PART NINE: CHAPTER 71.

INTESTINAL HELMINTHIC INFESTATIONS

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Anatomy of the gastrointestinal tract

The stomach is roughly J-shaped. It has the anterior and posterior surfaces, two curvatures ;the greater and lesser and two orifices ;the cardia and pylorus. The pylorus is connected to the duodenum, which is 25cm (10in) long. The duodenum curves in a C around the head of the pancreas, and is divided into four sections. The blood supply usually consists of the superior and inferior pancreatico-duodenal artery that arises from the gastro-duodenal artery and superior mesenteric artery respectively.

The small intestine comprises of the jejunum and ileum. The length varies from 3-10metres, with an average length of 6.5metres. The jejunum lies at the umbilical region, and the ileum in the hypogastrium and pelvis. The jejunum has thicker wall than the ileum.

The large intestine comprises of caecum with the appendix vermiformis, ascending colon, hepatic flexure, transverse colon, splenic flexure, descending colon, sigmoid colon, rectum and anal canal. The large intestines vary considerably in length, with an average of 1.5metres. Their blood supply is by the superior and inferior mesenteric arteries arising from the aorta at L1 and L3 respectively.

Embryology

The alimentary tract develops from the fore, mid, and hindgut. The foregut comprises the stomach and duodenum as far as the entry of the bile duct. The mid-gut extends from mid-duodenum to the distal transverse colon, and the hindgut forms the rest of the intestine

Physiology / biochemistry

The digestive system is the portal through which nutritive substances; vitamins, minerals and fluids enter the body. Digestion of major food substances involves the action of enzymes, some of which are found in the secretions of the salivary glands, the stomach, and the exocrine portion of the pancreas. Other enzymes are found in the luminal membrane and the cytoplasm of the cells that live the small intestine. The action of the enzymes is aided by the hydrochloric acid secreted by the stomach and the bile from the liver. Absorption of water-soluble vitamins is rapid, while that of fat-soluble vitamins A, D, E, K is dependent on fat absorption. Most vitamins are absorbed in the upper small intestine, but vitamin B12 is absorbed in the ileum. The amount of iron absorbed ranges from 3 to 6% of the amount ingested. Iron is more readily absorbed in the ferrous state (Fe2+), but most of the dietary iron is in the ferric form (Fe^{3+}). Only a trace of iron is absorbed in the stomach, but the gastric secretions dissolve the iron and aid its reduction to the easily absorbable form (Fe^{2+}). Iron absorption is an active process, and most of it occurs in the upper part of the small intestine. The absorption into the blood stream depends on the tissue ferritin level.

Introduction

infestations by helminths are indeed one of the most common and neglected of diseases affecting more than 30% of the world's people. The organisms are multicellular parasites comprising Nematodes (roundworms), Cestodes (tapeworms) and Trematodes (flukes). Most of these helminths pass through the intestine during the course of their life cycles but for purposes of child health only those whose habitat is the intestine will be discussed. These are the intestinal nematodes, which include: -

1. Ascaris lumbricoides
2. Ancylostoma duodenale (hookworm)
3. Necator Americans (hookworm)
4. Strongyloides stercoralis
5. Enterobius vermicularis (pinworm)
6. Trichuris trichuria (whipworm).

Epidemiology

Infection or infestation with intestinal nematodes is the most common helminthiasis of humans. Currently, more than three billion individuals are carrying a burden of worms. They are infections associated with economic underdevelopment and poverty. These infections are more prevalent in tropical and subtropical climates because these climates offer excellent opportunities for easy and rapid development of the different stages of these parasites, which are rapidly disseminated in the soil through gross and indiscriminate defecation habits. However, individuals residing in temperate and cold regions are not spared, Strongyloides stercoralis prefers warm climate and wet soil while clay soil favours survival of Ascaris lumbricoides and Trichuris trichuria eggs. Infective hookworm larvae in the soil are influenced by such factors as texture, humidity, salinity, pH and drainage of the soil habitat. Excessive rainfall, resulting in saturated soil, could exert checks on hookworm infection. Clay and other types of dense soil are unsuitable for larval development. Some disorders of immune system may increase risk of developing disseminated strongyloidiasis.

Children, generally, are more heavily infected than adults and are therefore more likely to suffer from the pathologic consequences of these infections. The age group most commonly affected is the 6-15 years group, followed by the 1-5 years age group. Lowest figures were obtained in children less than six months of age, for obvious reasons. Boys are more heavily infected than girls.

