CHAPTER 6

Tropical gastrointestinal infections

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Gastrointestinal infections are widespread in countries/regions with low levels of hygiene and sanitation. Mostly these areas are classed as "developing" and this may include many tropical countries. Infections of the gastrointestinal tract can be caused by viruses, bacteria, protozoa, helminths and occasionally fungi (e.g. *Candida* overgrowth syndromes).

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6.1 Acute gastroenteritis in the tropics

Diarrhoea and vomiting syndromes lasting less than two weeks are classified as acute gastroenteritis. In healthy individuals, who receive adequate rehydration therapy, the disease is generally self-limiting. It is an extremely common syndrome in the developing world and a major cause of morbidity and mortality, particularly in infants and young children. The clinical features in association with the infective cause are summarised in Table 6.1.[1] The contribution of various pathogens to the childhood diarrhoea in developing countries in the tropics can be seen in Table 6.2.[2] In certain countries, a high prevalence of HIV and AIDS further complicates this picture, increasing the mortality in adults, as well as the incidence of invasive disease due to certain bacteria, such as non-typhoidal *Salmonella*. This chapter is not an exhaustive overview, but rather serves to highlight the commoner and more severe forms of enteric disease in the tropics.

Table 6.1. Clinical features of acute diarrhoea (modified from Bandres and DuPont).[1]

CLINICAL OBSERVATION	ANATOMIC CONSIDERATION	POTENTIAL PATHOGEN
Few, voluminous stools	Diarrhoea of small bowel origin	Vibrio cholerae, enterotoxigenic *Escherichia coli*, *Shigella* (early infection), *Giardia lamblia*, *Vibrio parahaemolyticus*
Passage of many small volume stools	Diarrhoea of large bowel origin	*Shigella*, *Salmonella*, *Campylobacter*, diarrhoeagenic *E. coli*, *Yersinia enterocolitica*, *Entamoeba histolytica*
Tenesmus, faecal urgency, dysentery	Colitis	*Shigella*, *Salmonella*, enteroinvasive *E. coli*, enterohaemorrhagic *E. coli Campylobacter*, *E. histolytica*, *V. parahaemolyticus* (rare)
Predominance of vomiting	Gastroenteritis	Viral agents (rotavirus, calicivirus) or intoxication (*Bacillus cereus*, *Staphylococcus aureus*)
Predominance of fever	Mucosal invasion	*Shigella*, *Salmonella*, *Campylobacter*, enteroinvasive *E. coli*, viral agents

Table 6.2. Pathogens frequently identified in children with acute diarrhoea seen at treatment centres in developing countries[2]

PATHOGEN	%
Rotavirus	15-25
Escherichia coli	
-enterotoxigenic	10-20
-enteropathogenic	1-5
Shigella species	5-15
Campylobacter jejuni	10-15
Vibrio cholerae	5-10
Salmonella species (not *S. typhi*)	1-5
Cryptosporidium	5-15

6.2 Enteric viral infections

Viral diarrhoea is the most commonly recognised form of disease due to this group of pathogens, in association with enteric disease and a major cause of mortality in children under five years in the developing world. A number of enteric viruses are also recognised as causing systemic disease, although acquisition may be through the faecal-oral route. These pathogens specifically include poliovirus (an enterovirus), hepatitis A (a picornavirus) and hepatitis E virus (a calicivirus). These diseases will be more completely discussed in later chapters. The more important causes of viral gastroenteritis are highlighted here; other causes are listed in Table 6.3.[3]

Table 6.3. Diarrhoea caused by viral infections.[3]

ACUTE SPORADIC/ENDEMIC DIARRHOEA OF CHILDREN AND ADULTS	EPIDEMIC DIARRHOEA	DIARRHOEA IN IMMUNOCOMPROMISED HOSTS
Rotavirus (60% children)	Calicivirus (90% of cases)	Cytomegalovirus
Calicivirus (20% children)	Astrovirus	Epstein-Barr virus
Astrovirus	Rotavirus	Adenovirus
Adenovirus	Adenovirus	Astrovirus
Torovirus		Picornavirus

Rotavirus diarrhoea is an acute infection primarily of children less than 2 years of age, characterised by watery stools and vomiting. The viruses have a worldwide distribution and are recognised as the most important viral cause of acute gastroenteritis in children. In tropical climates, there is less seasonal variation in the incidence of rotavirus infection compared with temperate climates, although the disease may be slightly commoner in the cooler, drier months. Peak incidence of infection in the developing world appears to be between six months and one year of age, a younger age incidence than that associated with infection in the developed world. Rotavirus infection may be asymptomatic or cause a mild to severe diarrhoea. In severe cases, the diarrhoea is more prolific than that due to other enteric viruses, accounting for the high morbidity and mortality associated with the disease. The incubation period ranges from 1 to 5 days, but is usually less than 48 hours, with the

abrupt onset of watery diarrhoea and vomiting. Vomiting usually stops within the first 2 days of the disease. A low-grade fever may be associated. The disease is usually self-limiting and lasts between 3 to 8 days, but in a substantial proportion of cases, the severity of the dehydration is second only to that seen in cholera.[4] Rotavirus diarrhoea can be partially distinguished from acute bacterial gastroenteritis by the early onset of fever and vomiting, the prevalence in cooler drier weather and its relative restriction to children under the age of two.

The norovirus group of viruses (previously known as Norwalk-like agents) and other human caliciviruses cause diarrhoea and vomiting of abrupt onset and short duration. Diarrhoea may occur without vomiting and vomiting without diarrhoea. Acquisition of antibodies to these viruses in early life in developing countries suggests that these viruses are responsible for infection in young children. It is estimated that 1-2% of episodes of gastroenteritis in children in these populations are due to noroviruses.[3] The incubation period for Norwalk disease averages between 24 and 48 hours. Illness is mild and lasts between 1 and 3 days. It may be accompanied by myalgia, headache, anorexia, fever and abdominal cramps.[5] The presentation may be indistinguishable from other viral causes of gastroenteritis. The population affected may be older than is seen in rotavirus infection.

Astrovirus infection occurs predominantly in young children, as well as immunocompromised individuals and institutionalised patients. There is a peak incidence in the winter months and these viruses contribute significantly as a cause of diarrhoea in children in developing countries, usually those less than one year of age.[5] They are a significant cause of diarrhoea in patients with acquired immunodeficiency syndrome.[3] Astroviruses cause mild diarrhoea and are rarely detected in the stools of hospitalised patients. Illness usually lasts between 2 and 5 days in imunocompetent patients. Vomiting is less common than in calicivirus infections. Fever, anorexia, nausea and abdominal pain may occur. Dehydration in infants is less severe than that seen with rotavirus infection. Illness in immunocompromised patients may be prolonged.[6]

Enteric adenoviruses are the second commonest cause, after rotaviruses, of viral diarrhoea requiring hospitalisation of young children. There are six groups of adenoviruses, the enteric adenoviruses belonging to group F. Two serotypes, 40 and 41 are included.[5] Disease develops after an 8- to10-day incubation and is characterised by watery diarrhoea that lasts for 10 days. Most cases in developing countries are in children under 2 years of age. There is no seasonal variation associated with adenovirus gastroenteritis. Vomiting and fever may occur, but are mild. Secondary lactose malabsorption has been associated.[3, 5]

6.3 Laboratory diagnosis, treatment, prevention and control of viral diarrhoea

Laboratory diagnosis typically requires demonstration of viruses in the stool by using electron microscopy or by agglutination (especially for rotavirus), or by other immunological assays.

