Methodenseminar

Helminths and Helminthiasis

I. Schabussova
(SS 2014)

Institute of Specific Prophylaxis and Tropical Medicine
Medical University Vienna
Introduction and overview

- Parasites
- Helminths
- Developmental stages
- Transmission
- Life cycle
- Localisation
- Clinical presentation
- Diagnosis
- Treatment
- Examples
Parasite

- **CDC:** A parasite is an organism that lives on or in a host & gets its food from its host.

- **Schmidt & Roberts (1985):** "Parasites are those organisms studied by people who call themselves parasitologists."

- **Latin:** parasītus - a person who lives by amusing the rich

- **Greek:** parasītos – a person who eats at someone else's table
Parasite infestation & Parasitosis

- **Parasite infestation**: presence of parasites in/on the host *without* clinical manifestation

- **Parasitosis**: presence of parasites in/on the host *with* clinical manifestation (disease)
Incubation period & Prepatent period

- **Incubation period**: the period between the infection of an individual by a parasite and the manifestation of the disease it causes.

- **Prepatent period**: the period between infection with a parasite and the demonstration of the parasite in the body - determined by the recovery of an infective form (oocysts, larvae, or eggs) from the blood, urine or feces; is usually shorter than the incubation period.
Host, Definitive host, Intermediate host & Reservoir

- **Host**: is an organism that harbors a parasite, typically providing nutrition and shelter.

- **Definitive host/primary host**: is a host in which the parasite reaches maturity and, if possible, reproduces sexually.

- **Intermediate host/a secondary host**: is a host that harbors the parasite only for a short transition period, during which (usually) some developmental stage is completed.

- **Reservoir host**: can harbour a pathogen indefinitely with no ill effects. A single reservoir host may be reinfected several times.
Paratenic host & Dead-end host

- **Paratenic host:**
  - is similar to an intermediate host
  - it is not needed for the parasite’s development cycle to progress
  - serves as "dumps" for non-mature stages of a parasite in which
    - they can accumulate in high numbers

- **Dead-end host:**
  - or incidental host
  - an intermediate host that does not allow transmission to the definitive host
  - preventing the parasite from completing its development

- *Humans are dead-end hosts for Echinococcus canine tapeworms. As infected humans are not usually eaten by dogs, foxes etc., the immature Echinococcus - although it causes serious disease - is unable to infect the primary host and mature*
Helminths

- Helminths is a polyphyletic group of morphologically similar organisms
- the helminths are worm-like parasites
- multicellular eukaryotic invertebrates
- with tube-like or flattened bodies
- bilaterally symmetrical

- Consisting of members of the following taxa:
  - **Nemathelminthes** (Nematoda; roundworms)
  - **Platyhelminthes** (flatworms):
    - Cestoda (tapeworms)
    - ´Trematoda (flukes)
Helminths

Roundworms (Nematodes)
• adult & larval roundworms are bisexual, cylindrical
• they inhabit intestinal & extraintestinal sites

Tapeworms (Cestodes)
• adults are elongated, segmented, hermaphroditic
• inhabit the intestinal lumen
• larval forms are cystic or solid
• larval forms inhabit extraintestinal tissues

Flukes (Trematodes)
• adult flukes are leaf-shaped
• prominent oral & ventral suckers help maintain position in situ
• hermaphroditic except for blood flukes: bisexual
• the life-cycle includes a snail intermediate host
Life-cycle stages
Nematode cycle

- egg - larvae (L1-L4) - adult
Cestode cycle

egg - metacestode - adult
Trematode cycle

egg-miracidium-sporocyst-redia-cercaria-(metacercaria)-adult
Transmission
Faecal-oral transmission

- eggs or larvae passed in the faeces of one host & ingested with food/water by another
- ingestion of *Trichuris* eggs leads directly to gut infections in humans
- the ingestion of *Ascaris* eggs & *Strongyloides* larvae leads to a pulmonary migration phase before gut infection in humans
Transdermal transmission

- Infective larvae in the soil (geo-helminths) actively penetrating the skin and migrating through the tissues to the gut
- In the gut adults develop and produce eggs that are released in host faeces
- Larval hookworms penetrating the skin, undergoing pulmonary migration and infecting the gut where they feed on blood
Vector-borne transmission

- Larval stages taken up by blood-sucking arthropods or undergoing amplification in aquatic molluscs
- *Onchocerca* microfilariae ingested by black fly and injected into new human hosts
- *Schistosoma* eggs release miracidia to infect snails where they multiply and form cercariae which are released to infect new hosts
Predator-prey transmission

- Encysted larvae within prey animals (vertebrate or invertebrate) being eaten by predators where adult worms develop and produce eggs
- *Dracunculus* larvae in copepods ingested by humans leading to guinea worm infection
- *Taenia* cysticerci in beef and pork being eaten by humans
- *Echinococcus* hydatid cysts in offal being eaten by dogs
Transmission: *Ascaris lumbricoides*
Transmission: Hookworms

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
Transmission: Filaria

Mosquito Stages:
1. Mosquito takes a blood meal (L3 larvae enter skin)
2. L3 larvae
3. Migrate to head and mosquito’s proboscis
4. L1 larvae
5. Microfilariae shed sheaths, penetrate mosquito’s midgut, and migrate to thoracic muscles
6. Infective Stage
7. Diagnostic Stage
8. Adults in lymphatics

Human Stages:
1. Mosquito takes a blood meal (ingests microfilariae)
2. Adults produce sheathed microfilariae that migrate into lymph and blood channels
3. Adults in lymphatics

CDC
http://www.dpd.cdc.gov/dpdx
Transmission: *Diphyllobothrium latum*

1. Unembryonated eggs passed in feces
2. Eggs embryonate in water
3. Coracidia hatch from eggs and are ingested by crustaceans.
4. Proceroid larvae in body cavity of crustaceans
5. Proceroid larva released from crustacean, develops into plerocercoid larva
6. Predator fish eats infected small fish
7. Human ingests raw or undercooked, infected fish
8. Adults in small intestine
9. Proglottids release immature eggs

Infective Stage: $i$
Diagnostic Stage: $d$

Transmission route:
1. Eggs are passed in feces.
2. Eggs embryonate in water.
3. Coracidia hatch from eggs and are ingested by crustaceans.
4. Proceroid larvae develop in the body cavity of crustaceans.
5. Proceroid larvae are released and develop into plerocercoid larvae.
6. Plerocercoid larvae are ingested by small freshwater fish.
7. Predator fish feed on infected small fish.
8. Humans ingest raw or undercooked infected fish.
9. Adult worms develop in the small intestine.