Amongst the nematodes, the prevalence rate of infection with ascaris lumbricoides (AL) is the highest,

followed by Trichuris trichuria (TT), then hookworm (HK), Strongyloides stercoralis (SS) and Enterobius vermicularis (EV). **Table 71.I** below shows the frequencies reported from 4 Nigerian cities.

Table 71 .I.

Frequency of various nematode infestation in 4 Nigerian cities

Town	Year	AL	TT	HK	SS
Lagos	1983	65%	20%	15%	
Lagos	1987	68.3%	71.9%	22.5%	7.3%
Ilorin	1990	40.9%	27%	10.2%	9.7%
Ondo	1992	43.1%	23.4%	17.0%	0.8%
Jos	1997	9.1%	6.7%	15.2%	

In Lagos, multiple (triple) infestations with Ascaris, Trichuris and hookworm occurred in 8.8% of cases while 25.1% had double combinations of either of the three worms. In Jos, polyparasitism was noted in 14.2% of cases.

Ascaris: A. Lumbricoides inhabits the lumen of the small intestine and have a lifespan of 10-20months.The female worms produce 200,000eggs/24hr. The transmission is primarily hand-to-mouth but may also involve ingestion of contaminated raw fruits and vegetables.

Female ascaris begin depositing eggs in 8-10weeks. After passage in the faeces, the eggs embryonate and become infective in 5-10days under favourable environmental conditions. Ascaris egg can remain viable at 5-10^{o}C for as long as 2 years.

Infectivity of the soil is maintained for the most part because of promiscuous defecation. For those reasons, all fruits or vegetables that get in touch with contaminated soil or which are grown in contaminated environment, would likely carry the ova on their surfaces (especially Ascaris), either through direct contact with polluted soil or through the activity of insects like house flies, bees, ants and cockroaches. Dust is also known to play an important part in the dispersal of the Ascaris ova. They have the physical characteristics of aerosols and therefore can be airborne. They may be carried away by the wind from the surface of cultivated land and contaminate vegetables and exposed food items in houses and market places. This observation is very significant and relevant in situations where many food items are exposed for sale in open markets that are usually very dusty and close to the roadside. The use of human faeces as fertilizer on agricultural farms and gardens offers excellent opportunities for ascaris-transmission if the human faecal manure is not well treated. Ascaris ova also get flushed out by rainfall and may be carried away to other places by the rain water and into streams, uncovered wells, rivers and ponds which are often used as sources of domestic and drinking water suppliers.

Trichuris: The larvae mature in the upper segment of the small intestine to adult worms and penetrate the villi, and move down to reside in the caecum and ascending colon. In 1-3months,the adult female worm produces 5,000-20,000 eggs/24hr.After excretion in the faeces, embryonic development occurs in 2-4weeks with optimal temperature and soil conditions. The worm has no migratory phase in the lungs.

Enterobius; Ingested embryonated eggs hatch in the stomach and the larvae migrate to the caecal region where they mature to adult worms. The gravid female migrates by night to the perianal region to deposit masses of eggs. The resultant irritation leads to scratching and deposit of eggs on the fingernails. Eggs also contaminate the clothing, bedding or house dust. The eggs embryonate within 6hours and remain viable for 20days. Tissue invasion does not occur.

Strongyloides; Only adult female inhabit the small intestine. The released egg contains mature larva. Rhabditiform larvae immediately emerge from the ova and are passed in faeces. These penetrate the skin, and are carried through the veins to the lungs. There, they are coughed up, swallowed and when they reach the small intestine, they become adult worms. Egg deposition begins about 28days after initial infection. Autoinfection can occur when the infective larva develops during the passage of egg in the gut and then re-infects the host.

Hookworm; The eggs are passed in faeces and develop into infective larvae in the appropriate soil. The infective larva penetrates the skin, and migrates through the lung to get into the small intestine like Strongyloides. The eggs may be ingested. The larvae molt twice to develop into sexually mature male and female worms. Hookworms can remain in the intestine for 1-5years by attaching to the mucosa and submucosa of the small intestine, where they mate to produce eggs. Mature A. duodenale produces more eggs than N.Americanus at the rate of 30,000eggs/24hr compared to 10,000eggs/24hr.

