Cestodes
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Helminths

- Phylum Nematoda (Roundworms) - “Nematodes”
  - Pinworm, Whipworm, Ascaris + VLM, Hookworm + CLM
  - Elephantiasis, River Blindness, Dracunculiasis, etc.

- Phylum Platyhelminthes (Flatworms)
  - Class Cestoidea (segmented flatworms) - “Cestodes”
  - Class Trematoda (non-segmented flatworms) - “Trematodes”

The tapeworms
(Cestodes – All are flat, segmented worms and adults are obligate parasites of the intestinal tract)

  - Taenia saginata (beef tapeworm)

  - Taenia solium (pork tapeworm)
    --- Cysticerosis

  - Echinococcus granulosus (dog tapeworm)
    --- Hydatid Disease

Taenia saginata adult

“Bowl o’ Worms”

“Fields o’ beeves”
“Plate o’ Beef”
a la “Wellington”

Adult *Taenia saginata*

- Scolex (head)
- Proglottids (segments)
- Strobila (body and head)
- Tegument
- Nervous System
- Locomotion

Proglottid - Sex organs

*Cysticercosis - heart of cow*

*Cysticercus*

*Cysticerci*

*Cysticercosis*

Adult *Taenia saginata* scolex

Proglottid - Sex organs
Cestode hosts

*T. saginata*

Definitive Host: Human
Intermediate Host: Cow

Embryonated, infectious taeniid eggs

Cannot distinguish species of Taenia tapeworms based on morphology of eggs

Gravid Proglottid of *Taenia saginata*

Uterine branches

The central uterus of *T. saginata* has more than 12 branches on a side

Pathogenesis:

None

Clinical Disease:

None in humans

Diagnosis:

1. Find eggs or proglottids in stool
2. Identify species based on proglottid morphology, after formalin and India Ink
3. Identify scolex
Drug of Choice

**Praziquantel**

*Mode of Action:*
Increases permeability of flatworm tegument to Ca$^{2+}$ ions, Causing muscle tetany and worm detachment.

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**Prevention and Control:**
1. Sanitary disposal of human feces

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**Prevention and Control (cont’d):**
2. Prevent cows from coming into contact with human feces, ie good sanitation and physical restraints.
3. Freeze and/or cook all beef until well-done
   - Good luck Paris, good luck New York!!
   - (No more rare filet mignon or steak tartar)
4. Federal meat inspection programs (muscle exam or serum ELISA specific to larval stage).

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**Taenia solium**
The Pork Tapeworm

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*Whole cysticercus of Taenia solium*

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*When is a ‘still life’ With Ham still alive?*
**Adult Taenia solium**

**Taenia solium scolex**

**T. Solium Scolex**

**Gravid proglottid Taenia solium**

**Embryonated, infectious taeniid eggs**

Cannot determine the species of Taenia based on egg morphology
Pathogenesis:
None

Clinical Disease:
None

Diagnosis:
1. Find eggs or proglottids in stool
2. Identify species based on proglottid morphology
3. Identify scolex
4. Stool PCR or ELISA (not readily available)

Drug of Choice:
1. Praziquantel
   - Not absorbed systemically
   - Uncouples cestode oxidative phosphorylation, preventing ATP production.
   - Parasite is then digested by host enzymes.
2. Niclosamide
   - Not absorbed systemically
   - Uncouples cestode oxidative phosphorylation, preventing ATP production.
   - Parasite is then digested by host enzymes.

Prevention and Control:
1. Sanitary disposal of human feces

Prevention and Control (cont’d):
2. Sanitary practices on pig farms; separate disposal of human feces from pigs’ range.
3. Cooking and/or freezing pork products thoroughly.
5. Treat pigs (oxfendazole) or vaccinate pigs.
   There is a new oncosphere mRNA vaccine in trial in eradication programs. (WHO Assembly, 2003).
Cestode hosts

\[ T. \text{saginata} \quad T. \text{solium} \]

Definitive Host: Human \quad Human

Intermediate Host: Cow \quad Pig \quad Human

Human Cysticercosis

Cysticercus in brain, on post-mortem pathology

Asymptomatic cyst. Actual cause of death, mesothelioma

Cysticercosis and Neurocysticercosis

Multiple Intracerebral Cysts

Human Acquisition of Cysticercosis

- Foods contaminated by human feces in endemic locations - another person’s worm
- Auto-inoculation (est. 15%) – one’s own worm
- Reverse peristalsis or vomiting

Manifestations of Cysticercosis in Humans
Cysticercus floating freely in anterior chamber

Parasite (Cysticercus)

Cysticercosis of eye: cysticercus near optic nerve, mis-diagnosed as retinoblastoma.

Emulsated globe in cross-section

“The Alien”

Radiogram of lower leg with numerous calcified cystercerci of T. solium

Subcutaneous Cysts

Neurocysticercosis of the spine

Cerebello-pontine angle cysticercus
This may cause hydrocephalus

MRI sagittal (T1) and axial views (T1 + C)
Neuro-cysticercosis

T1 weighted  T1 with contrast  T2 weighted

Immuno-modulation

- Taeniastatin
  - protease inhibitor
- Paramycocin
  - Inhibits complement
- Other proteases:
  - Degrade Interleukin-12, immunoglobulins and interferon

Neurocysticercosis

MRI  CT Scan

Intracerebral Calcifications

How bad can things get?