*parasitesinhumans.org*
Transmission: *Taenia* spp.
Localisation
Lokalisation in the gut

- **Small intestine:**
  - *Trematodes, Taenia, Hymenolepis, Strongyloides, Hookworms, Trichuris, Ascaris*

- **Large Intestine:**
  - *Enterobius vermicularis*

*Ascaris lumbricoides* in the gut

*Cross-section of Trichuris trichiura in the gut*

*Enterobius vermicularis* in the colon
Lokalisation in the eye

Adult *Loa loa* in the eye

Male *Wuchereria bancrofti* in the anterior chamber of the eye 20µm long
Lokalisation in the skin

Cercarial dermatitis (Swimmer’s Itch): penetration of the skin by cercariae may give rise to an itchy rash (due to avian schistosomes)

Larva of hookworm in the epidermis of a foot
Lokalisation in the lymphatic vessels

Wuchereria bancrofti in an occluded lymphatic vessel
Lokalisation in the liver

Granuloma surrounding egg of *Schistosoma mansoni* in liver

Schistosomal periportal fibrosis of the liver
Lokalisation in the lungs

Transverse section of *Ascaris lumbricoides* larvae in the pulmonary alveoli
Lokalisation in the muscle

*Trichinella spiralis* larvae in muscle from a fatal human case
Encysted larvae remain alive for years

Calcification of the encysted larvae occurs after 18 months - detected by X-ray
Lokalisation in the brain

*Brain biopsy: cross section of a larva of Baylisascaris procyonis from a child with neural larva migrans*
Clinical Presentation
Cercarial dermatitis
Cerebral cysticercosis

larval cysticercoid in pig meat

Magnetic resonance imaging coronal section of brain

Computer tomography Cysticercus with surrounding oedema
Larva migrans

**Periorbital larva migrans**
Migrating subcutaneous swelling associated with pain and eosinophilia
Gnathostoma larvae may be recovered surgically from swellings

**Cutaneous larva migrans**
“creeping eruption”
Infected larvae of *Ancylostoma* fail to penetrate the human dermis, migrate through the epidermis, leaving typical tracks
Lymphatic Filariasis (Elephantiasis)

filarial worms lodge in the lymphatic system
Onchocerciasis

“Hanging groin” & scrotal elephantiasis

skin disease, including nodules under the skin or debilitating itching

River blindness

visual impairment or blindness
Hydatidosis

Hydatid cyst in the liver

Hydatid cyst in the brain
Signs and Symptoms

- diarrhoea, gastrointestinal upset, vaginal irritation, joint pain, mucous in stools, abdominal cramps & gas, loss of appetite, coughing, fever, vomiting
- generally feeling unwell, immune dysfunction, allergies, anemia, lethargy, fuzzy thinking, headaches, restlessness, hair loss, arthritis, mineral imbalances
- may last for weeks and return several times a year
- one or more symptoms
- in North America and Europe, parasites rarely cause serious complications
Diagnosis: Microscopic examination

Detection of parasites or eggs

- “Scotch tape test”
- Fecal/stool exam
  Kato-Katz Technique
Diagnosis: Endoscopy

Detection of parasites or other abnormalities that may be causing signs & symptoms

A Case of Tapeworm Infection Observed by Video Capsule Endoscopy
Diagnosis: Colonoscopy

• 58 year old American man who frequently travels to Guatemala was screened for colonoscopy
• was asymptomatic
• visualized here were numerous white worms seen throughout the colon
• Addendum: parasites were confirmed to be Pinworms, including several egg sacs which were recovered in the aspirate
Diagnosis: Blood test

Blood tests look for a specific parasite infection

- **Serology**
  used to look for antibodies or for parasite antigens

- **Blood smear**
  used to look for parasites that are found in the blood; e.g. filariasis can be diagnosed
Diagnosis: X-ray, MRI, CAT, PCR

- **X-ray, Magnetic Resonance Imaging scan (MRI), Computerized Axial Tomography scan (CAT)**
  - used to look for some parasitic diseases that may cause lesions in the organs

- **Molecular Diagnosis**
  - the stool specimen can be analyzed using molecular techniques such as PCR
  - PCR amplified fragments can be analyzed by using restriction fragment length polymorphisms (RFLP) or DNA sequencing if further characterization is needed
Size varies greatly: from 0.1mm – 20m

<table>
<thead>
<tr>
<th>size</th>
<th>Parasite</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 – 10 mm</td>
<td>Schistosoma sp., Trichinella sp.,</td>
</tr>
<tr>
<td>1 cm – 1 m</td>
<td>Fasciola hepatica, Brugia malayi</td>
</tr>
<tr>
<td>&gt; 1m</td>
<td>Taenia sp., Diphyllobothrium latum</td>
</tr>
</tbody>
</table>
Trichuris trichiura (A,B); Enterobius vermicularis (C); Trichinella spiralis (D,E); Ancylostoma duodenale (F,G) Necator americanus (H,I)
Treatment: Endoscopic removal: *Anisakis*

Endoscopy showed an active duodenal ulcer, about 10 mm 5 mm away from the ulcer margin, a whitish *Anisakis* larva was found with half of its body penetrating the duodenal mucosa.

