development, cognitive impairment
4.5 Diagnosis

- Detection in stool
  - Ova: thin clear shell
  - Sometimes also detection of rhabditiform larva in stool (DDx: Strongyloides)
  - Ova appears about 42d after infection
  - Sensitivity can be increased by examining multiple samples over consecutive days
  - Kato-Katz smear provides quantitative estimate (samples should be examined within an hour of preparation or earlier, depending on heat and humidity conditions)

- Serological diagnostic
  - Multiplex real-time PCR
4.6 Management/Treatment

- Treatment of anemia (iron supplementation)
- Treatment is targeted against adult stages
- Albendazole
  - 400mg single dose (80% cure rate)
  - 200mg daily x 3 days (100% cure rate)
- Mebendazole: only partially active and treatment over multiple days might be required for severe infections
- Levamisole and pyrantel pamoate are less effective
4.7 Control

- Proper disposal of faeces to minimize risk of contact with body
  - Provision/proper use of sanitation facilities

- Good hygiene to break fecal-oral transmission route

- In some (endemic) areas regular de-worming of children and examination of lactating mothers

Toxocariasis

ROUNDWORMS
5.1 Epidemiology

- Result of infection with dog ascarid *Toxocara canis* (most common) or the cat ascarid *Toxocara cati*
- Cosmopolitan in distribution
- Often associated with *A. lumbricoides* and *Trichuris trichiura* infection
- Mortality unusual; morbidity largely due to ocular involvement
  - Toxocariasis is an important cause of reduced visual acuity in tropical areas

Photo: http://www.cdc.gov/parasites/images/toxocariasis/home_page_image_toxocariasis.jpg
5.2 Risk factors

- Exposure to (particularly young) dog and cat faeces
  - Direct contact not necessary, as eggs need weeks of development in soil to become infective
  - Small children; more hand-to-mouth contact during play

- Outdoor parks in urban and suburban environments
  - Most likely to be contaminated by animal faeces
  - Children playing in the sand/soil higher risk of accidentally ingesting *Toxocara* eggs

- Pet ownership (litter)

- Geophagia (both in children and adults)
5.3 Biology

- Definitive hosts are dogs (*T. canis*) and cats (*T. cati*)

- Humans are incidental hosts; parasite does not undergo normal development in humans after ingestion

- Infected embryonated eggs ingested after exposure from soil/sand contaminated by dog/or cat faeces

- Eggs ruptured in GI tract, releasing larvae; further development is arrested at the larval stage

- Morphology similar to *A. lumbricoides*
  - Male worms: 40 – 60 mm long; Female worms: 65 - 100 mm long
  - Eggs: 85 x 75 µm
5.3 Biology

- Larvae survive in humans for months to years, causing damage to tissues as they wander through body
  - Complex mechanisms to evade immune system

- 3 recognized syndromes
  - Covert toxocariasis (long-term exposure to migrating juvenile larvae)
  - Visceral larva migrans (VLM)
  - Ocular toxocariasis (ocular larva migrans or OLM)

Photo: https://cms.revoptom.com/handbook/IMA/GES/oct02_sec5_fig7.jpg
5.3 Life cycle

- Life cycle in cats and dogs is similar to *A. lumbricoides* infection in humans.
- Difference: transplacental infection is common with offspring shedding numerous eggs from birth.
- Adult animals excrete few eggs.
- Dogs/cats are infected by ingesting eggs from contaminated soil.
- Eggs hatch in stomach of humans.
- Second stage larvae penetrate mucosa to enter circulation via the mesenteric vessels → intestinal viscera and liver → may stay there or travel to lungs, brain, eye.
- Larvae are eventually destroyed by granulomatous reaction → blocks further migration and causes pathology.
- Larvae can remain alive for > 11yr in humans.
5.4 Pathology

• Visceral larva migrans (VLM)
  o Stage larvae are arrested mostly in the liver where they cause few or many lesions. Granulomas form which can be seen as white subcapsular nodules
  o Other sites: lungs, kidneys, heart, striated muscle, brain, eye

• Ocular toxocariasis
  o Granulomatous reaction forms a large subretinal mass with a superimposed pathology of choroiditis which can closely resemble retinoblastoma

• Tissue damage due more to host inflammatory response to larvae than to parasite itself
5.5 Symptoms

- Symptoms depend on intensity of infection; most cases asymptomatic

- Incubation period dependent on worm burden (weeks to years)

- VLM can be self limiting to lethal (unusual)

- Ocular lesions can lead to strabismus, decrease in vision or blindness

- Milder infection more common in adults: ocular toxocariasis
5.5 Symptoms – Covert toxocariasis

• Covert toxocariasis in children (mainly <5yrs) usually subclinical or mild febrile illness
  o May result from long term exposure to migrating juvenile larvae
  o Can manifest as cough, behavioural or sleeping problems, headache, chronic/recurring abdominal pain, anorexia