Adequate rehydration is the mainstay of treatment in viral gastroenteritis. Oral rehydration is adequate in less severe forms, but must include fluids that can adequately replace the water and electrolyte losses experienced by the patient. Rehydration therapy should be initiated at home, and caregivers should be taught to make up rehydration fluids according to Table 6.4. Alternatively, packets of oral rehydration solution (ORS) as recommended by the WHO can be provided by the local clinic or hospital during diarrhoeal outbreaks. Severely dehydrated patients may require intravenous fluids such as Ringer's lactate or half-strength Darrow's in children, but this does not obviate the need to start oral rehydration before the child can

present at a facility for intravenous therapy. Children who are vomiting excessively may also need to receive intravenous rehydration.

Table 6.4. Signs of dehydration and rehydration of patients with gastroenteritis

DEGREE OF DEHYDRATION	REHYDRATION THERAPY	PLACE	SOLUTION
Mild Alert Mild thirst Slightly dry mouth Thirst Good skin turgor	Oral rehydration	Begin at home At the clinic or hospital	*5ml salt (1tsp), 50 ml sugar (10 tsp) in 1 litre boiled water †Sucrose 40g, NaCl 3.5g, Trisodium citrate 2.9g, KCl 1.5g, made up to 1 litre with boiled water
Moderate Restless, irritable Sunken eyes Dry mouth Thirsty Low blood pressure Poor skin turgor	Oral rehydration	Begin at home At the clinic or hospital	As per * above As per † above
Severe Lethargic or unconscious Very sunken dry eyes Very dry mouth Poor drinking Very poor skin turgor	Intravenous rehydration	At the clinic or hospital	Children: ½ strength Darrow's or Ringer's lactate Adults: Ringer's lactate

Diarrhoea is an important cause of malnutrition and withdrawal of other foods, including breast milk, may exacerbate this, increasing morbidity and mortality. Only in severe cases of lactose intolerance should milk feeds be reduced for a short period, until the intestinal mucosa has had some time to recover.[4] Antimotility agents are not indicated in management.

Preventive measures include sanitary waste disposal, avoidance water contaminated with human waste and good hygienic practices, such as hand washing. A rotavirus vaccine was licensed in 1998, but within one year it was withdrawn because of an increased rate of intussusception in vaccinees. There is no clear association of wild-type rotavirus infection with intussusception, and trials with new candidate vaccines are continuing.[7]

6.4 Enteric bacterial infections

Cholera remains one of the great epidemic diseases of the tropical world.[13] It is one of three internationally notifiable diseases in the world, with yellow fever and plague. *Vibrio cholerae*, the causative organism, is a Gram-negative, motile, non-spore-forming bacillus. The ability of

the organism to survive in a viable, but non-culturable form in the environment greatly enhances its epidemic potential. Only two serogroups, *V. cholerae* O1 and *V. cholerae* O139 have been associated with epidemic disease. *V. cholerae* O1 has 3 recognisable serotypes, Ogawa, Inaba and Hikojima, the last being an unstable intermediate between the first two. This serogroup can also be divided into two biotypes, classical and El Tor, which may be differentiated both biochemically and epidemiologically.[8,9]

- Classical *V. cholerae* O1 causes inapparent infection in approximately 60% of cases, as opposed to 75% of those due to *V. cholerae* O1 El Tor.
- Moderate to severe cholera (cholera gravis) due to classical *V. cholerae* O1 is seen in 25% of cases as opposed to approximately 10% of cases of *V. cholerae* O1 El Tor.

V. cholerae O1 El Tor is responsible for the current pandemic and has displaced classical *V. cholerae* O1 in most parts of the world as the commonest isolate.[8] *V. cholerae* O139 emerged on the Indian subcontinent in 1993 and appears to be a hybrid of *V. cholerae* O1 and other non-O1 strains. Clinically, patients are virtually indistinguishable from those with *V. cholerae* O1 El Tor biotype, although *V. cholerae* O139, being an encapsulated organism, has a greater tendency to become invasive.[9]

Patients are infected by *V. cholerae* O1 or O139 via contaminated food or water. In areas where cholera is endemic, there is a seasonal peak in warm wet summer months and numbers of cases decrease in winter.[8] The disease is toxin-mediated by means of an $A:B_5$ subunit toxin that causes active secretion of electrolytes and water into the gastrointestinal lumen, resulting in a profuse, watery, non-bloody diarrhoea. The B subunit binds to the epithelial cells of the small intestine. The A subunit is the active subunit, which activates adenylate cyclase intracellularly, increasing cyclic adenosine monophosphate (cAMP). The resultant effect is massive secretion of electrolytes, with concomitant osmotic loss of water.[9] The incubation period for cholera can range from several hours to 5 days depending on the inoculum size (between 10^8 and 10^{10} organisms). Patients may present with a brief prodrome of anorexia and abdominal discomfort and simple diarrhoea, or suddenly with profuse, watery diarrhoea. Vomiting may occur a few hours after the onset of diarrhoea. In cholera gravis, patients may lose up to 1 litre of water per hour, resulting in tachycardia, hypotension and death. The typical "rice-water" stool is only seen in a small proportion of cases, associated with severe diarrhoea.[8,9] Non-cholera vibrios have also been associated with gastroenteritis. These include *V. cholerae* non-O1, non-O139, *V. mimicus*, *V. parahaemolyticus*, *V. fluvialis* and *V. furnisii*.[8] *V. parahaemolyticus* has been associated with prolonged outbreaks due to contaminated seafood.[10]

Bacillary dysentery in the tropics is primarily associated with two of the four serogroups (species) of *Shigella*, namely *S. flexneri* and *S. dysenteriae*, particularly *S. dysenteriae* type 1. In certain tropical countries, *S. flexneri* may be responsible for up to 60% of cases in children presenting with bloody diarrhoea.[11] Case fatalities may be as high as 20%.[12] *Shigella* species are members of Enterobacteriaceae and are closely related to *Escherichia coli*. They are non-motile Gram-negative bacilli and have a characteristically inert biochemical profile. Humans are the only natural hosts and the infective dose may be as low as 10 to 100 organisms. The disease is associated with overcrowding, poor sanitation and inadequate water supplies. Patients with shigellosis present with diarrhoea after an incubation period of 1 to 5 days. This period may be as long as 6 to 8 days with *S. dysenteriae* type 1. *S. flexneri* and *S. dysenteriae* are associated with more severe illness than *S. sonnei*, which is the commonest isolate in the developed world, and *S. boydii*. Two enterotoxins have been shown to cause the small bowel

secretion and watery diarrhoea with which the patients present. The dysentery is caused by the organism's propensity to invade the large intestine and multiply within the mucosal epithelial cells, leading to cell death. Toxaemia, malaise and abdominal cramps, tenesmus and bloody mucoid stools follow the initial diarrhoea. Children may also develop vomiting and convulsions. *S. dysenteriae* type 1 has a particularly negative implication, due to the association with major epidemics, the production of Shiga toxin and the complications of the disease. Shiga toxin is a potent $A:B_5$ subunit exotoxin that has been associated with haemorrhagic enterocolitis and haemolytic uraemic syndrome (HUS). Acute HUS is primarily a syndrome of children exposed to Shiga toxin[2] although adults may also present with it. [3]

Escherichia coli are Gram-negative bacilli in the family Enterobacteriaceae. Although they are normal commensals of the gut, certain diarrhoeagenic strains (or pathotypes) exist within the species that can cause the full spectrum of diarrhoeal diseases, including watery diarrhoea, dysentery and haemorrhagic colitis, in association with HUS. Although these syndromes are frequently associated with particular serotypes, the difference in presentation lies at a molecular level, depending on which virulence genes are expressed by each organism and on the elaboration of enterotoxins.