The worm was removed by using biopsy forceps.

Endoscopy after treatment showed complete healing at the duodenal ulcer site and no *Anisakis*. 
Treatment: Surgical removal

12 years old male showing a hydatid cyst of the liver with spontaneous rupture in peritoneum
Treatment: Surgical removal

a peritoneal echinococcosis

a peritoneal echinococcosis
WHO Model List of Essential Medicines
Antihelminthics

- are selected with regard to disease prevalence, safety, efficacy, and comparative cost-effectiveness
- includes over 350 medicines to treat priority conditions
- is updated every two years, using a transparent evidence-based process

- **Intestinal antihelminthics**
  - Albendazole
  - Levamisole
  - Mebendazole
  - Niclosamide
  - Praziquantel
  - Pyrantel

- **Antifilarials**
  - Albendazole
  - Diethylcarbamazine
  - Ivermectin

- **Antischistosomals & other antitrematode medicines**
  - Praziquantel
  - Triclabendazole
  - Oxamniquine
Mebendazole

- Benzimidazole drug
- a heterocyclic aromatic organic compound
- It is used to treat infestations by pinworms, roundworms, tapeworms, hookworms, & whipworms
- It is on the WHO List of Essential Medicines
- The drug is a highly effective, broad-spectrum

**Adverse effects**
- Mebendazole is relatively free of toxic side effects or adverse reactions, although patients may complain of transient abdominal pain, heart pain, diarrhea, slight headache, fever, dizziness, or urticaria
Mebendazole

- **Contraindications**
  - Mebendazole is contraindicated in pregnant women because it has been shown to be embryotoxic & teratogenic in experimental animals.

- **Mechanism**
  - selectively inhibits the synthesis of microtubules in parasitic worms.
  - destroys cytoplasmic microtubules in their intestinal cells, thereby blocking the uptake of glucose and other nutrients, resulting in the gradual immobilization & eventual death of the helminths.
Praziquantel (PZQ)

- It is on the World Health Organization's List of Essential Medicines

- **Treatment:**

  - **Hydatid disease** caused by infection of various organs with larval stages of tapeworms of the genus *Echinococcus*

  - **Cysticercosis** caused by infection of the brain and/or muscles with the eggs & larvae of the pork tapeworm *Taenia solium*

  - **Schistosomiasis** caused by trematodes of the genus *Schistosoma*; it is usually effective in a single dose
Praziquantel: Side effects

- majority of side effects develop due to the release of the contents of the parasites as they are killed & the consequent host immune reaction
- the heavier the parasite burden, the heavier & more frequent the side effects
- dizziness, headache, & sickness
- ~ 90% of all patients have abdominal pain or cramps with or without nausea & vomiting
- diarrhea, sweating, fever
- asymptomatic & transient increases of liver enzymes are noted frequently
- sensitivity reactions: urticaria, rash, & eosinophilia
- generally: lower back pain, fever, & sweating
Praziquantel: Mechanism of action

• the mode of action is not exactly known
• Experimental evidence: PZQ increases the permeability of the membranes of schistosome cells towards Ca ions
• induces contraction of the parasites
• parasites are removed & may enter systemic circulation or may be destroyed by host immune reaction (phagocytosis)

• Additional mechanisms including disturbances of laying of eggs are seen in other types of sensitive parasites

• The drug seems to interfere with adenosine uptake in cultured worms, may have therapeutical relevance given that the schistosome, as the taenia and the echinococcus is unable to synthesize adenosine de novo
Performance and Safety of Praziquantel for Treatment of Intestinal Schistosomiasis in Infants and Preschool Children

José C. Sousa-Figueiredo¹,², Martha Betson¹, Aaron Atuhaire³, Moses Arinaitwe³, Annalan M. D. Navaratnam⁴, Narcis B. Kabatereine³, Quentin Bickle², J. Russell Stothard¹*

¹ Disease Control Strategy Group, Liverpool School of Tropical Medicine, Liverpool, United Kingdom, ² Department of Infectious and Tropical Diseases, London School of Hygiene and Tropical Medicine, London, United Kingdom, ³ Vector Control Division, Ministry of Health, Kampala, Uganda, ⁴ Department of Infectious Disease Epidemiology, Imperial College London, London, United Kingdom

Background: In 2012 the WHO formally recognized that infants and preschool children are at significant risk of schistosomiasis and qualify for treatment with PZQ

- Study determining both the performance & safety of PZQ in endemic area
- cohort of *Schistosoma mansoni*-infected children (aged 5 months–7 years old) in Uganda
- overall observed parasitological cure was 56.4%
- side-effects: mild and transient
Treatment: Mass drug administration (MDA)

- MDA treated: hookworm, *Ascaris*, whipworm, river blindness, lymphatic filariasis, schistosomiasis
- Since the drugs used are safe and inexpensive or donated, entire risk groups are offered preventive treatment
- MDA are conducted periodically (annually), commonly with drug distributors who go door-to-door
- multiple NTD are often treated simultaneously using MDAs
- Praziquantel
Ascaris lumbricoides
A. lumbricoides

- roundworm
- affects ~ 1 billion people worldwide
- 60,000 deaths/year mainly in children
- ascariasis: soil-transmitted helminthiasis (STH)
- one of the most common intestinal worm
- is found in association with poor personal hygiene, poor sanitation, in places where human feces are used as fertilizer of green-leaf vegetables (no adequate washing)
- the geographic distributions: worldwide in areas with warm, moist climates (tropical & subtropical areas)
The parasite: Adults

♀: 20 - 35 cm
♂: 15 - 30 cm
The parasite: Eggs

- Infertile
- Fertile

- Can survive for prolonged periods
- Warm, shade, moist conditions
- Can live up to 10 years
- Are removed by filtration and killed by boiling
- Oval to round; 40-75 µm
Life cycle