Rare GIANT Cyst

Symptoms vary based on cyst:
- Number: Single or multiple
- Size: GIANT or small
- State: cysts are living, degenerating, or dead and calcified

Neurologic Effects may be:
- Seizures
- CSF obstruction
- Hydrocephalus
- Arachnoiditis
- Mass effect
- Focal neurologic deficits...
Pathogenesis:

Space-Occupying lesion
Local Immunologic Reaction

Clinical Disease:

- Vision impairment / Blindness
- Seizures/Death
- Obstructive Hydrocephalus/Coma/Death
- Focal Neurologic deficits that depend upon location of mass and area affected.

Neurocysticercosis and Taeniasis:

Global Prevalence Map

Clinical Epidemiology of Cysticercosis

- Est. 50 million people with Intestinal Taeniasis, world-wide
- 20% have cysticercosis; at least half will be symptomatic (Sz)
- Leading cause of adult-onset seizures worldwide (~40%)
  - Other causes are trauma, TB, tumors, toxins, other.
- Leading cause of epilepsy among children in endemic areas
- In US: Est. 1000 new cases per year (no mandatory reporting)
  - Immigrants account for >95% annually
  - Travelers account for ~3%
  - Autochthonous transmission: rare. Typically within families where one member harbors adult tapeworm.

Diagnosis:

Must differentiate between cysticercosis and other possible lesions (benign cysts, solid tumors, etc.)

1. Biopsy whenever possible
2. Physical (palpation) and X-ray evidence
3. Enzyme-linked immunoblot serological test, can be as high as 98% sensitive, 100% specific.
4. MRI

Treatments:

1. Surgical removal of cysticercus when appropriate
2. Steroids (e.g., dexamethasone) during time of neurological symptoms
3. Anticonvulsants (e.g. Dilantin - Phenytoin)
4. Anti-emetics if patient has intestinal taeniasis
5. Antiparasitic antibiotics: Praziquantel or albendazole + steroids + anticonvulsants for multiple or symptomatic cysticerci, or for inoperable cysts - under study)
**Echinococcus granulosus**

The Dog tapeworm

Hydatid Disease in Humans

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**Cestode hosts**

<table>
<thead>
<tr>
<th>T. saginata</th>
<th>T. solium</th>
<th>Echinococcus granulosus</th>
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</thead>
<tbody>
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<tr>
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<td></td>
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</tbody>
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Traditional sheep husbandry and farming practices help to maintain the cycle in animals and humans.

Navaho, Arizona

Abattoir, Ecuador

Scotland

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**Echinococcus Granulosus**

Global Prevalence Map

Distribution map of *Echinococcus granulosus* (black) and *E. multilocularis* (marked by 'X'). The latter is now also found in Hokkaido (Japan), Alaska and also in the whole of Germany.

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**Adult of Echinococcus granulosus**

Mature proglottid

Gravid proglottid

Scolex with suckers and hooks

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Echinococcus Granulosus Adult

cute, n’est-ce pas?
11/13/09

Echinococcus Lifecycle

Radiogram of upper body showing elevation in right lobe of liver due to large hydatid cyst

Distribution of Hydatid cysts

Liver - 63%
Lungs - 25%
Muscles - 5%
Bone marrow - 3% (usually fatal)
Kidney - 2%
Spleen - 1%
Brain - 1% (usually fatal)

Hydatid cyst of Liver

Visualize:
1. Hydatid Cyst
2. Hydatid Fluid
3. Daughter Cysts

Hydatid cysts removed from human liver
Hydatid cyst of Parietal Lobe

Liver infected with hydatid cyst of Echinococcus granulosus

Histological section through brood capsules in hydatid cyst of Echinococcus granulosus

Hydatid Cyst diagram

Pulmonary Echinococcus

Petri dish filled with daughter cysts of Echinococcus granulosus
Pathogenesis and Clinical disease:

- When intact, hydatid cysts are immunologically and often clinically silent, especially in the liver.

- In other organs (e.g., brain, lung, bone marrow), hydatid cyst is a space-occupying lesion.

- It may leak or rupture, seeding/metastasizing adjacent areas.

- When hydatid cyst ruptures, allergic reactivity and anaphylaxis often ensue. This may be fatal.

Diagnosis:

A. Direct
   1. NO BIOPSY!
   2. CAN remove surgically. Find “hydatid sand” on microscopic examination of fluid from hydatid cyst.

B. Indirect
   1. ELISA-based serology
   2. Imaging: MRI, CAT scan, X-ray, Ultrasound
   3. Accurate case history (ownership of dogs, living on a sheep farm, etc.)

Treatment:

- Surgical, whenever possible

- PAIR Technique for liver lesions
  - (puncture, aspirate, Inject, re-aspirate)

- Pharmacologic has less than 50% success

Drug of Choice:

Albendazole (for up to 6 months)

Mode of Action:
Prevents microtubule polymerization, blocking glucose absorption, starving worm
Prevention and Control:

- Regularly treat all shepherding dogs with niclosamide. This drug kills the adult parasites (by inhibiting ATPase).
- Avoid feeding hydatid cyst material (sheep offal) to dogs.
- Public health education of sheep farmers.