Enteropathogenic *E. coli* (EPEC) is a major cause of primary acute diarrhoea in developing countries, particularly in children under two years of age (Table 6.2). Transmission is primarily faecal-oral. It usually manifests as acute diarrhoea, although rarely protracted diarrhoea has been associated. Vomiting and low-grade fever are common symptoms. The diarrhoea is watery with prominent mucus and rapid onset of dehydration. It is usually self-limiting.

Enterotoxigenic *E. coli* (ETEC) is associated with both weanling diarrhoea and Travellers' Diarrhoea, particularly in the developing world (Table 6.2). Illness usually starts abruptly after a short incubation period. Diarrhoea is watery without blood, mucus or leukocytes. Fever and vomiting occur in a minority of patients. The diarrhoea may be mild and self-limiting, or present with the severe purging typical of cholera. Most life-threatening cases occur in weanling infants.

Enteroinvasive *E. coli* (EIEC) invades the colonic mucosa, causing fever abdominal cramps, malaise watery diarrhoea and toxaemia. Dysentery occurs in 10% of patients, manifesting as scanty stools with blood and mucus. Outbreaks are usually food or water-borne; sporadic cases may be missed, due to non-specific features on culture.[13]

Enterohaemorhagic *E. coli* (EHEC) is an uncommon pathogen in developing countries although one such major outbreak has been described.[14] The incubation period averages 3 to 4 days. Mild cases manifest as diarrhoea indistinguishable from that caused by other infectious agents, but the EHEC Shiga toxins (stx 1 and stx 2) can cause a severe haemorrhagic colitis, with abdominal cramps, copious bloody diarrhoea but an absence of fever. HUS is commoner in children, and presents with a disseminated intravascular coagulation, haemolytic anaemia, thrombocytopenia and renal failure.[15] In developing countries, the syndrome is indistinguishable from that seen due to *S. dysenteriae* type 1.

Enteroaggregative *E. coli* (EAggEC) is increasingly recognised as a pathogen in the developing as well as the developed world. The diarrhoea presents as a watery, mucoid secretory illness with little or no vomiting and a low-grade fever. Bloody stools have been reported in up to 33% of patients.

Diffusely adherent *E. coli* (DAEC) is not well described clinically. Patients usually present with watery diarrhoea with absence of blood or faecal leucocytes.[13]

Salmonella typhi and the non-typhoidal salmonellas (NTS) are the same species, and represent different serotypes of *Salmonella enterica*. Common usage has resulted in the serotype being retained as though it were the species name and the epidemic and clinical significance of typhoid fever has promoted retention of *Salmonella typhi* as a microbiological diagnosis.[16] Typhoid (enteric) fever is caused by *Salmonella typhi*, a Gram-negative bacillus closely related to *E. coli*. It is a global health problem, particularly in developing countries, where incidence rates have been estimated as high as 1000 per 100,000 of population per year. In areas of endemicity and in large outbreaks, most cases occur in persons aged between 3 and 29 years. Humans are the only natural host and reservoir. The infection is transmitted by faecally contaminated water or food, the infectious dose being in the order of 10^5 organisms. This may be reduced depending on the vehicle of transmission and the patient's general health status.[16] Paratyphoid fever, which presents in a similar manner, is a less severe disease usually due to *Salmonella paratyphi* A and less commonly *S. paratyphi* B or *S. paratyphi* C. The incubation period is inversely proportional to the inoculum ingested, but averages around 14 days. Prolonged fever, initially remitting but later becoming sustained, headache, malaise, anorexia and a bronchitic cough characterize acute uncomplicated typhoid fever. Adults tend to present with constipation, whereas children develop diarrhoea. Up to 25% of patients may develop rose spots, a discrete macular-papular exanthem, on the trunk. The acute disease may be severe with up to 10% of patients developing complications, depending on the quality of the medical care. Occult blood is present in the stool of 10-20% of patients with 3% developing frank melaena. Intestinal perforation may occur with subsequent peritonitis. Altered mental status, either obtundation or delirium, has been associated with a high case fatality rate. Hepatitis, myocarditis, pneumonia, disseminated intravascular coagulation and haemolytic uraemic syndrome have been associated with typhoid fever.[16]

Gastroenteritis due to NTS is principally a zoonosis. The NTS may be harboured by many domestic animals, including chickens, turkeys, eggs, swine and cattle. These animals become infected via their environment or contaminated feeds. Infection occurs after ingesting contaminated foods or water.[17] Outbreaks are common and although data from developing countries are lacking, outbreaks of NTS gastroenteritis are well-recognised. These organisms have a propensity to cause nosocomial diarrhoea and nosocomial outbreaks in the tropics in association with NTS are well described.[18,19] Gastroenteritis develops 6-72 hours after ingesting contaminated food or water. There is sudden onset of abdominal pain, loose watery stools and occasionally mucus or blood. Nausea and vomiting are frequent, but rarely severe or protracted. Fever of 38-39 ºC is common. In uncomplicated cases the acute stage usually resolves within 48 hours. Illness may become more protracted with a low-grade fever for 10-14 days in rare cases. Symptoms are more severe in the very young and elderly, and in patients with underlying diseases.[18] This group has a higher than average mortality due to NTS, as the organisms are more likely to become invasive and cause bacteraemias. NTS may also localise to body sites and cause abscesses where there is damage due to pre-existing disease.[20] Mortality due to NTS bacteraemia in HIV infection in developing countries may be as high as 23-47%.[21,22]

Campylobacter jejuni, the most important species in the genus, is one of the most frequently associated bacteria from stools of infants with diarrhoea in developing countries as a result of

contaminated food and water. Rates in developing countries may be as high as 40,000 to 60,000 per 100,000 of children less than 5 years of age, compared with 300 per 100,000 in developed countries, although estimates in the general population for both are similar (90 per 100,000), suggesting that it primarily a disease of children in the former.[23] *C. coli* is the second commonest isolate causing gastroenteritis in 20% of cases.[24] The organism is highly associated with infections of domesticated animals, including poultry and other livestock and may be transmitted through undercooked foods or unpasteurised milk. In developing countries, where humans live in close proximity with their livestock, human strains have been shown to be identical to poultry strains in 71% of families and poultry faeces was the major environmental source.[25] Enteritis occurs after an infectious dose as low as 50 to 500 organisms, and this may be decreased by foods that neutralise gastric acidity. Average incubation is three days, starting with abdominal pain and diarrhoea, the major symptoms.[23] Diarrhoea may vary from watery, non-bloody, non-inflammatory diarrhoea to severe inflammatory diarrhoea. Fever, chills, headache and myalgia may occur.[24] Disease may be less severe in developing countries, although patients are often underweight and malnourished.[23] Up to 25% of patients may be asymptomatic.[24] *Campylobacter* bacteraemia may occur as a transient event in imunocompetent individuals, but is a serious complication in immune-suppressed individuals including those with HIV/AIDS.[23] Post-infectious complications such as Guillain-Barré syndrome and Reiter's syndrome are well recognised.