- Adults live in the lumen of the small intestine
- ♀ produce ~ 200,000 eggs/day
- Eggs passed with the feces
- Fertile eggs embryonate and become infective after 18 days - wk (optimum: moist, warm, shaded soil)
- Infective eggs are swallowed
- The larvae hatch; invade the intestinal mucosa, are carried via the portal, then systemic circulation to the lungs
- Larvae mature in the lungs (10-14 d), penetrate the alveolar walls, ascend the bronchial tree to the throat, are swallowed
- In the small intestine they develop into adult worms
- Cycle: 2-3 months
- Adult worms can live 1-2 years
Disease in the lungs

- often without symptoms
- light symptoms include abdominal discomfort
- heavy infections can cause intestinal blockage & impair growth in children
- Cough: due to migration of the worms through the body
  persistent cough, shortness of breath, wheezing – asthma like
- pulmonary eosinophilia (Loeffler’s syndrome)

Transverse sections in the pulmonary alveoli
Disease in the intestine

mild or moderate ascariasis:
• vague abdominal pain
• nausea and vomiting
• diarrhea or bloody stools

heavy intestinal ascariasis:
• severe abdominal pain
• tiredness
• vomiting
• weight loss
• worm in vomit or stool
• intestinal obstruction
Diagnosis

- examination of a fecal sample for eggs under a microscope

- Ultrasonography and radiology are the most appropriate tools to diagnose intestinal and biliary obstruction as well as to detect other abdominal localization of the worms.
Treatment

- **Mebendazol**
  - Pantelmin®, 100 mg- pills
  - 2 x 100 mg, 3 consecutive days

- **Albendazol**
  - Eskazole®, 400 mg- pills
  - 1 x 400 mg
Prevention

- Availability of water for use in personal hygiene
- Sanitation & education to promote using latrines
- Education on hand washing & washing of food
- Avoiding the use of uncomposted human feces as fertilizer
- Mass chemotherapy:

  Mebendazole & Albendazole administered in a single dose are safe, relatively inexpensive, & effective for several months
Ancylostoma duodenale & Necator americanus

The Hookworm infections
Human hookworm infection

- *A. duodenale* & *N. americanus*
- Soil-transmitted helminths; roundworms
- distribution in rural areas of sub-Saharan Africa, Latin America, Southeast Asia, & China
- afflicts an estimated 740 million people

*N. americanus* is the most common hookworm worldwide
*A. duodenale* is more geographically restricted
Ecology

- In tropical & subtropical areas wet soil supports the maturation of hookworms larvae from eggs deposited by indiscriminate defecation
- (at the edges of rice field, rubber plantation, in areas of high rainfall)
Symptoms

- irritation of skin at the site of penetration (dermatitis)
- abdominal pain
- diarrhea
- loss of appetite
- weight loss
- tiredness
- difficulty breathing
- cardiomegaly
- irregular heartbeat
- extreme cases include stunted growth and mental retardation
Hookworm infection is the leading cause of anemia in developing nations.

Blood film with a patient with hookworm anaemia

IRON DEFICIENCY ANEMIA

- Hypochromic
- Microcytic
- Pigmented neutrophils

Numerous platelets

Red cells

low serum iron
low ferritin levels
Risk groups

- **pregnant women**
  - anemia results in several adverse outcomes for both the mother & her infant
  - low birth weight, impaired milk production, & increased risk of death for both the mother & the child

- **children**
  - chronic hookworm infection has been shown to impair physical & intellectual development, reduce school performance & attendance, & adversely affect future productivity
Life cycle

- Eggs are passed in the stool.
- Larvae hatch in 1-2 days.
- Released larvae grow in the feces and/or the soil.
- After 5-10 days (2 molts) – infective filariform L3 can survive 3-4 wk.
- Larvae penetrate the skin.
- Carried through the blood vessels to the heart and then to the lungs.
- Penetrate into the pulmonary alveoli.
- Ascend the bronchial tree to the pharynx; are swallowed.
- Larvae reach the small intestine.
- Mature into adults.
- Adult worms live in the lumen of the small intestine, where they attach to the intestinal wall.
- Most adult worms are eliminated in 1-2 years, but the longevity may reach several years.

- *A. duodenale*: oral and transmammary.
- *N. americanus* requires transpulmonary migration phase.
Diagnosis

- definitive diagnostic is established by identifying hookworm eggs in feces under light microscopy
- quantitative methods of egg count
- **Kato-Katz** can be used to provide information on the intensity of infection

- Recent research has focused on the development of DNA-based tools for diagnosis of infection
- Because hookworm eggs are often indistinguishable from other parasitic eggs, PCR assays could serve as a molecular approach for accurate diagnosis of hookworm
Diagnosis: Capsule endoscopy

**Capsule endoscopy:** hookworms in the small bowel
A: Hookworms attached onto the mucosal surface, withdrawing blood, which can be seen inside their gut; B,C: Bleeding caused by the parasites.

