



7

Specific Gastrointestinal Microbial Infections

Tina Pakala

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SUGGESTED READING

CLOSTRIDIoidES (FORMERLY CLOSTRIDIUM)
DIFFICILE PSEUDOMEMBRANOUS COLITIS

(See Fig. 7.1 for an algorithm for the treatment of *Clostridioides difficile* pseudomembranous colitis)

VANCOMYCIN

Class: glycopeptide antibiotics

Brand name: Vancocin

Manufacturer: Pfizer

Dosage:

- First-line agent in *C. difficile* pseudomembranous colitis
- Non-severe or severe *C. difficile* infection: vancomycin 125 mg qid for 10 days

TREATMENT OF CLOSTRIDOIDES DIFFICILE COLITIS

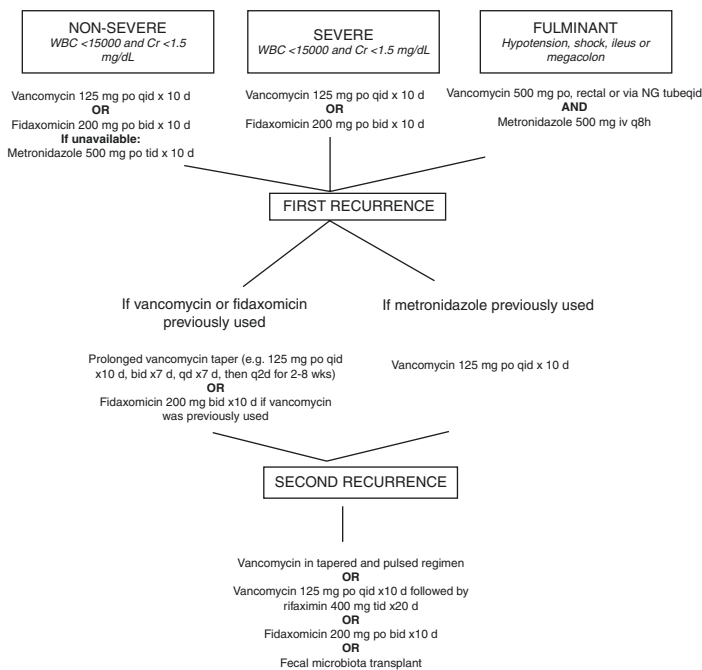


Fig. 7.1 Treatment of *Clostridioides difficile* pseudomembranous colitis. (Algorithm adapted by Drs. Clifford McDonald et al. [65]. With permission)

- Severe: vancomycin 125 mg po qid ×10 d or fidaxomicin 200 mg bid ×10 d
- Fulminant: vancomycin 125 mg qid with iv metronidazole 500 mg iv q8h

Contraindications/cautions:

- Hypersensitivity to vancomycin products
- Caution if impaired renal function
- Use with caution if hearing loss occurs

Adverse effects:

- Gastrointestinal: nausea and vomiting
- Cardiovascular: hypotension accompanied by flushing
- Renal: nephrotoxicity (rare)
- Hematologic: neutropenia (rare)

- Immunologic: anaphylaxis (rare)
- Dermatologic: erythematous rash on face and upper body (red neck or red man syndrome – infusion rate related)
- Otic: ototoxicity (rare)

Drug interactions:

- Increased nephrotoxicity with tenofovir, cidofovir, acyclovir, cyclosporine, ganciclovir

Pregnancy category: B

Lactation: probably safe

Relative cost: \$\$\$\$ (generic available: \$–\$\$\$)

FIDAXOMICIN

Class: macrolide antibiotics

Brand name: Dificid

Manufacturer: Merck

Dosing: recommended as alternative treatment option for pseudomembranous colitis

- Initial episode: 200 mg po bid for 10 days
- First recurrence: 200 mg po bid for 10 days
- Second or subsequent recurrence: 200 mg po bid for 10 days

Contraindications/cautions:

- Hypersensitivity reaction including angioedema, dyspnea
- Caution if macrolide allergy

Adverse effects:

- Gastrointestinal: nausea, abdominal distension, abdominal pain
- Hepatic: increased liver enzymes (rare)
- Hematologic: anemia (rare)
- Dermatologic: pruritus, skin rash

Drug interactions:

- Avoid combination with mizolastine, sodium picosulfate, cholera, and typhoid vaccines