The disease is usually self-limiting and recovery takes 2 to 6 days. Untreated patients may shed bacteria for several weeks to months, but long-term carriage is usually limited to patients with immune-deficiency. Antibiotic treatment is usually not indicated, but where it is, erythromycin remains the treatment of choice, although resistance is developing. Ciprofloxacin is an alternative although resistance to this antibiotic has also been described.[24] Antimicrobial therapy is listed in Table 6.5.

6.5 Diagnosis of bacterial gastroenteritis

Cholera is definitively diagnosed by isolating *V. cholerae* from the patient's stool. A fresh specimen should be plated immediately onto suitable selective and non-selective culture media but if a delay is likely, the specimen should be placed in Cary-Blair transport medium. *V. cholerae* transported by this method should remain viable for several weeks. In epidemics, it is unnecessary to culture every patient's stool, but occasional cultures may be taken to confirm the presence of *V. cholerae*, the absence of another pathogen and to monitor antimicrobial susceptibility patterns. Rapid (dipstix) tests are available for *V. cholerae* and may be used for rapid diagnosis in clinics, but culture confirmation is still mandatory at the start of an epidemic.

In shigellosis, stool microscopy shows an abundance of polymorphonuclear leukocytes and red blood cells. Specific diagnosis depends on stool culture, with special attention being paid to the culture of *S. dysenteriae* type 1, as this is the most fastidious of the serotypes. Fresh stool culture is optimal, but if this is not possible, a transport medium such as Cary-Blair or buffered glycerol saline should be used. Stool should be plated onto appropriate selective media such as xyline lysine desoxycholate (XLD) or Hektoen enteric (HE) agar. *Salmonella-Shigella* (SS) agar is not suitable for isolating *S. dysenteriae* type 1. Biochemical identification of suspicious colonies from culture media will confirm the presence of *Shigella*, but serotyping with specific antisera is necessary for identifying the different species or serogroups. Antimicrobial susceptibility testing should be done to guide antimicrobial therapy.

Table 6.5. Antimicrobial treatment of common bacterial causes of gastrointestinal infections in the tropics*

INFECTION, ANTIMICROBIAL TREATMENT	PAEDIATRIC DOSAGE	ADULT DOSAGE
Cholera[38,39]		
(Antibiotics not essential)		
Ampicillin	50mg/kg/d in 4 doses x 3d	
Trimethoprim-sulfamethoxazole (Cotrimoxazole)	8mg TMP, 40mg SMX/ kg/d in 2 doses x 3d	160mg TMP, 800mg SMX b.d. x 3d
	5mg/kg/d in 4 doses x 3d	100mg q.i.d. x 3d
Furazolidone	7mg/kg STAT (max 300g)	300mg STAT
Doxycycline	50mg/kg/d in 3 doses x 3d	250mg q.i.d. x 3d
Erythromycin	30mg/kg STAT (max 1g)	1g STAT
Ciprofloxacin		
Uncomplicated bacterial gastroenteritis	Antibiotics rarely indicated	Antibiotics rarely indicated
Bacillary dysentery[26,40,41]		
Ampicillin	100mg/kg/d in 4doses x 5d	1g q.i.d. x 5d
Trimethoprim-sulfamethoxazole	10mg TMP, 50mg SMX/kg/d in 2 doses x 5d	160mg TMP, 800mg SMX q.i.d. x 5d
Nalidixic acid	60mg/kg/d in 4 doses x 5d	1g q.i.d. x 5d
Ciprofloxacin	10mg/kg/d x 5d	500mg b.d. x 5d
Ceftriaxone	50mg/kg/d daily x 5d	1g b.d. x 5d
Typhoid fever[16,42,43]		
Ampicillin	100mg/kg/d in 4doses x 14d	1g q.i.d. x 14d
Chloramphenicol	75mg/kg/d in 4 doses x 14d	500mg q.i.d. x 14d
Trimethoprim-sulfamethoxazole	8mg TMP, 40mg SMX /kg/d in 2 doses x 14d	160mg TMP, 800mg SMX b.d. x 14d
Ciprofloxacin	10mg/kg/d x 5-7d[a]	500mg b.d. x 5d
Ceftriaxone	50-70mg/kg/d daily x 5d	1-2g b.d. x 5d
Azithromycin	10mg/kg/d daily x 7d	500mg daily x 7d
Campylobacteriosis[44]		
Erythromycin	30-50mg/kg/d in 4 doses x7d	250mg q.i.d x 7d
Ciprofloxacin	-	500mg b.d. x 7d
Azithromycin	-	250mg b.d. x 7d

*This table serves as a guide to treatment of syndromes and local resistance patterns and patient demographics must be taken into account.
[a]Treat for 7 days if nalidixic acid resistant strain.

Diagnosis of *E. coli* diarrhoea depends on stool culture and phenotypic or genotypic characterisation of the culture. Although serotyping may be highly suggestive of diarrhoeagenic *E. coli*, specific tests such as immunoassays, molecular diagnostic methods and HEp-2 cell adherence are necessary to confirm the diagnosis.[15] *E. coli* O157, which is commonly (but not solely) associated with EHEC disease may be screened for, using sorbitol MacConkey agar and selecting sorbitol-negative colonies for serotyping. If EHEC infection is suspected, specific diagnosis is important to attempt because of the organism's epidemic potential and the serious sequelae of the disease.

The specific diagnosis of typhoid fever depends on the isolation of *S. typhi* from blood, bone marrow or a specific anatomical lesion. Clinical symptoms suggestive of typhoid fever or the detection of a specific antibiotic response are not definitive. Blood culture specimens should be inoculated into appropriate media immediately, and transport time should be minimised. Once inoculated, blood culture bottles should not be kept cold, but rather incubated at 37 ºC or left at room temperature in tropical countries. Biochemical profiles are highly suggestive of *S. typhi* in the clinical microbiology laboratory, but aberrant strains occur and specific agglutination against the O:9 (somatic), H:d (flagellar) and Vi (capsular) antigens should be performed on the suspicious isolate. Antibiotic susceptibility testing should be done whenever possible for *S. typhi*, because of increasing reports of multi-drug resistant organisms from many laboratories worldwide. The Widal test is widely used in developing countries, where blood culture techniques may be suboptimal. It measures agglutinating antibody levels against the O and H antigens of *S. typhi*. It is only moderately sensitive and specific and may be negative in up to 30% of culture proven cases of typhoid fever. Cross reactions in other clinical conditions, such as in cases of malaria, typhus or cirrhosis, may lead to false positive results. Results of the Widal test should thus be interpreted with care, against knowledge of cut-off rates for antibody levels for the local population and preferably after testing paired sera from the acute and convalescent stages. Newer rapid tests are being brought on to the market, but many of these are still being evaluated. Early work suggests that these may replace the Widal as a rapid test, in areas where blood culture is not available.[16] These tests will not guide antibiotic management and should only be used if the antimicrobial susceptibility patterns of local strains of *S. typhi* are known.