The capsule is the size and shape of a pill & contains a tiny camera.
Treatment

- Mebendazol (2 x 100 mg/d  3 days)
- Albendazol (2 x 400 mg/d  3 days)
- Pyrantel (11 mg/kg 3 days)

- oral iron supplementation!!
Prevention

- not to walk barefoot in areas where hookworm is common and where there may be human fecal contamination of the soil

- Infection can also be prevented by not defecating outdoors & by effective sewage disposal systems
Enterobius vermicularis
The parasite

- Pinworm; small, white round worm
- Has a direct life cycle with no tissue migrate phase
- One of the most common intestinal nematodes

- Eggs are not resistant to desiccation: survive 6-12 h
- Eggs remain viable for a few weeks in colder, more humid environments

- The adult worms inhabit the cecum & colon
- ♀ ~ 10 mm in length ♂ 3 mm
- ♂ dies right after mating
- ♀ migrate out the anus depositing eggs on the perianal skin
The parasite

- humans get this infection by mouth & by autoinfection
- humans are the only species that can transfer this parasite
- household pets like dogs & cats cannot become infected
- eggs can survive in the indoor environment for 2-3 wk
- incubation period of 1-2 months or longer
Life cycle

- Infective eggs are ingested
- The larvae hatch in the small intestine
- The adults establish themselves in the colon
- The time interval from ingestion of infective eggs to oviposition by the adult females is about 4 wk
- Life span of the adults is ~ 8 wk
- Gravid ♀ migrate nocturnally outside the anus; crawling on the skin
- Eggs are deposited on perianal folds
- The larvae develop in the eggs
- The eggs become infective in 4 - 6 h
Transmission

- **Self-infection:** transferring infective eggs to the mouth with hands that have scratched the perianal area
- **Person-to-person:** through handling of contaminated clothes or bed linens, curtains, carpeting
- **Airborne:** some eggs may be inhaled; swallowed and follow the same development as ingested eggs
- **Retroinfection:** or the migration of newly hatched larvae from the anal skin back into the rectum
Symptoms

- 1/3 of pinworm-infected persons are asymptomatic
- the adult worms may cause slight irritation of the intestinal mucosa
- major symptom is anal pruritus
- restlessness, nervousness, & irritability (resulting from poor sleep associated with anal pruritus)
- in young girls: migration of the worms may produce vaginitis or granuloma of the peritoneal cavity
Diagnosis

- depends on recovery of the characteristic eggs
- eggs & female adults can be removed from the folds of the skin in the perianal regions by the use of the Scotch-tape swab method
- The examination should be made in the morning, before the patient has washed or defecated
Case report

- 35-year-old ♂ presented complaints of cramps, diarrhoea, lower abdominal pain, mild iron-deficiency anaemia
- without: weight loss, nausea, vomiting or gastrointestinal bleeding
- Gastroscopy, colonoscopy, small bowel follow-through, laboratory data and faecal microscopy were normal

- **Capsule endoscopy**: multiple small live worms were identified
- ~4mm long; swam in the distal jejunum & ileum
- Histopathology: *E vermicularis*

- **Treatment**: with Albendazole 400 mg once a day for 3 days and iron supplements; symptoms had completely disappeared
Treatment

- **Pyrantel Pamoat**
  - Combantrin®, 250 mg-pills or Suspension
  - 1 x 11 mg/kg; repeat after 2 weeks

- **Mebendazol**
  - Pantelmin®, 100 mg- pills
  - 1 x 100 mg; repeat after 2 weeks

- **Albendazol**
  - Eskazole®, 400 mg- pills
  - 1 x 400 mg; repeat after 2 weeks

- The medication does not kill all eggs
- The second dose prevent re-infection by adult worms that hatch from any eggs not killed by the first treatment
- In households where more than one member is infected it is recommended that all household members be treated at the same time
Lymphatic filariasis
Key facts

- *Wuchereria bancrofti*: (90% of the cases)
- *Brugia malayi*
- *B. timori*

- ~1.4 billion people in 73 countries are at risk for infection
- leads to elephantiasis
- >120 million people are currently infected, with about 40 million disfigured
- lymphatic filariasis can result in an altered lymphatic system & the abnormal enlargement of body parts, causing pain, severe disability & social stigma
- WHO recommends an annual large-scale treatment with single doses of 2 medicines to all eligible people where the infection is present
Distribution of lymphatic filariases

From all people living in areas where lymphatic filariasis is transmitted and are at risk of being infected; ~80% of them are in the following 10 countries: Bangladesh, Democratic Republic of Congo, Ethiopia, India, Indonesia, Myanmar, Nigeria, Nepal, Philippines and the United Republic of Tanzania.
Life cycle

- During a blood meal, an infected mosquito introduces third-stage filarial larvae onto the skin of the human host, where they penetrate into the bite wound.
- Adults reside in the lymphatics.
- Adults produce microfilariae which are sheathed and normally have nocturnal periodicity.
- The microfilariae migrate into lymph & blood channels moving actively through lymph & blood.
- Mosquito ingests the microfilariae during a blood meal.
- Microfilariae lose their sheaths & some of them move to midgut; reach the thoracic muscles.
- Developing into L1 - infective L3.
- L3 migrate to the mosquito's proboscis.
- Infect another human when the mosquito takes a blood meal.

\[\text{Life cycle diagram}\]
The parasite

Male (4 cm) and female (8-10 cm) *Wuchereria bancrofti* adults

Giemsa-stained microfilarie 250 - 300 µm
Vectors

Female *Aedes* feeding

Larvae in mosquito thorax

*Anopheles*

*Culex*
Disease

- Elephantiasis: NTD
- Infection occurs when filarial parasites are transmitted to humans through mosquitoes (Anopheles, Culex, Aedes)
- Infection is usually acquired in childhood causing hidden damage to the lymphatic system
- The painful and profoundly disfiguring visible manifestations of the disease, lymphoedema, elephantiasis and scrotal swelling occur later in life and lead to permanent disability
- Patients are not only physically disabled, but suffer mental, social & financial losses contributing to stigma & poverty

Hydrocele
Orchitis may occur in the acute stage; commonly associated with hydrocele, microfilariae may be found in the hydrocele fluid. Late lesion in Tanzanian patient
Symptoms

asymptomatic
- the majority of infections are asymptomatic
- showing no external signs of infection
- still cause damage to the lymphatic system & the kidneys, alter the body's immune system

acute
- acute episodes of local inflammation involving skin, lymph nodes and lymphatic vessels often accompany the chronic lymphoedema or elephantiasis
- are caused by the body's immune response to the parasite
- bacterial skin infection

chronic
- lymphoedema (tissue swelling)
- elephantiasis (skin/tissue thickening) of limbs
- hydrocele (scrotal swelling)

Urine containing lymph
The dilated lymph vessels rapture and release chyle into the urinary tract, thus producing the milky appearance - chyluria
Elephantiasis

Early elephantiasis due to *Brugia malayi*
Lymphatic obstruction (especially in the leg) progressing in chronic cases to elephantiasis may occur in regions of high endemicity.