Pregnancy category: B

Lactation: safety unknown

Relative cost: \$\$\$

METRONIDAZOLE

(See Chap. 6 on General GI Infections)

HELICOBACTER PYLORI

CLARITHROMYCIN-BASED THERAPY

PPI + amoxicillin (1 g po bid), clarithromycin (500 mg po bid)

BISMUTH QUADRUPLE THERAPY

PPI + metronidazole (500 mg po tid), tetracycline (500 mg po qid), bismuth subsalicylate or subcitrate (po qid)

CONCOMITANT TRIPLE THERAPY

PPI + amoxicillin (1 g po bid), clarithromycin (500 mg po bid), metronidazole (500 mg po tid)

AMOXICILLIN

Class: penicillin antibiotics

Brand names: Amoxicot, Amoxil, Amoxil Pediatric Drops, Biomox, Dispermox, Trimox, Wymox

Manufacturer: Generic; Amoxil – GlaxoSmithKline; Dispermox – Ranbaxy; Trimox – Apothecon Inc.

Dosage: for *H. pylori* eradication: 1 g po bid in combination with PPI and other antibiotics. See table

Contraindications/cautions:

- Hypersensitivity to amoxicillin
- Infectious mononucleosis: risk of developing skin rash
- Caution in phenylketonurics
- Hypersensitivity to cephalosporins: risk of cross reactivity

Adverse effects:

- Gastrointestinal: diarrhea, nausea, vomiting

- Immunologic: immune hypersensitivity reaction
- Dermatologic: rash

Drug interactions:

- Typhoid vaccine, live oral: antibiotic may inactivate vaccine

Pregnancy category: B

Lactation: safe

Relative cost: \$ (generic available: \$)

BISMUTH SUBSALICYLATE

Class: anti-diarrheals

Brand name: Bismatrol, Pepto-Bismol

Manufacturer: Generic

Pharmacology: cytoprotectant

Dosage: *H. pylori* eradication: 262–524 mg po qid for 10–14 days in combination with PPI and other antibiotics

Contraindications/cautions:

- G6PD deficiency
- Coagulation disorder
- Severe renal impairment

Adverse effects:

- Fecal discoloration
- Tongue discoloration
- Constipation
- Tinnitus

Pregnancy category: inadequate data to assess risk, possible risk of fetal harm

Lactation: safety unknown, considerate alternative

CLARITHROMYCIN

Class: macrolide antibiotics

Brand names: Biaxin, Biaxin Filmtab, Biazin XL

Manufacturer: generic; Biaxin – Abbott Laboratories

Dosage:

- *H. pylori* eradication: 500 mg po bid in combination with PPI and other antibiotics. (See Table 7.1 for treatment of *H. pylori*)

Table 7.1 Treatment of *H. pylori*

<i>H. pylori</i> treatment	Drug (oral)	Duration	Eradication rates	Indication for use
Standard	Proton pump inhibitor (PPI) bid, clarithromycin 500 mg bid, amoxicillin 1000 mg bid	10–14 days	70–85%	Non-penicillin (PCN) allergy No prior macrolide exposure Low prevalence of clarithromycin resistant strains of <i>H. pylori</i>
PCN allergy	PPI bid, clarithromycin 500 mg bid, metronidazole 500 mg bid	10–14 days	70–85%	PCN allergy Low prevalence of clarithromycin resistant strains of <i>H. pylori</i>
Bismuth quadruple therapy	Bismuth 525 mg qid, metronidazole 250 mg qid, tetracycline 500 mg qid, PPI bid	10–14 days	75–90%	Prior macrolide exposure PCN allergy Can substitute doxycycline if tetracycline difficult to obtain
Concomitant or non-bismuth based quadruple therapy	PPI + amoxicillin 1 g bid + clarithromycin 500 mg bid + metronidazole/tinidazole 500 mg bid	10–14 days	>90%	Low prevalence of clarithromycin resistant strains of <i>H. pylori</i>
FQ-based therapy	PPI SD, amoxicillin 1 g bid, levofloxacin 500 mg qd	10 days	87%	Prior macrolide exposure

Adapted from: Chey et al. [2]

Contraindications/cautions

- Concomitant cisapride, pimozone, astemizole, terfenadine, ergotamine, or dihydroergotamine
- Hypersensitivity to clarithromycin, erythromycin, or any macrolide antibiotics
- Dose adjustment required in renal failure patients

Adverse effects:

- Gastrointestinal: abdominal discomfort, abdominal pain, diarrhea, disorder of taste, indigestion, nausea, liver failure
- Neurologic: headache
- Immunologic: immune hypersensitivity reaction (severe), anaphylaxis, Stevens-Johnson syndrome, toxic epidermal necrolysis

Drug interactions:

- phenothiazines, cisapride, dofetilide, pimozone, ranolazine: increase risk of QT prolongation and cardiac arrhythmias.
- Ergot alkaloids: increase risk of ergot toxicity, severe vasospasm, and ischemia.
- Eplerenone: risk of hyperkalemia

Pregnancy category: C

Lactation: possibly safe

Relative cost: \$\$ (generic available: \$)

LEVOFLOXACIN

Class: fluoroquinolone antibiotics, inhibits DNA gyrase promoting breakage of DNA strands

Brand name: Levaquin

Manufacturer: Ortho-McNeil-Janssen Pharmaceuticals

Dosage: *H. pylori* eradication: 500 mg po qd in combination with PPI and other antibiotics. See table

Contraindications/cautions:

- Hypersensitivity to FQs
- Prior cardiac history or underlying QTc prolongation
- In the elderly, concern for toxic psychosis and tendon rupture
- Caution in people with G6PD deficiency and risk of hemolytic reactions
- In patients with myasthenia gravis may increase muscle weakness

Adverse effects:

- GI: nausea, diarrhea, constipation, abdominal pain, dyspepsia, vomiting
- GU: vaginitis
- CV: chest pain, edema
- CNS: headache, insomnia, dizziness
- Derm: skin rash, pruritus

Drug interactions:

- Concomitant administration with other QTc-prolonging agents
- Antacids may decrease absorption

Pregnancy category: C

Lactation: small amounts excreted in breast milk, consider cessation of drug or breastfeeding during administration

Relative cost: \$\$\$ (generic available: \$-\$\$)

TINIDAZOLE

Class: imidazole derivative antibiotics

Brand name: Tindamax

Manufacturer: Mission Pharmacol Company

Pharmacology: causes cytotoxicity by damaging DNA and preventing further synthesis

Dosage: *H. pylori* eradication: 500 mg bid in combination with PPI and other antibiotics

Contraindications/cautions:

- Hypersensitivity to nitroimidazole derivatives (including metronidazole)

Adverse effects:

- CNS: fatigue, malaise, dizziness
- GI: metallic taste, nausea, anorexia, flatulence, dyspepsia, vomiting, constipation
- GU: pelvic pain, urine abnormality
- MS: weakness
- Respiratory: URI

Drug interactions:

- Alcohol and disulfiram: result in toxic effects of disulfiram

Pregnancy category: C

Lactation: contraindicated in nursing mothers and 3 days after cessation of treatment

Relative cost: \$\$\$ (generic available: \$\$-\$\$\$)

E. COLI (EP AND EI) GASTROENTERITIS

- Ciprofloxacin 500 mg po bid for 3–5 days
- Bactrim 1 double strength tab po bid for 3–5 days

SHIGELLA COLITIS

- Ciprofloxacin: drug of choice: 500 mg po bid for 3 days. If *S. dysenteriae*, extend therapy 5–7 days
- Bactrim: 1 double strength tab (160 mg trimethoprim (TMP)/800 mg sulfamethoxazole (SMX)) po bid for 5 days
- Azithromycin: 500 mg po qd for 1 days, then 250 mg po qd for 3 days

SALMONELLA GASTROENTERITIS

1. Usually symptomatic management with fluids and electrolyte replacement
2. In severely ill, immunocompromised adults and children or elderly patients:
 - Ciprofloxacin 500 mg po bid for 3–7 days or
 - Levofloxacin 500 mg po qd or
 - Trimethoprim-sulfamethoxazole 160 mg/800 mg po bid or
 - Amoxicillin 500 mg po tid or
 - If intravenous therapy were required: a third-generation cephalosporin (ceftriaxone 1 to 2 g iv qd or cefotaxime 2 g iv q8h)

CAMPYLOBACTER GASTROENTERITIS

1. Usually symptomatic management with fluids and electrolyte replacement
2. In severely ill, elderly, pregnant, or immunocompromised patients, and those with bloody stools, high fever, extraintestinal infection, worsening or relapsing symptoms, or symptoms lasting longer than 1 week
 - Azithromycin 500 mg po qd for 3 days or
 - Ciprofloxacin 750 mg po bid for 3 days