Transmission of Ascaris, Trichuris and Enterobius is by ingestion of the ova while that of hookworm and strongyloides is by penetration of the skin by the larvae while the individual walks barefoot.

Pathogenesis

Worms affect nutrition in several ways, altering the lining of the intestine, which reduces the surface membrane available for digestion and absorption, ingesting blood and leading to loss of iron and other nutrients. The inter-relationship between worm infestation, malnutrition and increased susceptibility to infections is illustrated in **Figure 71. 1.**

Blood loss from hookworm may arise due to:

(ii) downregulation of host inflammation by release of anti-inflammatory polypeptides at the site of worm attachment which anticoagulate host blood,
(ii) rupture of capillaries with extravasation of blood,
(iii) ingestion of blood by the worms.
In strongyloides infection, reduction in cellular and humoral immunity in immunocompromised state may lead to systemic dissemination as seen in Acquired immune deficiency syndrome (AIDS).

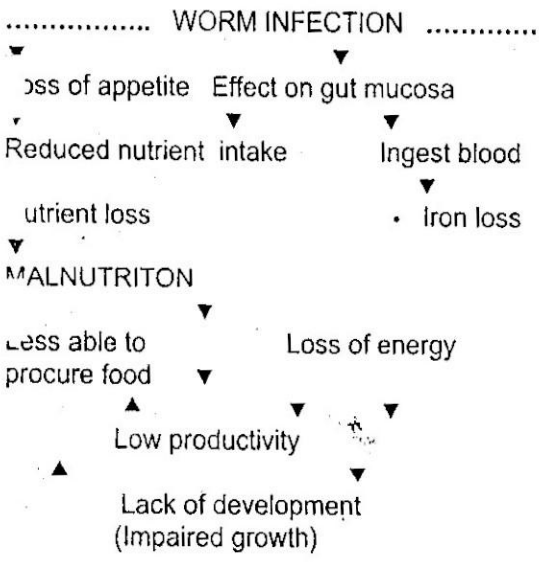

Figure 71.1. Cycle of worm infection and malnutrition

Clinical features / Complications

Ascariasis;

1 Larva stage occurs in the tissues and lungs and is usually acute. It can cause allergic reactions like cutaneous signs: urticaria, Loeffler's syndrome: comprising of severe pneumonia, haemoptysis, bronchospasm and eosinophilia, as well as respiratory complications.

2 Adult stage occurs in the small intestine. It causes digestive and nutritional disturbances, usually chronic, like abdominal colic and intermittent diarrhoea. This is due to irritation of sensory receptors in the intestinal mucosa, The result may be interference with normal peristalsis and even ischemia of the gut mucosa, nausea and vomiting, malabsorption, lactose intolerance and impaired growth.

Surgical complications include:-

i) Intestinal obstruction, which is common. It occurs usually between ages 1-6 years. The relatively small diameter of the child's gut lumen facilitates blockage by an entangled mass of worms. The usual site of such obstruction is the terminal ileum. Intestinal spasm produced by irritation of mucosal sensory receptors, and inflammation of the gut wall by toxic metabolites of the worms may add to the problem. Features include

Table 71 . II.

Grading of intensity of helminths by World Health Organisation (WHO). (*EPG = Eggs per gram of stool.*)

HELMINTH	TERM	DEFINITION
Ascaris lumbricoides	- Ascariasis - Light ascariasis - Moderate ascariasis - Heavy ascariasis - Fatal ascariasis	- Any infection by ascaris - infection with less than 5000EPG - infection with 500-50,000EPG - infection with over 50,000EPG - death attributable directly to ascariasis (intestinal obstruction)
Hookworm species	Hookworm infection - Light infection - Moderate infection. - severe infection	- Any infection with Ancylostoma/ Necator Species - infection with less than 4000EPG - infection with 4000-80000EPG - infection with more than 80000EPG
Trichuris trichiuria	- Trichuriasis - light trichuris infection - heavy trichuris infecton	- Any infection with trichuris - infection with 1000 to 10,000EPG - infection with more than 10,000EPG
Strongyloides stercoralis	- Strongyloidiasis - disseminated strongyloidiasis - heavy strongyloidiasis	- Any infection with strongyloides species - Any infection with strongyloides with involvement of other organs. - Any infection with strongyloides stercolaris usually symptomatic occurring mainly in immuno- compromised host.
Taenia species	- Taeniasis - Teania solium Cysticercosis - Taenia Solium Taeniasis -Taenia Saginata Taeniasis	- Any infection with unspecified Taenia -Any infection with larval form of Taenia solium. -Any infection with Taenia solium. - Any infection with Taenia Saginata
More than one Helminth	Mixed intestinal helminthiasis (polyhelminthism)	- Any infection caused by more than one common species ofhelminths

