Tissue Helminths
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Tissue nematodes - adults or larval stage in tissue
- *Trichinella spiralis*, native etc
- *Toxocara canis* (visceral larva migrans)
- *Filaria* - *Wuchereria bancrofti*
  - *Brugia malayi*
  - *Onchocerca volvulus*
  - *Loa loa*, etc.

Tissue cestodes
- *Taenia solium* - cysticercosis
- *Echinococcus granulosus* (unilocular hydatid)
- *Echinococcus multilocularis* (alveolar hydatid)
**Trichinella spp.**

<table>
<thead>
<tr>
<th>Species or genotype</th>
<th>Geographical distribution</th>
<th>Host range</th>
<th>Main source of infection of humans</th>
<th>Resistance of larvae in frozen muscles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encapsulated</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><em>T. spiralis</em></td>
<td>Cosmopolitan</td>
<td>Domestic and sylvatic mammals</td>
<td>Domestic and sylvatic swine horses</td>
<td>Yes in horse muscles</td>
</tr>
<tr>
<td><em>T. nativa</em></td>
<td>Arctic and subarctic areas of America, Asia, Europe</td>
<td>Sylvatic carnivores</td>
<td>Bears, walruses</td>
<td>Yes in carnivore muscles</td>
</tr>
<tr>
<td><em>Trichinella</em> genotype T6</td>
<td>Canada, Alaska, Rocky Mountains, and Appalachian Mountains in the United States</td>
<td>Sylvatic carnivores</td>
<td>Carnivores</td>
<td>Yes in carnivore muscles</td>
</tr>
<tr>
<td><em>T. britovi</em></td>
<td>Temperate areas of Europe and Asia, Northern and Western Africa</td>
<td>Sylvatic mammals and seldomly domestic pigs</td>
<td>Wild boars, domestic pigs horses, foxes, jackals</td>
<td>Yes in carnivore and horse muscles</td>
</tr>
<tr>
<td><em>Trichinella</em> T8</td>
<td>South Africa and Namibia</td>
<td>Sylvatic carnivores</td>
<td>None documented</td>
<td>No</td>
</tr>
<tr>
<td><em>T. murrelli</em></td>
<td>United States and Southern Canada</td>
<td>Sylvatic carnivores</td>
<td>Bears, horses</td>
<td>No</td>
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<tr>
<td><em>Trichinella</em> genotype T9</td>
<td>Japan</td>
<td>Sylvatic carnivores</td>
<td>None documented</td>
<td>No</td>
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<tr>
<td><em>T. nelsoni</em></td>
<td>Eastern-Southern Africa</td>
<td>Sylvatic mammals</td>
<td>Warthogs, bush pigs</td>
<td>No</td>
</tr>
<tr>
<td><em>Trichinella</em> genotype T12</td>
<td>Argentina</td>
<td>Cougars</td>
<td>None documented</td>
<td>Unknown</td>
</tr>
<tr>
<td>Nonencapsulated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>T. pseudospiralis</em></td>
<td>Cosmopolitan</td>
<td>Sylvatic mammals and birds, domestic pigs</td>
<td>Domestic and wild pigs</td>
<td>No</td>
</tr>
<tr>
<td><em>T. papuae</em></td>
<td>Papua New Guinea, Thailand</td>
<td>Wild pigs, saltwater crocodiles</td>
<td>Wild pigs</td>
<td>No</td>
</tr>
<tr>
<td><em>T. zimbabwensis</em></td>
<td>Zimbabwe, Mozambique, Ethiopia, South Africa</td>
<td>Nile crocodiles, monitor lizards</td>
<td>None documented</td>
<td>No</td>
</tr>
</tbody>
</table>

* Based on data from reference 125.
Trichinella spiralis

- Infection occurs by ingestion of larvae, in poorly cooked meat, which immediately invade intestinal mucosa and sexually differentiate within 18 to 24 hours.
- The female, after fertilization, burrows deeply in the small intestinal mucosa, whereas the male is dislodged (intestinal stage).
- On about the 5th day eggs begin to hatch in the female worm and young larvae are deposited in the mucosa from where they reach the lymphatics, lymph nodes and the blood stream (larval migration).
- Larval dispersion occurs 4 to 16 weeks after infection.
Trichinella spiralis