VIBRIO CHOLERAE

1. Usually management with fluids and electrolyte replacement either orally or intravenously
2. As adjunct to appropriate rehydration
 - Tetracycline 500 mg po qid for 3 days or
 - Doxycycline 300 mg once or
 - Erythromycin 500 mg po qid for 3 days or
 - Azithromycin 1000 mg po once or
 - Ciprofloxacin 1000 mg po once

YERSINIA GASTROENTERITIS

1. Usually symptomatic management with fluids and electrolyte replacement
2. In severely ill, elderly, pregnant, or immunocompromised patients, or those having an underlying comorbid illness
 - Ciprofloxacin 500 mg bid for 5 days or
 - Trimethoprim-sulfamethoxazole in children (TMP 8 mg/kg/d and SMX 40 mg/kg/d bid)
 - If septicemia: ceftriaxone 2 g/d combined with gentamicin 5 mg/kg/d in qd to tid for 3 weeks

LISTERIA MONOCYTOGENES

Isolated gastrointestinal illness does not require antibiotic treatment

TRIMETHOPRIM-SULFAMETHOXAZOLE

(See Chap. 6)

CIPROFLOXACIN

(See Chap. 6)

WHIPPLE DISEASE

(See Table 7.2 for treatment of Whipple disease)

AZITHROMYCIN

Class: macrolide antibiotics

Brand name: Zithromax

Manufacturer: Pfizer, Inc.

Table 7.2 Treatment of Whipple disease

<i>Agent</i>	<i>Dosage</i>	<i>Indication</i>
Ceftriaxone	2 gm iv qd	Initial phase or relapse
OR	General infection: 2 weeks	Alternative agent for
Penicillin G	Cardiac involvement: 4 weeks CNS involvement: 2–4 weeks If relapse: ceftriaxone 2 gm iv bid for 4 weeks 2 million units iv q4h General infection: 2 weeks Cardiac involvement: 4 weeks CNS involvement: 4 million units IV q4h for 2–4 weeks If relapse: penicillin G 4 million units q4h for 4 weeks	initial phase or relapse
Meropenem	1 g iv q8h for 2–4 weeks	If allergy to PCN and ceftriaxone
Trimethoprim- sulfamethoxazole	160 mg/800 mg po bid	Long-term therapy for 1 year; first-line drug; good CNS penetration but CNS relapses may occur
Doxycycline + hydroxychloro- quine	100 mg po bid + 200 mg po tid	If sulfa allergy: long-term therapy for 1-year clinical relapses including CNS are well described

Source: Lagier et al. [62]; Boulos et al. [63]; Feurle et al. [64]; Feldman et al. [66]

Dosage:

- *Shigella* and enterohemorrhagic *E. coli*: 500 mg po qd for 3 days

Contraindications/cautions:

- Hypersensitivity to drug or components
- Use with caution in impaired renal function, impaired hepatic function
- Use with caution in QT prolongation

Adverse effects:

- Gastrointestinal: cholestatic jaundice, pseudomembranous colitis, diarrhea, nausea, abdominal pain, dyspepsia
- Cardiovascular: QT prolongation
- Dermatologic: angioedema, Stevens-Johnson syndrome, pruritus

Drug interactions:

- Increased risk of QT prolongation with cisapride, phenothiazines, pimozide, ranolazine, antiarrhythmics class IA and class III, chloroquine, droperidol, haloperidol, erythromycin, flecainide, methadone, pentamidine, ziprasidone

Pregnancy category: B

Lactation: enters breast milk/use caution

Relative cost: \$\$\$ (generic available: \$-\$\$)

ERYTHROMYCIN

Class: macrolide antibiotics

Brand name: E-mycin

Manufacturer: Abbott

Dosage:

- 250–500 mg po q6 to q12h

Contraindications/cautions:

- Hypersensitivity to drug or components

Adverse effects:

- Gastrointestinal: abdominal pain, anorexia, pancreatitis, pseudomembranous colitis, diarrhea
- Cardiovascular: QT prolongation, torsade de pointes, ventricular arrhythmia
- Otic: hearing loss

Drug interactions:

- Substrate of CYP2B6 and CYP3A4, P-glycoprotein, Inhibits CYP1A2, CYP3A4, P-glycoprotein

Pregnancy category: B

Lactation: enters breast milk/use caution

Relative cost: \$ (generic available: \$)