• May also have lymphadenitis, hepatomegaly

• *Toxocara* titres lower than in VLM, and eosinophilia less common and less pronounced

• Long-term exposure of larvae to lungs can lead to asthma
5.5 Symptoms - VLM

- Classic VLM syndrome
  - Fever, coughing/wheezing, anemia, hepatomegaly, eosinophilia, positive *Toxocara* titre
  - Most commonly with heavy infection in childhood

- Pulmonary signs (e.g. coughing, wheezing), asthma

- Cardiac dysfunction

- Nephrosis

- CNS involvement: aseptic meningitis, mass lesions causing seizures*, paresis (spinal cord lesions)

*less common, but may contribute to higher rates of epilepsy in parts of developing countries with high infection rates
5.5 Symptoms – Ocular toxocariasis

- Usually unilateral

- Presenting symptoms is often strabismus due to macular damage → low grade iridocyclitis can progress to general endophthalmitis and retinal detachment
  - Eye pain

- If lesion is central → decrease in visual acuity

- Solid retinal tumor close to macula

- In early stages closely mimics retinal neoplasm since it is raised above the level of the retina

- Later lesion remains a clear-cut circumscribed area of retinal degeneration
5.6 Diagnosis

- SVLM
- Stable persistent eosinophilia (sometimes >70%), leucocytosis, hypergammaglobulinemia
- Decreased albumin:globulin ratio, increase in IgG, IgH, anti-A and anti-B isohemaglutinin titres
- High resolution ultrasonography: hypoechoic areas in liver
- Demonstration of larvae is difficult and seldom achieved, sometimes found partially destroyed in centre of granuloma
- Serology: ELISA using excretory-secretory antigens harvested from second stage larvae in vitro
  - Sensitivity > 95%, specificity > 90%
  - Can be improved by indirect Ab – competition: e.g. specific IgE, IgG4
- Ocular toxocariasis
  - Ophthalmological examination; second stage larvae rarely seen with slit-lamp microscope in anterior chamber of eye
5.7 Treatment

- **Anti-helminthic therapy for VLM**
  - Albendazole (preferred), Mebendazole, Thiabendazole
  - DEC reportedly more effective than benzimidazoles but more adverse reactions

- In VLM, eosinophilia may persist over months after clinical cure (decrease in hepatomegaly, subsiding fever)

- Possible increased inflammatory reaction during therapy; corticosteroids often beneficial

- Treatment of OLM more difficult, surgical therapy may be needed for severe disease

- Recurrence unlikely, providing risk factors mitigated
5.8 Control

- Breaking hand-to-mouth transmission especially in children
  - Hand washing before eating, especially after handling pets, pet litter or soil
- General education on disease, transmission and risk factors for toxocariasis
- Animal control in public areas
  - Fencing, limiting access to playgrounds
- Regular de-worming of dogs and cats

Photo: http://www.vetbiomed.murdoch.edu.au/nombatnews/content_images/Deworming-CommunityProject.JPG
Dracunculiasis

Guinea worm disease
6.1 Epidemiology

- Dracunculus = Latin “little dragon”; also called “Guinea fire worm”
- Infection caused by nematode *Dracunculus medinensis*
- Found in abundance in natural freshwater bodies
- Presence is an indicator of extreme poverty
- Mortality is low - associated with untreated secondary infection
- Morbidity is high - associated with months of debilitating pain, incapacitation

Photo: http://plpnemweb.ucdavis.edu/nemaplex/taxadata/Dmedinensis.HTM
6.1 Epidemiology

- > 3.5 million cases, in 20 countries, reported in the 1980s
- Following eradication campaigns since 1986, dramatic reduction (>99%) in reported cases
  - 5,000 in 2008
  - <1,800 in 2010 (94% in South Sudan)
- Sustained campaigns (largely by Carter Center) of community education, safer water provision (especially using appropriate filters), political mobilization
- Remains endemic in only 6 African countries: Ethiopia, Ghana, Mali, Niger, Nigeria and Sudan

6.1 Distribution

Certification of Dracunculiasis Eradication
Status as of January 2005

Countries not yet certified
Endemic countries (reporting indigenous cases in 2004)
Countries under pre-certification surveillance
Countries and territories certified free of transmission

Data Source: WHO
Map Production:
Public Health Mapping & GIS
Communicable Diseases (CDS)
World Health Organization
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6.2 Risk factors

- Dependence on poor quality drinking water, unsafe water sources
- Drinking water from still freshwater reservoirs
  - Ponds, shallow wells, streams, etc.
- Contact of affected individuals with water sources, continuing transmission cycle
- Civil unrest, hindering other efforts to control disease and associated risk factors (e.g. S. Sudan)
6.3 Biology

- Nematode parasite related to filarial worms
- Larvae released into water by adult female worms
- Vectors: cyclopoid copepods (water fleas) – tiny free swimming crustaceans – swallow larvae after release
  - Development within vector, larvae infective after ~ 3wks
- Humans acquire infection by drinking water containing the copepod vectors infected with guinea worm larvae
- Stomach digestive acids kill copepods, but not larvae
  - Larvae migrate through stomach wall into subcutaneous tissue of abdomen, thorax
• After 2-3 months, worms develop and mate, after which males die; females continue their development and migration.