- The larvae are deposited in muscle fiber and, in striated muscle, they form a capsule which calcifies to form a cyst.
- In non-striated tissue, such as heart and brain, the larvae do not calcify; they die and disintegrate.
- The cyst may persist for several years.
- One female worm produces approximately 1500 larvae.
- Man is the terminal host.
- The reservoir includes most carnivorous and omnivorous animals.
<table>
<thead>
<tr>
<th>Trichinosis symptomatology</th>
<th>Intestinal mucosa (24-72 hrs)</th>
<th>Circulation and muscle (10-21 days)</th>
<th>Myocardium (10-21 days)</th>
<th>Brain and meninges (14-28 days)</th>
</tr>
</thead>
</table>
Trichinosis - symptomatology

- Trichinosis symptoms depend on the severity of infection: mild infections may be asymptomatic.
- Trichinella pathogenesis is due to the presence of large numbers of larvae in vital muscles and host reaction to larval metabolites.
- The muscle fibers become enlarged, edematous, and deformed.
- The paralyzed muscles are infiltrated with neutrophil, eosinophils, and lymphocytes.
- Splenomegaly is dependent on the degree of infection.
- The worm induces a strong IgE response which, in association with eosinophils, contributes to parasite death.
Trichinosis - diagnosis

- Diagnosis is based on:
  - symptoms
  - recent history of eating raw or undercooked meat
  - laboratory findings (eosinophilia, increased serum creatine phosphokinase and lactate dehydrogenase)
  - antibodies to *T. spiralis*
Toxocara canis & cati

- Toxocariasis is an infection caused by the ingestion of larvae of the dog roundworm *Toxocara canis* or the cat roundworm *Toxocara cati*.
- The soil of parks and playgrounds is commonly contaminated with the eggs of *T canis*, and infection may cause human disease that involves the liver, heart, lung, muscle, eye, and brain.
Toxocara canis – life cycle

(a) Egg in feces
(b) Morula stage
(c) First stage juvenile in egg
(d) Rodent host with visceral larva migrans
(e) Human accidentally ingests eggs, causes visceral larva migrans
(f) Some juveniles enter alveoli and some enter developmental arrest in other sites
(g) Adult worms mate and produce eggs in small intestine
(h) Direct maternal-fetal transmission

Predation
Three syndromes of *Toxocara* infection

- In children, **covert toxocariasis** is a mild, subclinical, febrile illness.
- Symptoms can include cough, difficulty sleeping, abdominal pain, headaches and behavioral problems.
- Examination may reveal hepatomegaly, lymphadenitis, and/or wheezing.
Three syndromes of *Toxocara* infection II

- **Visceral larva migrans** is caused by the migration of larvae through the internal organs of humans and the resulting inflammatory reaction.
- Examination may reveal hepatomegaly, lymphadenitis, and/or wheezing.
- Chronic urticaria has been described.
- Severe cases can lead to myocarditis or respiratory failure.
• **Ocular larva migrans**, which is caused by migration of larva into the posterior segment of the eye, tends to occur in older children and young adults. Patients may present with decreased vision, red eye, or leukokoria (white appearance of the pupil). Serum antibodies to *Toxocara* are often absent or present in low titers.
Toxocariasis – diagnosis

- Diagnosis of toxocariasis is difficult because confirmation of infection requires demonstration of larvae via biopsy.
- Serologic testing - ELISA, immunoblot to infer diagnosis.
Taenia solium – Cysticercosis

- When the eggs of *Taenia solium* are ingested by humans, the tapeworm eggs hatch and the embryos penetrate the intestinal wall and reach the bloodstream.
- The formation of cysts in different body tissues leads to the development of symptoms, which will vary depending on the location and number of cysts.
Cysticercosis transmission

- Human cysticercosis, however, develops after humans ingest *Taenia solium* eggs.
- The eggs are typically spread via food, water, or surfaces contaminated with infected feces.
- Oftentimes, the eggs may be spread from the hands of infected food handlers who do not clean their hands or from foods fertilized/irrigated with water containing infected human feces.
- Though the source of this fecal-oral transmission often occurs from other infected individuals, it is also possible for individuals who carry the tapeworm to autoinfect themselves.
Cysticercosis is a systemic parasitic infestation.

The symptoms of this illness are caused by the development of characteristic cysts (cysticerci) which most often affect the central nervous system (neurocysticercosis), skeletal muscle, eyes, and skin.