DOXYCYCLINE

Class: natural and semi-synthetic tetracycline antibiotics

Brand names: Adoxa, Doryx, Doxy Lemmon, Doxy-Caps, Doxy-D, Monodox, Oracea, Periostat, Vibra-Tabs, Vibramycin, Vibramycin Calcium, Vibramycin Hyclate, Vibramycin Monohydrate

Manufacturer: generic

Dosage:

- *Vibrio cholerae* – 300 mg po one dose

Contraindications/cautions:

- Hypersensitivity to drug or components
- Children less than 8 years old
- Caution in impaired liver function, impaired renal function
- Avoid sun/UV light exposure
- Caution if history of, or predisposition to, candidiasis
- Pregnancy

Adverse effects:

- Dermatologic: photosensitivity, skin discoloration, rash, erythema multiforme, Stevens-Johnson syndrome
- Gastrointestinal: hepatotoxicity, esophagitis, pseudomembranous colitis, pancreatitis, diarrhea, nausea, dyspepsia
- Hematologic: neutropenia, thrombocytopenia, hemolytic anemia
- Other: tooth discoloration in children less than 8 years old, headache, joint pain, pericarditis

Drug interactions:

- Contraindicated with acitretin due to increased risk of pseudotumor cerebri and papilledema
- Increased levels and risk of digoxin, lithium toxicity if given together
- Increased phototoxicity with hydroquinone/retinoic acid combinations

Pregnancy category: D

Lactation: unsafe

Relative cost: \$ (generic available: \$)

TETRACYCLINE

Class: natural and semi-synthetic tetracycline antibiotics

Brand name: Sumycin

Manufacturer: generic

Dosage: 1 to 2 g/d po bid-qid. Give at least 1 h before or 2 h after meals

Contraindications/cautions:

- Hypersensitivity to drug or components
- Use with caution in impaired renal function, impaired hepatic function
- Use with caution in systemic lupus erythematosus
- Pregnancy

Adverse effects:

- Gastrointestinal: hepatotoxicity, pseudomembranous colitis, pancreatitis, diarrhea, nausea, dyspepsia, abdominal discomfort
- Hematologic: neutropenia, thrombocytopenia, hemolytic anemia
- Dermatologic: photosensitivity, skin discoloration, rash, erythema multiforme, Stevens-Johnson syndrome
- Other: tooth discoloration in less than 8 years old, headache, dizziness

Drug interactions:

- Contraindicated with acitretin due to increased risk of pseudotumor cerebri and papilledema
- Increased levels and risk of digoxin, lithium toxicity if given together
- Increased phototoxicity with hydroquinone/retinoic acid combinations

Pregnancy category: D

Lactation: possibly unsafe

Relative cost: \$ (generic available: \$)

FUNGAL INFECTIONS

OROPHARYNGEAL CANDIDIASIS

1. HIV negative patients:

Topical therapy, with either clotrimazole troches (10 mg troche five times daily) or nystatin suspension (400,000 to 600,000 units qid)

2. HIV positive patients:

For initial episode of oropharyngeal candidiasis in HIV-infected patients with mild disease – topical therapy

3. For patients with recurrent infection, moderate to severe disease, or in those with advanced immunosuppression ($CD4 < 100$) – fluconazole 200 mg loading dose, followed by 100 to 200 mg qd for 7 to 28 days

ESOPHAGEAL CANDIDIASIS

- Fluconazole 400 mg loading dose followed by 200–400 mg po qd for 14 to 28 days
- Voriconazole 200 mg po bid for 14 to 28 days
- If iv therapy needed – caspofungin 50 mg intravenously for 7–21 days
- Clotriazole 10 mg troche five times daily for 7–14 days

FLUCONAZOLE

Class: azole antifungals

Brand name: Diflucan

Manufacturer: Pfizer, Inc.