Non-typhoidal salmonellas (NTS) can be isolated from infected foodstuffs or stools. Culture may be assisted by the use of an enrichment broth. Biochemical tests followed by serological typing with O (somatic) and H (flagellar) antisera to these specific antigens define the particular serotype.[20] In disseminated disease, culture of the infected tissue will provide the diagnosis.

Campylobacter species may be detected on a wet mount of fresh stool using phase contrast or darkfield microscopy, by an experienced operator. Stool culture requires enriched media and isolation is improved by filtration techniques that exclude the normal flora. Certain species that have birds as primary hosts grow at higher temperatures i.e. 40 ºC. The organisms occasionally take as long as 72 hours to grow.[24]

6.6 Treatment of bacterial gastroenteritis

Details of rehydration treatment and antibiotics are given in Tables 6.4 and 6.5, respectively.
In cholera, rehydration therapy is the mainstay of treatment. As the diarrhoea is self-limiting, inadequate rehydration therapy is the greatest contributor to high death rates from cholera, and rehydration should be started early, ideally at the patient's home. Prompt therapy should

reduce the death rate to less than 1%. In the recent cholera epidemic in KwaZulu-Natal, South Africa, the death rate was recorded as low as 0.2%, despite the decision not to use antibiotics, simply because of an adequate and proactive rehydration scheme (Claire Lise Chaignat, personal communication). Antibiotic treatment has been shown to reduce the length of time of diarrhoea and volume of diarrhoea due to *Vibrio cholerae*, but has not been shown to decrease the death rate. Antimicrobial resistance to most commonly used antimicrobials has been described, including to ampicillin, cotrimoxazole, tetracycline (doxycycline), furazolidone and erythromycin. The fluoroquinolones have been shown to be effective, but decreasing susceptibility to nalidixic acid in certain parts of the world suggests that they may eventually become ineffective as well.[26-28]

Treatment of shigellosis depends on the presenting signs and symptoms. Patients with uncomplicated diarrhoea can be treated by rehydration alone. Specific antimicrobial therapy may be indicated in bloody diarrhoea, as antimicrobials have been shown to decrease the duration of fever, diarrhoeal illness and duration of fever. Antibiotics that have been used in the past include ampicillin, cotrimoxazole, tetracycline and nalidixic acid, and resistance to all these has been described.[27,11,12,29-33] The fluoroquinolones have been shown to be highly effective and are gaining recognition as a treatment option in children. In severely ill children who cannot take treatment orally, a third generation cephalosporin may be used. Treatment of HUS is primarily supportive and the disease is associated with a high morbidity and mortality.

In *E. coli* diarrhoea, specific antimicrobial therapy is usually unnecessary in uncomplicated diarrhoea. Antimicrobial resistance is increasing in diarrhoeagenic *E. coli* strains, specifically ETEC.[33] Dysentery requires antibiotic treatment. Antimicrobial usage may increase the risk of HUS in EHEC infection.[34] In most cases, with adequate rehydration therapy, prognosis is good and the diarrhoea is self-limiting.

Regarding *Salmonella* species infections: in the pre-antibiotic era, the death rate from typhoid fever was as high as 40%. Antibiotic management is mandatory and knowledge of local resistance patterns critical to guide therapy. Isolates from many parts of the world are now being reported as multi-drug resistant, including resistance to first-line drugs such as ampicillin, chloramphenicol and cotrimoxazole. Alternative regimens include fluoroquinolones, third generation cephalosporins or azithromycin. Uncomplicated diarrhoea due to NTS does not require antibiotic treatment, but supportive rehydration therapy only. Antibiotic management is indicated for dysentery and in those at risk for serious infection, such as the elderly or HIV patients.[26] Local knowledge of resistance patterns is mandatory, as NTS have been strongly associated with multidrug resistance, certain serotypes such as *S. enterica* serotype Typhimurium.[17] This resistance includes the production of extended-spectrum beta-lactamases (ESBL) and quinolone resistance. Invasive disease requires antibiotic therapy as well as drainage of any abscess sites.

6.7 Prevention and control of bacterial gastroenteritis

In general, prevention of bacterial enteric disease is achieved through adequate water and sanitation provision, proper personal and food hygiene practices, control measures in animal reservoirs in some cases, and health education. Some infections are amenable to vaccine prevention.

Once a cholera epidemic has started, it is extremely difficult to halt through normal patient interventions and education of the local population. Pro-active education is advisable before

the disease has reached epidemic proportions. Epidemics generally continue until population immunity is sufficiently high so as to prevent further spread of the disease, or due to alteration in the environmental conditions, so that the organism no longer has an optimal setting in which to survive. Infection-derived immunity is approximately 90% due to *V. cholerae* O1 El Tor, and the immunity to the 2 major serotypes appears cross-protective. The older type of cholera vaccine, consisting of phenol-killed *V. cholerae* organisms, engendered moderate short-lived immunity. Subsequently, two new vaccines have become available which produce far better and longer-lasting immunity. The first, an oral combination vaccine of killed *V. cholerae* organisms and purified B subunit (WC/rBS), is given in a two-dose schedule; inoculations are 10-14 days apart. Protection lasts for 3 years. The second is a live attenuated mercury-resistant strain of classical *V. cholerae* O1, which has been genetically manipulated (CVD 103-HgR). It is an oral vaccine requiring single dose therapy, which is less immunogenic than WC/rBS, but immunity develops more rapidly with the CVD 103-HgR vaccine. It may be useful, therefore, when logistics prevent the administration of the two-dose vaccine. The WHO position paper on the use of cholera vaccines is that the primary indication is in populations at risk in endemic areas and vaccination should be used in conjunction with other protective measures.[35]

The role of person-to-person transmission in shigellosis is well-recognised.[12,33] Epidemics due to *S. dysenteriae* type 1 may follow one of three patterns, with cessation of the epidemic as the population acquires immunity, repeated recurrences over a prolonged time period, or development of endemicity.[32] Currently, there are no vaccines available, although specific immunity does develop, as indicated by the increasing prevalence of *S. flexneri* 2b over *S. flexneri* 2a in Bangladesh, the latter being the commonest *Shigella* isolate in the developing world.[36] Vaccine trials for *S. flexneri* 2a are currently underway.

No vaccines are currently available for any forms of *E. coli* diarrhoea, although there are vaccines under development for EPEC, ETEC and EHEC.