Many individuals with cysticercosis never experience any symptoms (asymptomatic).
Cysticercosis localization
Tests that may be done include:

- Blood tests to **detect antibodies** to the parasite
- **Biopsy** of the affected area
- **CT** scan, **MRI** scan, or **x-rays** to detect the lesion
Echinococcus granulosus

- Geographically, *E. granulosus* is found almost worldwide.
- Is the causative agent of cystic echinococcosis in humans.
- The greatest prevalence of human infection happens in areas where large amounts sheep and cattle are found.
- The highest concentration of *E. granulosus* is found in Asia, Africa, Australia, Europe and South America.
Echinococcus granulosus

- The adult worm lives in domestic and wild carnivorous animals.
- Eggs, passed by infected animals, are ingested by the grazing farm animals or man, localize in different organs and develop into hydatid cysts containing many larvae (proto-scolices or hydatid sand).
- When other animals consume infected organs of these animals, protoscolices escape the cyst, enter the small intestine and develop into adult worms.
- Echinococcus eggs, when swallowed by man, produce embryos that penetrate the small intestine, enter the circulation and form cysts in liver (70%), lung (25%), bones, and sometimes, brain. The cyst is round and measures 1 to 30 cm diameter.
Echinococcus granulosus

- Adult
- Egg
The cyst consists of an outer anuclear hyaline cuticula and an inner nucleated germinal layer containing clear yellow fluid. Daughter cysts attach to the germinal layer, although some cysts, known as brood cysts, may have only larvae (hydatid sand). Man is a dead end host.
A physical examination depend of size and localization of the cyst and may show signs of:
- Abdominal pain
- Problems with the skin and other organs
- Shock

The following tests may be done to find the cysts:
- Ultrasound or abdominal CT scan
- Abdominal X-ray
- Chest X-ray
- Blood test (serology for antibody detection)
- Liver function tests
- Thoracic CT scan or ultrasound
- Most often, echinococcosis is found accidentally when an imaging test is done for another reason.
E. granulosus - Treatment

• Many patients can be treated with albendazole or mebendazole (these medications are often used for up to 3 months).
• Praziquantel, may be helpful combined with albendazole or mebendazole.
• The cysts may be removed with surgery, if possible (this can be a complicated surgery).
E. granulosus cyst

Cystic hydatidosis during surgery

Daughter cysts
Echinococcus multilocularis

- *Echinococcus multilocularis* is the causative agent of alveolar echinococcosis in humans.
- AE is found worldwide, mostly in northern latitudes.
- Cases have been reported in central Europe, Russia, China, Central Asia, Japan, and North America.
Echinococcus multilocularis

- AE disease results from being infected with the larval stage of *Echinococcus multilocularis*, a microscopic tapeworm (1-4 millimeters) found in foxes, coyotes, dogs, and cats.
- Although human cases are rare, infection in humans causes parasitic tumors to form in the liver, and, less commonly, the lungs, brain, and other organs.
- If left untreated, infection with AE can be fatal.
E. multilocularis – life cycle

- Foxes or domestic canine are the definitive hosts for the adult stage of the parasite.
- The parasite attaches and resides in the mucosa of the intestines by hooks and suckers.
- It then produces hundreds of microscopic eggs, which are dispersed through the feces of foxes or carnivores.
- Wild rodents such as mice serve as the intermediate host.
- Eggs ingested by rodents develop in the liver, lungs and other organs to form multilocular cysts.
- Humans could also become an intermediate host by handling infected animals or ingesting contaminated food, vegetable, and water.
- The life cycle is completed after a fox or canine consumes a rodent infected with cysts. Larvae within the cyst develop into adult tapeworms in the intestinal tract of the definitive host.
**E. multilocularis** – diagnosis & treatment

- Serological and imaging tests are commonly used to diagnose this disease.
- Frequently used serological tests include antibody tests, ELISA and indirect hemagglutination (IHA).
- Also, an intradermal allergic reaction test (Casoni test) has also been used to diagnose patients.
- Imaging tests include: X-rays, cat scans, MRI, and ultrasound.
- Surgery is the most common form of treatment for AE, although removal of the entire parasite mass is not always possible.
- After surgery, medication may be necessary to keep the cyst from growing back.