Dosage:

- Esophageal candidiasis: Loading dose of 400 mg po/iv on day 1, then 200 to 400 mg po qd for 14–21 days

Contraindications/cautions:

- Hypersensitivity to drug or components
- Caution in impaired liver function, renal function
- Caution in QT prolongation, pro-arrhythmic conditions, electrolyte abnormalities, heart disease, elderly

Adverse effects:

- Gastrointestinal: hepatotoxicity, nausea, vomiting, abdominal pain, diarrhea, dyspepsia, taste changes
- Neurologic: seizures, headache, dizziness
- Cardiac: QT prolongation, torsades de pointes
- Hematologic: leucopenia, agranulocytosis, thrombocytopenia
- Dermatologic: Stevens-Johnson syndrome, angioedema, rash

Drug interactions:

- Decreased levels of antifungal drug with concomitant use of barbiturates, carbamazepine, rifampin, rifabutin
- Increased risk of QT prolongation with cisapride, droperidol, phenothiazines, pimozide, quinidine, ranolazine, amiodarone

Pregnancy category: C

Lactation: probably safe

Relative cost: \$\$\$ (generic available: \$-\$\$\$)

VORICONAZOLE

Class: azole antifungals

Brand name: Vfend

Manufacturer: Pfizer, Inc.

Dosage:

- Esophageal candidiasis: 200 mg po q12h. Treat for 14 days minimum and for 7 days after symptom resolution. Give 1 h before or after meal

Contraindications/cautions:

- Hypersensitivity to drug or components
- Caution in impaired liver function, renal function
- Caution in proarrhythmic conditions, electrolyte abnormalities, galactose intolerance, lactase deficiency, hematologic malignancy

Adverse effects:

- Gastrointestinal: hepatitis, fulminant hepatic failure, nausea, vomiting, diarrhea, abdominal pain, increase in liver transaminases, increase in alkaline phosphatase
- Cardiac: QT prolongation, torsades de pointes, tachycardia
- Dermatologic: Stevens-Johnson syndrome, angioedema, rash
- Other: color vision changes, photophobia, hallucinations, renal failure, peripheral edema

Drug interactions:

- Decreased levels of antifungal drug with concomitant use of barbiturates, carbamazepine, rifampin, rifabutin
- Increased risk of QT prolongation with cisapride, droperidol, phenothiazines, pimozide, quinidine, ranolazine, amiodarone

Pregnancy category: D

Lactation: safety unknown

Relative cost: \$\$\$\$ (generic available: \$\$-\$\$\$)

CASPOFUNGIN

Class: echinocandins antifungals

Brand name: Cancidas

Manufacturer: Merck & Co., Inc.

Dosage:

- Esophageal candidiasis: 50 mg iv q24h for 7–21 days

Contraindications/cautions:

- Hypersensitivity to drug or components
- Caution in impaired liver function

Adverse effects:

- Gastrointestinal: hepatotoxicity, nausea, vomiting, diarrhea, abdominal pain, increase in liver enzymes, increase in alkaline phosphatase
- Pulmonary: adult respiratory distress syndrome, pulmonary edema
- Other: fever, chills, infusion-related reaction, hypercalcemia, hypokalemia, flushing, eosinophilia

Drug interactions:

- Cyclosporine may increase caspofungin levels and risk of hepatotoxicity
- Carbamazepine, dexamethasone, efavirenz, nevirapine, phenytoin, rifabutin, rifampin may decrease caspofungin levels
- Caspofungin may decrease sirolimus, tacrolimus levels

Pregnancy category: C

Lactation: safety unknown

Relative cost: \$\$\$\$\$

CLOTRIMAZOLE

Class: antifungals

Brand name: Mycelex Troche

Manufacturer: Janssen Pharmaceuticals

Dosage:

- Esophageal candidiasis: 10 mg troche five times daily for 7–14 days

Contraindications/cautions:

- Hypersensitivity to drug or components

Adverse effects:

- Gastrointestinal: abnormal liver function

Drug interactions:

- Avoid concomitant use with tolvaptan

Pregnancy category: C

Lactation: safety unknown

Relative cost: \$\$\$ (generic available: \$-\$\$)

CRYPTOSPORIDIUM HOMINIS

- Nitroxanide 500 mg po bid for 7 days
- See below for product details

CYCLOSPORA CAYETANENSIS

- Bactrim 160/800 mg po bid for 7 days

(See Chap. 6 for more drug details)

NITAZOXANIDE

Class: agents for amoebiasis

Brand name: Alinia

Manufacturer: Romark Laboratories, LC

Dosage:

- Infectious diarrhea: 500 mg po q12h for 3 days. Give with food
- *Cryptosporidium hominis*: 500 mg po bid for 7 days

Contraindications/cautions:

- Hypersensitivity to drug or components

- Caution in impaired liver function, renal function
- Caution in biliary disease, diabetes, HIV, immunodeficiency

Adverse effects:

- Gastrointestinal: abdominal pain, diarrhea, nausea
- Other: headache

Drug interactions:

- May increase levels of warfarin and phenytoin

Pregnancy category: B

Lactation: safety unknown

Relative cost: \$\$\$

VIRAL INFECTIONS

CYTOMEGALOVIRUS (CMV)

- *Gastrointestinal disease*
 - Ganciclovir (5 mg/kg po bid) or foscarnet (90 mg/kg po bid) for induction therapy for 3–6 weeks
 - Switch to oral valganciclovir (900 mg bid) to complete induction therapy when presenting clinical manifestations have resolved.
- *Hepatitis*
 - Usually self-limited course. In severe CMV hepatitis, ganciclovir or valganciclovir has been recommended. Consider liver transplant evaluation in fulminant disease

HERPES SIMPLEX (HSV)

- *Gastrointestinal disease*
 - Acyclovir 400 mg po tid for 14 to 21 days. In immunocompromised individuals: 400 mg po five times a day for 14 to 21 days
 - If unable to swallow – acyclovir 5 mg/kg iv q8h for 7 to 14 days or iv foscarnet 40 mg/kg/dose every 8–12 h for 14–21 days
- *Hepatitis*
 - Acyclovir 10 mg/kg iv q8h for up to 21 days for any HSV hepatitis or in cases of severe disseminated disease

EPSTEIN BARR VIRUS (EBV) HEPATITIS

- Usually self-limited course. In severe cases, consider antiviral therapy with either acyclovir or ganciclovir (optimal dosing and duration undefined). Consider corticosteroid therapy and evaluation for liver transplantation in cases of severe fulminant hepatitis

GANCICLOVIR

Class: nucleoside and nucleotide DNA polymerase inhibitor antivirals

Brand name: Cytovene

Manufacturer: Roche Laboratories

Dosage:

- CMV prophylaxis in solid organ transplant: 5 mg/kg iv q12h for 7–14 days, then 5 mg/kg iv q24h \times 1 week or 6 mg/kg q24h 5 times/week. Alternative: 1000 mg po tid. Give with food
- CMV gastrointestinal disease: 5 mg/kg iv bid \times 3–6 weeks for induction therapy

Contraindications/cautions:

- Hypersensitivity to drug or components
- Hypersensitivity to acyclovir
- Absolute neutrophil count less than 500
- Platelets less than 25,000
- Caution in impaired renal function
- Caution in myelosuppression, elderly

Adverse effects:

- Gastrointestinal: pancreatitis, perforation, diarrhea, vomiting, increased liver transaminases
- Neurologic: seizures, neuropathy
- Hematologic: pancytopenia, anemia
- Other: depression, retinal detachment, hypertension, nephrotoxicity, impaired fertility, fever

Drug interactions:

- Increased risk of nephrotoxicity with cidofovir, aminoglycosides, carboplatin, cisplatin, clofarabine, efavirenz/emtricitabine/tenofovir, tacrolimus
- Increased risk of myelosuppression with clozapine, azathioprine, cisplatin, methotrexate

- Increased risk of seizures with imipenem

Pregnancy category: C

Lactation: unsafe

Relative cost: \$\$\$

VALGANCICLOVIR

Class: nucleoside and nucleotide DNA polymerase inhibitor antivirals

Brand name: Valcyte

Manufacturer: Roche Laboratories

Dosage:

- CMV colitis: 900 mg po bid for 21–42 days

Contraindications/cautions:

- Hypersensitivity to drug or components
- Hypersensitivity to ganciclovir
- Absolute neutrophil count less than 500
- Hemoglobin less than 8 mg/dl
- Platelets less than 25,000
- Caution in impaired renal function
- Caution in myelosuppression, elderly, chemotherapy, pregnancy

Adverse effects:

- Gastrointestinal: diarrhea, vomiting, abdominal pain
- Neurologic: seizures, neuropathy, agitation, psychosis
- Hematologic: aplastic anemia, leucopenia, thrombocytopenia, neutropenia, myelosuppression
- Other: infertility, nephrotoxicity

Drug interactions:

- Increased risk of nephrotoxicity with cidofovir, aminoglycosides, carboplatin, cisplatin, clofarabine, efavirenz/emtricitabine/tenofovir, tacrolimus
- Increased risk of myelosuppression with clozapine, azathioprine, cisplatin, methotrexate
- Increased risk of seizures with imipenem