Massive elephantiasis due to *Brugia malayi*
The enlargement is commonly unilateral.
Diagnosis

- Rapid serological diagnosis of filariasis
- The test is negative in old case where adult worms are not longer viable
- Highly sensitive and species-specific
Treatment: Large-scale treatment (MDA)

- Prevention of lymphatic filariasis is possible by stopping the spread of the infection
- Large-scale treatment: a single dose of 2 medicines given annually to an entire at-risk population
- 2000 - 2012 > 4.4 billion treatments were delivered to a targeted population of about 984 million individuals in 56 countries, considerably reducing transmission in many places
- In 2012, the WHO NTD Roadmap reconfirmed the target date for achieving elimination by 2020
How is *Ascariasis lumbricoides* transmitted?

a) Faecal-oral transmission

b) Transdermal transmission

c) Vector-borne transmission

d) Predator-prey transmission
How are hookworms transmitted?

a) Faecal-oral transmission

b) Transdermal transmission

c) Vector-borne transmission

d) Predator-prey transmission
The filarial worm that can be seen in the conjunctiva is:

a) *Toxocara canis*

b) *Schistosoma mansoni*

c) *Loa loa*

d) *Ancylostoma duodenale*
These are developmental stages of:

a) Roundworms (Nematodes)
   egg - metacestode - adult

b) Tapeworms (Cestodes)

c) Flukes (Trematodes)

d) It is hard to say
These are developmental stages of:

a) Roundworms (Nematodes)

b) Tapeworms (Cestodes)

c) Flukes (Trematodes)

d) It is hard to say

- egg-miracidium-sporocyst-redia-cercaria-(metacercaria)-adult
This might be the life cycle of:

a) *Schistosoma mansoni*

b) *Necator americanus*

c) *Ancylostoma duodenale*

d) *Enterobius vermicularis* (pinworm)
This is a life cycle of:

a) *Toxocara canis*

b) *Diphyllobothrium latum*

c) *Wuchereria bancrofti*

d) *Enterobius vermicularis* (pinworm)
The picture shows an example of:

a) Elephantiasis
b) Onchocerciasis
c) Cerebral cysticercosis
d) Cercarial dermatitis (Swimmer’s Itch)
A brave scientist infected himself with:

a) *Echinococcus*

b) *Enterobius vermicularis*

c) Filarial worm

d) *Necator americanus*
The End
Onchocerciasis
Distribution

Parts of Central & South America, Africa - disease of riverine countries
Key factors

• insect-borne disease
• caused by *Onchocerca volvulus*
• transmitted by blackflies *Simulium damnosum*
• “river blindness”: the blackfly which transmits the disease is abundant in fertile riverside areas
• ♀: 33 - 50 cm; ♂: 19 - 42 mm

• 25 million people are infected with
• 300,000 are blind
• 800,000 have some sort of visual impairment
• ~123 million people are at risk for becoming infected
Life cycle

- infected blackfly introduces L3 onto the skin
- penetrate into the bite wound
- in subcutaneous tissues L3 develop into **adult** reside in nodules
- live in the nodules for ~ 15 years
- nodules may contain numerous ♀♂
- ♀ produce **microfilariae** for ~ 9 years
- microfilariae live ~2 years
- occasionally: in peripheral blood, urine, sputum
- typically: in the skin & lymphatics of connective tissues
- blackfly ingests the **microfilariae** during a blood meal
- migrate from the blackfly’s midgut through the hemocoel to the thoracic muscles
- **microfilariae** develop into L1- infective L3
- L3 migrate to the blackfly’s proboscis & can infect another human
Disease

No symptoms

- the larvae can migrate through the human body without provoking a response from the immune system

Symptoms

- itchy skin rashes, nodules under the skin, & vision changes
- most symptoms caused by the body’s response to dead or dying larvae
- the inflammation in the skin can result in long-term damage to the skin
- changes in the color - "leopard skin" appearance
- loss of elastic tissue - "cigarette-paper" appearance
- conditions such as "hanging groin"
Disease

- The inflammation caused by larvae that die in the eye results initially in reversible lesions on the cornea
- Without treatment progress to permanent clouding of the cornea - resulting in blindness
- Inflammation of the optic nerve resulting in vision loss, particularly peripheral vision, & eventually blindness

Slit-lamp examination of the eye
Microfilariae in the anterior chamber of the eye
Snowflake-like opacities in the cornea
Prevention and treatment

• controlled through spraying of blackfly breeding sites with insecticide

• drug is available that kills the microfilariae, alleviating symptoms & reducing transmission

• an international control effort aims to bring annual treatment with this drug to all populations at risk

Ochocerciasis Control Programme

Following the emergence of resistance to the organophosphate insecticide Abate, *Bacillus thuringiensis* BTI was used to destroy the aquatic stages of *S. damnosum*
Taenia saginata & Taenia solium
**Taenia saginata & T. solium**

- **T. saginata:**
  - eating raw or undercooked beef
  - Eastern Europe, Russia, eastern Africa & Latin America
  - adults have ~ 1,000 - 2,000 proglottids
  - produce ~ 100,000 eggs per proglottid
  - 4-10 m long (can reach 25 m!)