Regarding typhoid, between 1 and 3% of patients have been reported to become chronic carriers, depending on age, sex and treatment regimen. A carrier is defined as an individual who continues to have a positive stool culture for *S. typhi* one year following recovery from acute illness. Carriage rates are increased in females, and in the presence of gall bladder pathology, schistosomiasis, and increased age. Co-morbid conditions should be treated before prolonged antibiotic treatment with amoxicillin, cotrimoxazole or ciprofloxacin. Ciprofloxacin achieves the highest rate of clearance. Three typhoid vaccines are available. The whole cell inactivated vaccine is an effective parenteral vaccine, but severe side effects make it intolerable to many patients. Ty21a is a live attenuated *S. typhi* oral vaccine requiring three doses and is probably contraindicated in immune-suppressed individuals, but it does provide herd immunity. It may be inactivated by concomitant use of antibiotics. Typhim-Vi is a parenteral vaccine given as a single dose and provides long-term immunity. The latter two are probably equally efficacious at preventing typhoid fever.[37]

In nosocomial outbreaks of NTS, education of staff and caregivers in the hospital on appropriate hand washing and infection control techniques is mandatory. There are no vaccines currently available for NTS.

Campylobacter infections produce a specific immune response and individuals from highly endemic areas develop measurable levels of antibodies and have less severe disease.

Protection is strongly associated with antibodies to strains carried by household chickens.[25] No effective vaccine is available.

6.8 Intestinal protozoan infections

A wide range of intestinal protozoa infect the human intestinal tract. Many of these are world-wide in distribution, but the range of species and their prevalence is higher in developing areas with low levels of sanitation and hygiene, be they temperate or tropical. *Entamoeba histolytica* tends however, to be endemic in many tropical regions of the world. The protozoan species infecting the human GIT are shown in Table 6.6 and this topic is covered in detail by Bell [45], Mills and Goldsmid[46], Guerrant,Walker and Weller[47] and Goldsmid, Speare and Bettiol[48].

Table 6.6: Intestinal protozoa infecting humans

Species	Site	Infective stage	Clinical association	Diagnositc stage	Epidemiology
Sarcodina:					
Entamoeba histolytica	L.I.	cyst	dysentery	troph/cyst	humans
Entamoeba coli	L.I.	cyst	commensal	troph/cyst	humans
Entamoeba dispar	L.I.	cyst	commensal	troph/cyst	human
Entamoeba hartmanni	L.I.	cyst	commensal	troph/cyst	humans
Iodamoeba butschlii	L.I.	cyst	commensal	troph/cyst	humans
Blastocystis hominis	L.I.	cyst	? diarrhoea	cyst	?zoonosis
Flagellata (Mastigophora):					
Giardia duodenalis	S.I.	cyst	diarrhoea	troph/cyst	zoonosis
Dientamoeba fragilis	L.I.	troph	?diarrhoea	troph.	humans
Trichomonas hominis	L.I.	troph	?commensal	troph	humans
Embadomonas intestinalis	L.I.	cyst	commensal	troph/cyst	humans
Chilomastix mesnili	L.I.	cyst	commensal	troph/cyst	humans
Enteromonas hominis	L.I.	cyst	commensal	troph/cyst	humans
Ciliophora:					
Balantidium coli	L.I.	cyst	dysentery	troph/cyst	zoonosis
Sporozoa (Apicomplexa):					
Isospora belli	S.I.	oocyst	diarrhoea	oocyst	humans
Cryptosporidium spp.	GIT	oocyst	diarrhoea	oocyst	zoonosis
Cyclospora cayetanensis	GIT	oocyst	diarrhoea	oocyst	humans
Microsporidia	GIT	oocyst	diarrhoea	oocyst	humans

As can be seen from Table 6.6, most of these gastrointestinal protozoa are commensals and their presence in a stool specimen merely indicates that the patient has ingested infected food or water. Repeat specimens may reveal the presence of pathogens such as *Giardia* (where cysts are shed in irregular showers) or *Entamoeba histolytica* (where cysts are shed in 8-10 day cycles).

The two best recognised pathogens are *Giardia duodenalis* (= *G. lamblia*; *G. intestinalis*) and *Entmoeba histolytica.* The latter species causes amoebiasis which can vary from the asymptomatic cyst passer (lumenal amoebiasis) to the patient presenting with non-dysenteric colitis, frank amoebic dysentery, amoeboma or extraintestinal invasive amoebiasis (eg liver/lung abscess)[46,47] Giardiasis (often termed "Bushwalker's Diarrhoea) may vary from asymptomatic to a malabsorbtive and often chronic diarrhoea lasting weeks or months if untreated[46]. It's interpretation as a significant pathogen is more variable and in regions of low sanitation and hygiene and with a host of other more serious intestinal pathogens, it may be so common as to be left untreated (see Chapter 18).

The role of *Blastocystis hominis* as a pathogen is controversial but it can be associated with a watery and often chronic diarrhoea[46]. A sensible approach to interpretation when finding this species in a stool specimen is to consider it significant if found in a patient with watery diarrhoea and in whom no other pathogens have been isolated after adequate laboratory investigations.

Both *Cryptosporidium* and *Isospora* can cause a watery diarrhoea, mostly in children or in patients with AIDS while *Cyclospora* is also recognised as a cause of a watery diarrhoea – mostly in travellers to developing regions [46,47]. The Microsporidia, which include the genera *Microsporidium* and *Enterocytozoon* amongst others, also tend to be pathogens in AIDS patients and again can be associated with a watery diarrhoea[46].

Dientamoeba fragilis is a flagellate which is probably transmitted in the egg of the threadworm (*Enterobius vermicularis*)[46] and, with *Trichomonas hominis* it is believed, arguably, by some, to be one of the " lesser lights of the protozoal diarrhoea syndrome".[49]

Diagnosis of these infections is mostly based upon repeat stool examinations, species being identified by trophozoite/cyst morphology and size after staining wet drop preparations with iodine or permanent faecal smears with stains such as Gomori or iron haematoxylin[46]. Antigen testing is now widely used for *Giardia* and *Cryprosporidium* and to differentiate the pathogen *E. histolytica* from the morphologically identical commensal, *E. dispar*[50]

Where treatment is needed, the most widely used drugs are metronidazole or tinidazole, but albendazole can be used for *Giardia* and the microsporidia while co-trimoxazole is used for *Cyclospora* and azithromycin for *Cryptosporidium*[51]

6.9 Intestinal helminth infections

Intestinal helminths comprise a wide range of species including trematodes, cestodes, nematodes and acanthocephalans. Like the intestinal protozoan species, some are world-wide in distribution but tending to be more common in areas of poor sanitation and hygiene. These may occur in both temperate and tropical regions but some species are confined to the tropics, requiring warm soil for development or needing intermediate hosts such as water snails which can only survive in warm water.