• Adult female guinea worm
  - Up to 60-80cm long and 1.5-2mm thick
  - Inhabits the subcutaneous connective tissues of humans
  - Located anywhere in the body; in late stage usually attracted to lower extremities (most likely to come into contact with water)

• Formation of blister, which bursts after ~48hrs

• Female worm protrudes its tip through resulting ulcer, releasing fluid filled with larvae upon contact with water.

• Embryos taken up by vector, and cycle begins again.
6.3 Life cycle

• Human is seeking freshwater reservoir for relief → blister ruptures → discharge of first stage larvae into water

• It remains protruding for the next 2-6 weeks, releasing larvae each time

• Larvae are infective in water for 5-6 days

• For further development must within this period be swallowed by a copepod → penetrates gut wall and reaches the infective 3rd stage within 2 weeks
6.4 Symptoms

- Usually asymptomatic in **prepatent period** (interval between infection of an individual by a parasitic organism and the first ability to detect from that host a diagnostic stage of the organism)

- First symptoms occur a few days prior to the worm piercing the skin, and largely related to hypersensitivity reaction

- If worm is close to joint may also cause arthritis

- Dermis becomes elevated and blister develops
  - with intense burning, itching sensation
  - ~24-48 hrs later blister bursts
  - Intense sensations provoke patient to submerse area in water, which relieves some of the burning sensation
Further inflammation or calcification of worms may cause stiff joints in lower limbs → crippling of patient

If secondary bacterial infection of ulcer (common), cellulitis or tetanus can develop

If worm is only incompletely extricated, the worms withdraws into the host causing a severe inflammatory reaction with ulcer formation and scarring

Encysting or calcification of worms, sterile subcutaneous abscess formation

Rarely migration of worms to vital organs
  - Brain - cerebral/subdural abscess can develop
  - Eyes - blindness can develop
6.4 Symptoms

Ulcer formed after worm emerges from burst blister; these frequently become infected.

(Photo credit: Global 2000 / The Carter Center)
6.5 Diagnosis

• Diagnosis usually clinical; cannot diagnose in prepatent period = first 8-10 months of infection
  o Shortly prior to appearance the worm can sometimes be palpated under the skin
  o Later: observing female protruding from the blister
  o Typical appearance of blister with local itching, burning pain

• Serology is of no practical use in diagnosis
  o Constant exposure in high endemic areas – variably detectable antibody titers
  o No acquired immunity
  o People in endemic areas suffer from repeated infections

• High eosinophilia is common

• Dead calcified worms can be seen on radiographic imaging
6.6 Treatment

- Affected areas should be kept clean & bandaged
- Most effective: slow extraction of emergent guinea worm
  - Protruding part of the adult female worm is attached to a stick, which is twisted a small amount each day until the whole worm has been removed (can take up to a month)
  - Care should be taken not to break the worm
  - Should be accompanied by supportive antibiotics, cleaning and dressing of ulcers as well as Tetanus vaccination
- Antibiotics for secondary/superinfection
- Analgesics for pain

Photo: http://www.parasitemuseum.com/wp-content/gallery/guinea-worm/guineaworm2j_lores.jpg
6.6 Treatment

Slow extraction of adult female worm after emergence from blister

6.6 Treatment

- Surgical extraction of the guinea worm prior to eruption – has resulted in less associated disability
  - However, not widely available in problematic area

- No curative antihelminthic treatment is available
  - Niridazole has been reported to decrease inflammation around the worm, allowing for easier extraction
  - Metronidazole, thiabendazole (adults) also used as adjunct to stick removal; however to be used with caution due to one study’s finding that these were associated with aberrant migration of worms
6.7 Control

• Community education on disease & transmission
  o Educating affected individuals not to immerse the affected areas in water which is used for public consumption

• Promotion and provision of safe drinking water sources

• Boiling water

• Point-of-use filtration of drinking water to “strain” copepods
  o Nylon filters, straw filters
  o Low-cost methods effective, e.g. filtration through clean cloth

• Larvicide to kill copepods
6.7 Control

Simple filtration of water to remove copepod vectors

(Photo: Carter Center/L. Gubb)
6.7 Control

Pipe filters: portable, for use anytime and at any water source available.

Photo: Carter Center / L. Gubb
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