- **T. solium:**
  - eating raw or undercooked pork
  - prevalent in under-developed communities with poor sanitation: Eastern Europe, sub-Saharan Africa, Latin America, India, Asia
  - adults have ~ 1,000 proglottids
  - produce ~ 50,000 eggs per proglottid
  - 3 m long
Life cycle

- **Eggs** or gravid **proglottids** are passed with feces
- The eggs can survive ~ months in the environment
- Hosts become infected by ingesting contaminated vegetation
- **Oncospheres** hatch in the gut, invade the intestinal wall, and migrate to the muscles
- Develops into **cysticerci** (survive for several years)
- Ingesting raw or undercooked infected meat
- **Cysticercus** develops in the gut an **adult**
- **Adult** attach to the small intestine by their scolex and reside in the small intestine for years
- **Adults** produce proglottids which mature, become gravid, detach from the tapeworm
- Migrate to the anus or are passed in the stool (approximately 6/day)
Symptoms

- no or mild symptoms
- digestive problems including abdominal pain, loss of appetite, weight loss, & upset stomach

The most visible symptom is the active passing of **proglottids** (tapeworm segments) through the anus and in the feces.
Cysticercosis

- tissue infection with larval stage (cysticerci) of *T. solium*
- infect brain, muscle, or other tissue
- are a major cause of adult seizure

- **Neurocysticercosis**
- common infection of the human nervous system
- is the most frequent preventable cause of epilepsy in the developing world
Treatment & Prevention

Praziquantel: 10 mg/kg
Niclosamide (2 g)

Strict slaughterhouse supervision including adequate inspection of carcasses
Schistosomiasis
Schistosomiasis: an important cause of disease in many parts of the world, most commonly in places with poor sanitation.

School-age children are often most at risk because they tend to spend time swimming or bathing in water containing infectious cercariae.

Human faeces deposited at the edge of a pond in which snail hosts of *S. mansoni* are breading.

Eggs enter the water, hatch & perpetuate the cycle of transmission.
Distribution regulated by the presence of susceptible snail intermediate host & human sanitary habits
Schistosomiasis: Facts

- is an acute and chronic disease caused by parasitic worms

- At least 249 million people required preventive treatment in 2012

- more than 200,000 deaths per year!!!
Sites of human infection with *S. mansoni*

These women and children become infected by cercariae while washing clothes in contaminated water.
Species of *Schistosoma* infecting humans

- **intestinal schistosomiasis:**
  - *Schistosoma mansoni*
  - *Schistosoma intercalatum*
  - *Schistosoma japonicum*
  - *Schistosoma mekongi*

- **urinary schistosomiasis:**
  - *Schistosoma haematobium*
Life cycle stages

egg              miracidium      cercaria      schistosomulae
Life cycle stages

Snail shedding living cercaria of *S. mansoni* + 200/day
Heavily infected snail may shed 1500-2000/day

Head of cercaria

Male and female *S. mansoni*
Life cycle

- eggs hatch and release miracidia
- swim and penetrate specific snail
- 2 generations of sporocysts & cercariae
- cercariae swim, penetrate the skin of the host
- shed forked tail: schistosomulae
- migrate to veins, mature
- adult worms migrate to mesenteric venules
- ♀ deposit eggs in the small venules
- *S. mansoni* and *S. japonicum* eggs move toward the lumen of the intestine; eliminated with feces
- *S. haematobium* eggs move towards bladder; eliminated with urine
Pathology

- *S. mansoni* and *S. japonicum*
- Katayama fever, hepatic egg granulomas, periportal fibrosis, portal hypertension, and occasional embolic egg granulomas in brain or spinal cord

- *S. haematobium*
- hematuria, scarring, calcification, squamous cell carcinoma, and occasional embolic egg granulomas in brain or spinal cord

Children in a village with urine samples **haematuria** is often best seen at the end of urination and is a characteristic early clinical feature of infection with *S. haematobium*
Pathology

Growth retardation by chronic infection with *S. mansoni*

Ascites secondary to chronic portal hypertension, splenomegaly
Diagnosis: Detection of eggs

- Examination of stool and/or urine for eggs is the primary methods of diagnosis for suspected schistosome infections
- Kato-Katz
Diagnosis: Biopsy

Biopsy showing *S. mansoni* eggs in a colonic polyp
Definitive diagnosis
Diagnosis: ELISA

- one of the most sensitive tests for the detection of schistosome-specific IgG, IgM or IgE
- distinguish acute from chronic infections

A new rapid diagnostic test for detection of anti-Schistosoma mansoni and anti-Schistosoma haematobium antibodies

Jean T Coulibaly\textsuperscript{1,2,3,*}, Eliézer K N’Goran\textsuperscript{3,4}, Jürg Utzinger\textsuperscript{1,2}, Michael J Doenhoff\textsuperscript{5} and Emily M Dawson\textsuperscript{5}
Treatment

WHO has developed guidelines for community treatment of schistosomiasis based on the impact the disease has on children in endemic villages:

- When a village reports > 50% of children have blood in their urine, everyone in the village receives treatment
- When 20 - 50% of children have bloody urine, only school-age children are treated
- When < 20% of children have symptoms, mass treatment is not implemented

<table>
<thead>
<tr>
<th>Schistosoma species infection</th>
<th>Praziquantel dose and Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Schistosoma mansoni, S. haematobium, S. intercalatum</em></td>
<td>40 mg/kg per day orally in two divided doses for one day</td>
</tr>
<tr>
<td><em>S. japonicum, S. mekongi</em></td>
<td>60 mg/kg per day orally in three divided doses for one day</td>
</tr>
</tbody>
</table>
Swimmer’s itch - Cercarial dermatitis
avian schistosomes of the genus Trichobilharzia
Trichobilharzia regenti

- neuropathogenic bird schistosome
- discovered in 1998
- In addition to birds, the infectious larvae (cercariae) proved to penetrate also the skin of mammals
Trichobilharzia regenti