The range of commoner species of intestinal helminth are given in Table 6.7. Species marked with an asterisk are zoonotic and details of these helminthiases are available in such texts as that of Guerrant, Walker and Weller[47] and that of Goldsmid, Mills and Kibel[52]

Table 6.7. Intestinal helminths infecting humans[48]

Species	Geographical distribution	Life cycle	Mode of infection	Diagnostic stage
Trematoda:				
Fasciola spp*	Widespread	Indirect	plants	egg
*Fasciolopsis buski**	SE Asia	Indirect	plants	egg
Opisthorchis spp*	Asia/SE Asia	Indirect	fish	egg
*Clonorchis sinensis**	Asia/SE Asia	Indirect	fish	egg
Echinostoma spp*	Asia/SE Asia	"	snails/fish	"
*Gastrodiscoides hominis**	"	"	plants	"
Heterophyes spp*	"	"	fish	"
Metagonimus spp*	"	"	"	"
Schistosoma mansoni	Africa/S.America	"	water contact	"
*S. japonicum**	Far East/SE Asia	"	"	"
*S. mekongi**	Viet Nam	"	"	"
*S. intercalatum**	W. Afri ca "	"	"	"
Cestodes:				
*Dipylidium caninum**	Widespread	Indirect	flea	proglottid/ egg capsule
*Diphyllobothrium latum**	N. Hemisphere	Indirect	fish	egg
*Taenia saginata**	Widespread	"	beef	proglottid
*T. s. asiatica**	Taiwan	"	pork	"
*T. solium**	Widespread	"	pork	"
Hymenolepis nana	Widespread	Direct	egg	egg
*H. diminuta**	"	Indirect	insect	"
*Inermicapsifer madagascarensis**	Africa/Cuba	"	mite	proglottid
Nematodes:				
Ascaris lumbricoides	Widespread	Direct	egg	adult/egg
*A. suum**	"	"	"	"
*Ancylostoma caninum**	Tropics	Direct	skin	egg
*A.ceylanicum**	"	"	"	egg
A. duodenale	"	"	"	"
Anisakids*	Widesread	Indirect	fish	gastroscopy
*Capillaria philippinensis**	SE Asia	Indirect	crustacean	egg
*C. hepatica**	Widespread	Direct	egg	egg (liver)
*C. aerophila**	Widespread	Direct	egg	egg
Enterobius vermicularis	Widespread	Direct	egg	adult/egg
Necator americanus	Tropics	Direct	skin	egg
Strongyloides stercoralis	Tropics	Direct	"	larva
*S. fulleborni**	Africa/PNG	Direct	"	egg
*Ternidens deminutus**	Africa/?China	?Direct	?	"
Oesophagostomum spp*	Widespread	Direct	larva	egg
Trichostrongylus spp*	"	"	"	"
Trichuris trichiura	"	"	egg	"
Trichinella spp*.	Widespread	Indirect	larva/meat	larva/muscle
Acanthocephala:				
Macracanthorynchus hirudinaceus *	Russia	Indirect	insect	adult/egg
*Monilliformis moniliformis**	Widespread	"	"	"

*** zoonoses**

Whether or not helminth infections cause symptoms, usually depends on the worm load and, unlike protozoan infections, worm load is usually dependant on the infective dose. Another important feature of helminth infections is that of eosinophilia which usually occurs where there is a tissue invasive stage in the life cycle (as opposed to those species in which all stages are confined to the lumen of the gut). Eosinophilia is thus often a useful clue to the presence of an invasive helminth infection and is not a feature of protozoan infections

6.10 Trematodiases

All trematodes are transmitted from snail intermediate hosts. In some cases the snails release cercariae into water and these settle as metacercariae on water plants which are ingested by humans. In other cases, the metacercariae settle in fish or water invertebrates such as crabs and again human infection results from ingestion of these hosts[48]. In the case of the schistosomes, which live in the human mesenteric veins, infection results from cercariae in the water infecting through skin penetration.

Details of trematode infections are well covered by Guerrant, Walker and Weller,[47] Goldsmid, Mills and Kibel[52] and the trematode infections associated with food are covered by Goldsmid, Speare and Bettiol[48]

Clinical features are associated with worm load and in many cases trematode infections are asymptomatic or present as a mild enteropathy[48]. In the case of the schistosomes, however, the clinical spectrum of disease is wide and variable[47,52,53] Thus in schistosomiasis, patients may present with a spectrum of symptomatology varying from malaise, fever and occasionally diarrhoea during the early Katayama Syndrome phase, to anaemia and multiorgan damage in the later phase. The organ damage results mostly from egg deposition with resultant bilharzial pseudotubercle formation resulting in fibrosis of the intestinal wall, the liver, spleen and other organs[47,52,53] In most cases of schistosomiasis, infection dies out in about 5 years, but it can persist for years due to the ability of the adult worms to evade the host's immune responses. Clinical disease is thus dependant upon worm load and the duration of infection.

The diagnosis of trematode infections is usually based upon egg recovery from faecal specimens. In schistosomiasis, repeat stools may be necessary, particularly in chronic infections and in these latter cases, antibody serology may be required. This is very useful in short term travellers, but may be useful only as a negative screen in residents of highly endemic areas where infection may well be almost universal.

A good broadspectrum anthelmintic for most trematode infections, including schistosomiasis, is praziquantel[47,51-53] For intestinal schistosomiasis, an alternative is the drug oxamniquine[52]

6.11 Cestodiases

Most adult tapeworms in the intestine cause little or no overt discomfort to the host but theoretically they may contribute to malnutrition by competition for food in the gut[48]. Occasionally, however, the larger species (*Taenia* or *Diphyllobothrium*) may cause intestinal obstruction and *T. saginata* can cause a simulated appendicitis through wandering gravid proglottids blocking the appendix. Taeniasis due to *T. solium* (the Pork Tapeworm) is however particularly dangerous as the eggs passed by the human definitive (or final) host are infective not only to the pig, but also to humans by autoinfection (re-swallowing eggs passed

by self) or heteroinfection (swallowing eggs passed by someone else and contaminating food or water). This can result in cysticercosis, or infection with *Cysticercus cellulosae*, the cysticercus larva of *T. solium.* *Diphyllobothrium latum* can cause a megaloblastic (macrocytic) anaemia in the host if attached high up in the small intestine due to competition for Vitamin B12.

Infection of humans usually results from eating raw or undercooked fish or meat of the intermediate host animal depending on the species of tapeworm[48] but in some species, infection may follow accidental ingestion of an insect or mite intermediate host[47,48]

Diagnosis is by finding proglottids or eggs in a faecal specimen and again praziquantel is effective for treatment of most species. Niclosamide can be used as an alternative[47,51,52]

6.12 Nematodiases

Again, most intestinal nematode infections are asymptomatic, particularly when worm loads are low. However, the size of the adult *Ascaris* makes it liable to cause intestinal obstruction where loads are heavy, although even single migratory adult worms may cause bile duct or tracheal obstruction or intestinal perforation[47]. Heavy loads of hookworm (*Ancylostoma duodenale*, *A. ceylanicum* and *Necator americanus)* can all cause an iron deficiency (microcytic hypochromic) anaemia due to their blood sucking activities in the host small intestine[47,52,54] and *A.caninum* has been reported to be associated with eosinophilic enteritis[51].

In enterobiasis, anal pruritis is common and appendiceal blockage with an appendicitis-like presentation or presentation with a vaginal discharge may follow ectopic wanderings by the adult threadworms[47,52]. In trichuriasis, bloody diarrhoea can result when very heavy worm loads are encountered[52].