vomiting, passage of worms (by mouth or per rectum), abdominal pain and the palpation of typical putty-like masses on the abdomen;
ii) Biliary and pancreatic obstruction because of the ability of the worm to explore orifices and ducts, leading to ascending cholangitis or pancreatitis.
iii) Hepatic abscess. From the biliary tree, the worms can invade the liver itself. Intrahepatic worms almost always die, stimulating a granulomatous reaction that either heals with fibrosis or progresses to a pyogenic abscess.
iv) Appendicitis
v) Peritonitis, which may result from the worms passing through the defect of previous appendectomy scar.

Wandering adult worms may be found in abnormal sites like the pleural cavity, heart, ear, nose or lachrymal duct, and reproductive tract. It is also known that Ascaris can serve as a vehicle of bacterial infections.

Trichuriasis;

Trichuriasis may either be asymptomatic or present with vague abdominal complaints, colic and abdominal distention. Heavy infection may lead to anaemia, chronic bloody diarrhoea with tenesmus especially in undernourished children, rectal prolapse or volvolus, poor growth as well as developmental and cognitive deficit. Adult worm sucks approximately 0.005ml of blood/24hr. However, there is no significant oesinophilia.

Hookworm;

This infection can manifest as pruritic erythematous papules on the skin, which may lead to vesiculation i.e. "Ground itch". The vesiculation and oedema of ground itch are exacerbated by repeated infection. Eosinophilia occurs. Gastrointestinal symptoms include abdominal pain, anorexia, indigestion, failure to thrive, diarrhoea and melena. A constant feature is anaemia. The pathogenesis of the anaemia caused by hookworm is dependent on three parameters: (i) the iron content of the human diet; (ii) the iron reserves and (iii) the intensity and duration of infection. These factors will vary in different tropical countries but must always be taken into account for a proper evaluation of a particular situation. Thus in Nigeria where iron intake is high, 21-30mg daily, the threshold of worm-load for anaemia to occur is high. The loss of red cells into the gut is proportional to the worm-load and has variously been reported as between 0.03-0.05mls of blood/worm/day, for Necator Americanus and between 0.16 and 0.34mls for Ancylostoma duodenale. Hypoalbuminaemia can also occur from a combined loss of blood and lymph as well as protein in the stools. There is nearly always a limited capacity for albumin synthesis brought about by such factors as anaemia, which affects the liver cell function, as well as failure to reabsorb amino-acids from the albumin passing into the gut. Oedema and anasarca may occur from loss of intravascular oncotic pressure. Chronic hookworm disease can cause a yellow-green pallor known as chlorosis. Respiratory symptoms such as cough occur when the larvae migrate through the lungs to cause laryngotracheobronchitis, usually about 1week after exposure. Pharyngitis may also occur. In ancylostoma doudenale, there is a period of arrested development (in countries like West Bengal and India) from larvae to adulthood. This appears to be seasonal, leading to a reduction in the output of eggs in an inhospitable environment and a marked increase in eggs entering the environment just before the monsoon.

Strongyloidiasis;

The symptoms correlate with the three stages of infection. This may manifest on the skin as pruritus and larva currens; the latter being an allergic reaction to filariform larvae as they migrate through the skin, characterized by large erythematous urticarial lesions, with rapidly moving (3.5cm/min) edges, which disappear in 2-3 days. It is usually found over the lower abdominal wall, buttocks, or thighs and has the tendency to recur. Gastro-intestinal symptoms include vomiting, diarrhoea. It is not unusual to observe malabsorption state and protein losing enteropathy due to destruction of the mucosal lining, leading to severe enteritis. Pulmonary symptoms resembling Loffler's syndrome occur rarely. Disseminated infection occurs in malnourished children and those with defects in cell-mediated immunity (AIDS, steroid therapy, lymphomas, Hodgkins disease). This leads to hyper-infection syndrome caused mainly by auto-infection which can be lethal. Multiple organs can be affected, with resulting bacteremia and septicaemia. Eosinophilia may be absent in immunocompromised persons.