- Egg
- miracidium
- cercaria
- schistosomula
Echinococcosis
Echinococcosis

- Hydatid disease, hydatidosis
- caused by the larval stages of cestodes (tapeworms) of the genus *Echinococcus*

In humans:

- Cystic echinococcosis
- Alveolar echinococcosis
Cystic echinococcosis
Cystic echinococcosis in Austria (1984 – 2012)

During last 15 years 35 cases were documented every year in Austria.
Cystic echinococcosis (hydatid disease)

- *Echinococcus granulosus*
- (Hydatid worm; Dog tapeworm)
- Cestode; tapeworm

**Definitive hosts:** dogs & wild carnivores
- parasites reach maturity & reproduce
- adults: in the small intestine

**Intermediate hosts:** wild or domesticated large mammals (sheep, goat, swine, cattle, horses, camel) or humans

- The adult: length 2-7 mm
- 3 proglottids: immature; mature; gravid
- 4 suckers on its scolex ("head")
- a rostellum with hooks
Life cycle *E. granulosus*

- **adult** in the small intestine
- gravid proglottids release eggs
- passed in the feces
- In intermediate host the **egg** hatches in the small intestine
- releases an **oncosphere** that penetrates the intestinal wall
- migrates through the circulatory system into various organs (liver or lungs)
- oncosphere develops into a cyst that enlarges gradually
- producing **protoscolices** and **daughter cysts** that fill the cyst interior
- definitive host becomes infected by ingesting the cyst-containing organs of the infected intermediate host
- After ingestion, the protoscolices evaginate, attach to the intestinal mucosa, and develop into adult stages in 32 - 80 d
Echinococcus egg in faeces

Hydatid with daughter cysts

Protoscolices released from a hydatid cyst
Disease

- often asymptomatic
- Symptoms: hydatid cysts containing the larval parasites grow: discomfort, pain, nausea, and vomiting
- the cysts grow several years before reaching maturity
- symptoms depends on the location of the cyst
- the cysts: the liver, lungs (spleen, kidneys, heart, bone, & CNS including the brain & eyes
- cyst rupture may cause mild to severe anaphylactic reactions, even death, as a result of the release of cystic fluid

Massive hydatid cyst
Turkana region of northern Kenya: close association between dogs & human: “nurse dogs” guard the household, encouraged to lick small infants clean: encouraging infection (enlarged liver)
Diagnosis

It is difficult to diagnose without imaging tools such as computed tomography or ultrasound.

Computer tomography scan of hydatid cyst in liver

Ultrasound scan of hydatid cyst
Immuno-diagnosis

Sensitivität und Spezifität neuer kommerziell erhältlicher Tests zum Nachweis von *Echinococcus*-Antikörpern

Herbert Auer, Cornelia Stöckl, Susanne Suhendra, Renate Schneider

Abteilung für Medizinische Parasitologie, Institut für Spezifische Prophylaxe und Tropenmedizin der Medizinischen Universität Wien, Wien, Österreich

Development of a new PCR protocol for the detection of species and genotypes (strains) of *Echinococcus* in formalin-fixed, paraffin-embedded tissues

Renate Schneider a, Bernd Gollackner b, Bernhard Edel b, Katharina Schmid c, Friedrich Wrba c, Georg Tuczek d, Julia Walochnik d, Herbert Auer a,*
Treatment

- mainly surgical intervention
- high dose, long-term therapy with albendazole alone or in combination with praziquantel
Hydatid cyst in the liver & brain
Prevention

Risk factors:
• abundance of stray dogs, poor meat inspection in abattoirs, improper disposal of offal and home slaughtering practices

Prevention:
• de-worming dogs & vaccinating dogs & other livestock, such as sheep, that also act as hosts for *E. granulosus*

• Education: general lack of awareness of transmission factors & prevention measures among the population at risk
Alveolar echinococcosis

*Echinococcus multilocularis*

adult 1.5 - 3.5 mm in length
rostellum, scolex, neck, strobila
28-30 hooks; 4 suckers
3 - 4 segments- the last the largest & gravid
no mouth; anus
each proglottid has a complete set of reproductive organs
AE: emerging disease in Europe
Alveolar echinococcosis (1937 – 2007; n = 75)

BU: 1/1,3 %
WI: 3/3,9 %
NÖ: 7/9,3 %
OÖ: 2/2,7 %*
SA: 3/4,0 %

TI: 33/44,0 %
VO: 13/17,3 %
ST: 5/6,7 %
KÄ: 8/10,7 %
Alveolar echinococcosis (1985-2011)
Life cycle

- **adult** worm present in intestine of definitive host
- **eggs** passed in feces, ingested by humans or intermediate host
- **onchosphere** penetrates intestinal wall, carried via blood vessels to organs
- **hydatid cysts** develop in liver, lungs, brain, heart
- **protoscolex** ingested by definitive host
- Ingested protoscolex attach to small intestine, develops into **adult** worm
Alveolar echinococcosis

- closely mimics hepatic carcinoma cirrhosis
- more common in older people
- radiographs show hepatomegaly and characteristic scattered areas outlined by calcific rings 2 - 4 mm
- Serologic test results are usually positive at high titers
- titers with specific antigens permit the serologic discrimination between patients infected with *E. multilocularis* & *E. granulosus*
Multilocular hydatidosis in liver
<table>
<thead>
<tr>
<th>Organism</th>
<th>Definitive Hosts</th>
<th>Intermediate Hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. granulosus</em></td>
<td>dogs and other canidae</td>
<td>sheep, goats, swine, kangaroos, and other wild herbivores</td>
</tr>
<tr>
<td><em>E. multilocularis</em></td>
<td>foxes, dogs, other canidae and cats</td>
<td>small rodents</td>
</tr>
</tbody>
</table>
THANK YOU FOR YOUR ATTENTION!!