Summary

- Blood-sucking worms 1 cm long (but never seen in the stool); in the jejunum
- Transmission by larvae: transcutaneous and oral
- Brief local itch after skin penetration, lung passage (but very rarely noticed)
- Generally asymptomatic
- In severe infection iron deficiency anaemia

Life cycle

There are two important hookworms: *Necator americanus* and *Ancylostoma duodenale*. [L. necator = murderer; Gr. ancylo = hook, stoma = mouth]. There are a few zoonotic hookworms which are of much less clinical importance and seldom cause infections in humans (e.g. *Ancylostoma ceylanicum*, *A. caninum*, *A. malayanum*, *Cyclodontostomum purvisi*). The adult worms are found in the small intestine. It is estimated that the life span of adult worms is 5 to 15 years. *Necator* lives longer than *Ancylostoma*.

The adults measure approximately 1 cm. A few weeks or months after infection eggs can be found in the faeces. Once the eggs arrive in the outside world with the faeces, they take one week to mature to infectious larvae. At first they are rod-shaped = rhabditiform, later thread-shaped = filariform. They may survive for weeks or months (at an optimal temperature and humidity for as much as 2 years). A soil with neutral pH is optimal for their development, as is shade and a sufficiently high temperature (23°C to 30°C is ideal). If the faeces mix with urine the eggs die. Frost, direct sunlight and a soil saturated with salt or water are unfavourable conditions.

Infection occurs via the mouth (*A. duodenale*) or via the skin (*A. duodenale* and *N. americanus*). If they enter through the skin, the young parasites have to pass through the lungs. A new dimension in the epidemiology of hookworm disease emerged when it was found that insufficiently cooked meat from paratenic hosts (= an intermediate host in which no development of the parasite occurs) such as pigs, cattle, rabbits and sheep can be responsible for transmission.

The adult hookworms bore a hole in the mucosa of the duodenum and the small intestine and

suck blood.

They adhere with hooked teeth in their mouth (*Ancylostoma*) or with two buccal cutting plates (*Necator*). *A. duodenale* sucks 5 to 10 times more blood than *N. americanus* (approximately 30 µl per day for *Necator* and 260 µl for *Ancylostoma*). Blood loss is caused primarily by parasite release of anticlotting agents -anticoagulant peptides that inhibit activated factor X and factor VIIa/tissue factor complex and that inhibit platelet activation- which causes continuous blood loss in the stool and only secondly due to actual blood consumption by the worm.

Clinical aspects

At the site where the hookworms penetrate, the skin may rarely develop a rash and itch (called “ground itch”). This is short-lived and rarely noticed. Lung passage also rarely produces symptoms, but may be accompanied by Loeffler’s syndrome. There are few intestinal symptoms. When infection with *A. duodenale* occurs by the oral route, the early migrations of third-stage larvae cause a syndrome known as Wakana disease, which is characterized by nausea, vomiting, pharyngeal irritation, cough, dyspnoea and hoarseness. Significant infections (>1000 worms) may result in pronounced anaemia. The haemoglobin level may sometimes be very low. Children and pregnant women in whom the iron supplies are already low, are particularly affected. Hypoproteinaemia may also occur and results in oedema and anasarca. Protein deficiency also has consequences for the production of immunoglobulins. Some patients exhibit geophagia. In history, certain regions in the USA were famed for their “quality” clay and people would cover great distances to eat this iron-containing soil.

Differential diagnosis:

Differentiation from *Strongyloides* larvae is based chiefly on the difference in morphology of the “head” end. The mouth is elongated in ancylostomes and shorter in *Strongyloides*. Sometimes, if intestinal transit has been swift eggs of *Strongyloides stercoralis* may be found in the faeces. These too should be differentiated from hookworm eggs.

Diagnosis

The eggs are found in fresh faeces. In an old stool (>24 hours) the eggs will have hatched and rhabditiform larvae can be seen (Gr. rhabdos = rod). There is mild eosinophilia. Since an adult hookworm lays approximately 25,000 eggs per day, as a very rough estimate 100 eggs per gram of faeces corresponds to 1 adult worm. The Kato-Katz concentration technique can be used to estimate the number of eggs per gram of faeces. The eggs of N. americanus and A. duodenale are morphologically indistinguishable.

Eggs of *Oesophagostomum* are morphologically identical to those of hookworms. Identification of the latter parasite can only be made by coproculture (identification of the typical stage 3 larvae).

Treatment

- Mebendazole 2 x 100 mg/day for 3 days. Also give iron supplementation and folic acid in anemia.
- Albendazole may be used in treatment (400 mg single dose) and is generally effective.
- Pyrantel 10 mg/kg for 3 days or levamisole 2.5mg/kg once or twice (less used nowadays)
- *Necator* and *Ancylostoma duodenale* are less sensitive to ivermectin (cure rate around 30%).
- Tribendimidine has a promising activity on hookworms

Prevention

Mass chemotherapy together with health education and sanitary provisions are strategies which are often used for morbidity control. The most heavily infected individuals are the chief target group.

There are however increasing concerns about long-term sustainability. Wearing footwear only partly prevents infection because oral infection is also important for *Ancylostoma duodenale*. Children are the main victims as they rarely wear shoes and their whole skin is a portal of entry.

Cutaneous larva migrans

Some larvae from animal hookworms may penetrate human skin, but do not migrate deeper to the underlying tissues and organs. Their cycle thus reaches a dead end in the skin. Examples are the hookworms of dogs and cats (Ancylostoma braziliense, Ancylostoma caninum) and animal Strongyloides species. The migration of these larvae causes very itchy red lines on the skin which slowly move about (i.e. creeping eruption). A single oral administration of 12 mg of ivermectin (or albendazole 400 mg x 5 days) is effective.