Enterobiasis;

Presents mainly with nocturnal anal pruritus and/or sleeplessness. Careful statistical studies have associated these infections with low intelligence quotient (1Q) and slightly retarded growth, probably from the psychological effects of the symptoms.Perianal granuloma containing live or dead worms are rare.

Diagnostic features of helminthiasis

Ascariasis:

(i) Eosinophilia of Loeffler's syndrome
(ii) Direct faecal smear with quantification of worm and by Kato thick smear method
(iii) Abdominal X-rays: calcifications, shadows
(iv) Barium enema: demonstrates worms as linear filling defects, either singly or in group.

Trichuriasis:

Stool smears reveal characteristic eggs.

Hookworm:

i. Faecal smears – requires prompt examination because the ova disappear within one hour
ii. Kato thick smear
iii. Species identification requires egg hatching ar.. examination of the released larva.
iv. Polymerase chain reaction methods are beii developed.

Strongyloidiasis:

i. Faecal and duodenal aspirate for larva
ii. Larva may be found in sputum, gastric aspirates and rarely in small intestinal biopsy specimen
iii. Faecal sample for concentration-methods like formaldehyde-ether or Baermann technique.
iv. Estimation of antibodies against Strongyloides using Enzyme-linked-immunosorbent Assay (ELISA) or FAB technique.

Enterobiasis:

Eggs are detected on adhesive cellophane tape pressed against the peri-anal region early in the morning and then stuck on microscopic slide for laboratory examination. Multiple examinations are required for high detection rate. Routine stool samples rarely demonstrate the ova.

Treatment

The drug treatment of nematodes is outlined in **table71 .III.**

Prevention and control

Chemotherapy schemes for the control in ıe community:

i. Mass chemotherapy for everybody who comes for treatment (population)
ii. Selective for patients predisposed to large worm burdens (individuals)
iii. Targeted for preschool and school-age children (groups)
iv. Others: those patients who present with infection to health workers.

Because of the high rate of re-infection, chemotherapy has to be repeated at three to six months intervals. The feasibility and cost of such an undertaking will have to be evaluated before it can be widely accepted. Repeated treatments are required for institutionalized children to prevent enterobiasis. Also, individuals who will be given immunosuppressive drugs before organ transplantation or cancer chemotherapy should be screened for S.stercoralis,and treated before immunosuppression is induced.

Sanitary practices

i. Hand-washing before eating or handling of food
ii. Vegetables and fruits should be washed thoroughly
iii. Efficient sewage disposal system
iv. Untreated sewage should not be used as fertilizer.

Health Education

Integration of worm control into already established health-care programmes e.g. family planning schemes. This control can also be used to introduce communities to Primary Health Care for which they themselves can become both the managers and clients. An example is the construction of pit latrines and improvement of sanitation in their neighbourhood.

e. **wearing of shoes when in contact with soil,** for hookworm and strongyloides,.

f. **Genetically engineered hookworm antigen** for vaccination is in progress for hookworm prevention.

Table 71 .III.

Specific antihelminthic drugs for common nematodes

NEMATODE	DRUG OF CHOICE	ALTERNATIVE DRUGS
Ascariasis	Albendazole 400mg PO once for all ages **or** Mebendazole, 100mgbid x 3 days. **or** Pyrantel Pamoate 11mg/kgstat,max 1G	Piperazine, 75mg/kg/day x 2 days or Levamisole
Trichuriasis	Mebendazole 100mg.b.d. x3 days	Hexyl-redorcinol Albendazole Thiabendazole-25mg/kg.bd. x2 days.,
Hookworm	Albendazole 100mg bid PO x 3days **or** Mebendazole 100mg.b.d.x3 days	Pyrantel pamoate, 11mg/kg once dlyx3days Bephenium, Thiabendazole. Levamisole
Strongyloidiasis	Ivermectin 200µg/kg/day once dly x1-2days Thiabendazole 50mg/kg bid.x2days, max 3G/24hr	Albendazole 400mg bidx3days Pyrinvinium Pamoate 5mg /kg in 1 dose, Levamisole.
Enterobiasis	Mebendazole 100mg stat repeat in 2wks or Albendazole400mg PO for all ages or Pyrantel Pamoate 11mg/kg stat	Pyrivinium pamoate Piperazine, 65mg/kg daily for 7 days.

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