Strongyloidiasis due to *S. stercoralis* can be dangerous due to the ability of this species to autoinfect – an ability which enables the infection to persist in the host for 50 years or more after leaving an endemic region[55]. Such cases of chronic autoinfection often present with a typical "larva currens" rash[55]. The related zoonotic species *S. fulleborni* occurs in Central Africa[54] and is the cause of "Swollen Belly Syndrome" in PNG[54].

Oesophagostomum spp. are the so-called nodular worms, living in nodules in the wall of the large bowel and occcasionally resulting in intestinal perforation[54]. *Ternidens deminutu*s is a related species found in monkeys over a wide area of the tropics in Africa and Asia. It has been found to be common in Africans in Zimbabwe but the mode of infection is still speculative. It is known locally as "False Hookworm" due to the similarity of the eggs causing many misdiagnoses unless egg measurements are utilised in the diagnostic laboratory[54].

The trichinellids are nematodes which infect through the ingestion of meat containing the infective larvae. The adult male and female worms mature in the small intestine of the host and produce larvae which migrate through the gut wall to encyst in the muscles. During the initial stage of adult maturation in the gut, the host may suffer a transient diarrhoea, but most of the symptomatology results from the migrations and settling of the larvae in the muscles. This phase results, depending on worm load, in the host developing a severe allergic/toxaemic response with myositis, oedema (especially around the eyes), eosinophilia, fever and even death. Five species of the genus are recognised – *T. spiralis* (widespread); *T. nelsoni* (Africa);

T. nativa (Arctic); *T. britovi* (Palaearctic) and *T. pseudospiralis* (widespread, but diagnosed from a human in Tasmania)[48].

Diagnosis of intestinal nematode infections relies largely on the recovery of eggs in stool specimens, although the eggs of *E. vermicularis* need to be collected by the use of an anal tape technique[47,52]. Nematode eggs can usually be identified on shape and size[50,54]. In the case of *S.stercoralis*, larvae are passed in the faeces and repeat stool examination or examination of duodenal fluid may be required[47,54].

Good broadspectum anthelmintics for intestinal nematodes include albendazole, mebendazole and pyrantel[45,47,51,54]. *Trichuris* and *Strongyloides* tend to be more difficult to eradicate and are best treated with albendazole.

Albendazole/mebendazole+corticosteroids is recommended for the treatment of trichinosis, which is diagnosed by muscle biopsy or by antibody serology[51].

6.13 Acanthocephalan infections

Human infection with thorny-headed worms is uncommon but are encountered at times[52,56]. Diagnosis is usually based upon identification of passed adult worms, but eggs are typical in appearance and treatment involves the use of albendazole or mebendazole[56].

6.14 Closing remarks

The treatment of intestinal helminthic infections is given in Table 8.8.

It is worth mentioning that, when considering the need for treatment of parasitic infections in developing regions, and additionally where one might be faced with a limited budget, the following points should be considered for helminth infections:

- Is the infection clinically significant or likely to be so if the infection is allowed to become chronic (eg schistosomiasis)?
- Will treatment be worthwhile if reinfection is almost inevitable?
- Where control measures are in place at a community level, treatment of all cases no matter how light might be warranted.
- Where there are no control measures in place, might the retention of a low helminth load by the patient provide some degree of immunity to further infection and thus to the acquisition of a heavier load.

Table 6.8 Treatment of intestinal parasitic infections [45,51,57-59]

Infection	Drug	Dose regime (Adult – unless specified otherwise)
Protozoan infections:		
Amoebiasis - lumenal	Diloxanide furoate (?+ tetracycline)	500mg td x 10 d
- invasive	Metronidazole	500-750 mg td x 10d (Child: 15mg/kg td x 5-10d)
	Tinidazole	2g/d x 3-5d or 600-800 mg td x 5d
	(?+ Diloxanide	as above)
- liver abscess	as for invasive (?+ chloroquine)	600 mg base stat, then 300 mg base/d x 3d ????
Giardiasis	Metronidazole	250-400mg td x 3-7d (Child:15mg/kg/d x 3-7d)
	Tinidazole	2g stat (Child: 50-75mg stat)
	Albendazole	400 mg bd x 21d???
Dientamoebiasis	Doxycycline	100 mg bd x 3-10d
	Metronidazole	400 mg td x 3-7d (Child: 10mg/kg bd x 3-7d)
Blastocystosis	Metronidazole	400-750 mg td x 7-10d
Balantidiasis	Metronidazole	750 mg td x 5d
	Tetracycline	500 mg qd x 10d
Isosporiasis	Co-trimoxazole	160 mg TMP; 800 mg SMX qd x 10d, then bd x 21d
Cryptosporidiosis	Azithromycin	1200 mg bd day 1, then 1200 mg/d x 27d, then 500-750 mg daily long term
	Nitazoxanide	500 mg bd x 3d (Child: 100-200 mg bd x 3d)
Cyclosporidiosis	Co-trimoxazole	160 mg TMP; 800 mg SMX bd x 3-14d
Microsporidiosis	Albendazole	400 mg bd x 21-28d (Child: 200 mg bd x 21d)

Helminth infections:

Fascioliasis	Triclabendazole	10-12mg/kg x 1-2d
Fasciolopsiasis	Praziquantel	75mg/d in 3 doses x 1-2d
Clonorchiasis etc	Praziquantel	25mg/kg td x 1-2d
	Mebendazole	10mg/kg x 7d
Paragonimiasis	Praziquantel	25mg/kg td x 3d
Schistosomiasis	Praziquantel	20-30mg/kh bd STAT (or 3d)
Taeniasis	Praziquantel	10-20mg STAT
	Niclosamide	2g stat
Hymenolepiasis	Praziquantel	25mg/kg single dose
	Niclosamide	2g STAT, then 1g/d x 6d (Child: 1-1.5 g, then 0.5-1g/d x 6d)
Inermicapsifer	Niclosamide	? as for taeniasis
Dipylidium caninum	Niclosamide	? as for taeniasis
Ascariasis	Mebendazole	<10kg 50mg bd x 3d > 10kg 100mg bd x 3d
	Albendazole	<10 kg 200mg stat > 10kg 400mg stat
	Pyrantel emboate	11-20mg/kg STAT (max 750mg-1g)
Enterobiasis	Mebendazole	100-200 mg STAT,repeat after 21d (Child: 100 mg STAT, repeat after 21d).
	Albendazole	400mg STAT, repeat after 21d) (Child: 200mg STAT, repeat after 21d)
Hookworm	As for ***Ascaris***	
Trichuriasis	Mebendazole	As for ascariasis
	Albendazole	As for ascariasis
Strongyloidiasis	Albendazole	400mg STAT
	Ivermectin	200microg/kg x 1-2d
	Thiabendazole	25mg/kg bd x3d (max 3g/d)
Oesophagostomum	As for hookworm	
Trichostrongylus	As for hookworm	
Trichinosis	Albendazole	400mg x 3d
	Mebendazole	200-500mg td x 3d, then 400-500 mg td x 10d + corticosteroids 20-60 mg/d x3-5d
Anisakiasis	Surgical removal	-
	?Mebendazole	200mg bd x 3d
Moniliformis	As for hookworm	
Macracanthorhynchus	As for hookworm	

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