Pregnancy category: C

Lactation: unsafe

Relative cost: \$\$\$\$\$

FOSCARNET

Class: non-nucleoside DNA polymerase inhibitor antivirals

Brand name: Foscavir

Manufacturer: Clinigen Group plc

Dosage:

- CMV colitis: 60 mg/kg po q8h or 90 mg/kg q12h for 3–6 weeks

Contraindications/cautions:

- Hypersensitivity to drug or components
- Caution in impaired renal function.
- Caution in myelosuppression, seizure, cardiac disease, electrolyte abnormalities, combination with nephrotoxic agents

Adverse effects:

- Gastrointestinal: pancreatitis, nausea, vomiting, diarrhea
- Neurologic: paresthesias
- Hematologic: anemia, granulocytopenia, leukopenia, thrombocytopenia
- Other: hypomagnesemia, hypokalemia, hypocalcemia, nephrotoxicity, fever

Drug interactions:

- Increased nephrotoxicity with cidofovir, aminoglycosides, carboplatin, cisplatin, clofarabine, efavirenz/emtricitabine/tenofovir, gallium, tenofovir
- May cause QT prolongation with droperidol, erythromycin, amiodarone

Pregnancy category: C

Lactation: safety unknown

Relative cost: \$\$\$\$

PROTOZOAN INFECTIONS

ANTIHELMINTHIC THERAPIES

(See Table 7.3 for antihelminthic therapies)

AMEBIASIS

1. To eliminate intraluminal infection
 - 500 to 750 mg po tid for 7 to 10 days

Table 7.3 Antihelminthic therapies

<i>Agent</i>	<i>Treatment</i>	<i>Alternatives</i>
Angiostrongyliasis	Supportive and corticosteroids	
Ascariasis	Mebendazole 100 mg bid for 3 d	Pyrantel pamoate 11 mg/kg or albendazole 400 mg po once
Cutaneous larva migrans	Ivermectin 200 µg/kg po qd for 1–2 days	Albendazole 400 mg po qd for 3 days
Cysticercosis	Albendazole 15 mg/kg/day po in 2 doses for 10–14 days Concurrent steroids for CNS disease	Praziquantel 50 mg/kg/day po tid for 10–14 days
Dracunculiasis	Metronidazole 250 mg po tid for 10 days plus worm removal	
Echinococcosis/ hydatid cyst	Perioperative albendazole	Albendazole 400 mg po bid for 1–6 months
Enterobiasis/ pinworm	Pyrantel pamoate 11 mg/kg po once or albendazole 400 mg po once or mebendazole 100 mg po once Repeat after 2 weeks	
Hook worm/ ancylostomiasis	Albendazole 400 mg po once or mebendazole 100 mg po bid for 3 days or pyrantel pamoate 11 mg/kg po for 3 days	
Onchocerciasis	Ivermectin 150 µg/kg po once, repeat every 6–12 months	
<i>Flukes</i>		

(continued)

Table 7.3 (continued)

<i>Agent</i>	<i>Treatment</i>	<i>Alternatives</i>
Liver flukes	Praziquantel 25 mg/ kg/day	
Intestinal flukes	po tid for 1 day	
Lung fluke	Praziquantel 25 mg/ kg/day po for 2 days	
Sheep liver fluke	Triclabendazole 10 mg/kg po once	
<i>Schistosomes</i>		
<i>S. mansoni</i>	Praziquantel 40 mg/kg/day	
<i>S. haematobium</i>	po in 2 doses for 1 day	
<i>S. japonicum</i> , <i>S. mekongi</i>	Praziquantel 60 mg/kg/day po in 3 doses for 1 day	
Strongyloidiasis	Ivermectin 200 µg/kg/day po for 2 days If immunocompromised: repeat at 2 weeks	Albendazole 400 mg po qd for 3–7 days
Tapeworm intestinal infections	Praziquantel 5–10 mg/kg po once	
Trichinellosis	Steroids for severe symptoms plus mebendazole 200–400 mg po tid for 3 days, then 400–500 mg po tid for 10 days	Albendazole 400 mg po bid for 10–14 days
Trichuriasis (whipworm)	Mebendazole 100 mg po bid for or albendazole 400 mg po qd for 3 days	Ivermectin 200 Mg/kg/d po for 3 days

Adapted from Rezaizadeh and Olson [61]

- Tinidazole 2 g po qd for 3 days
2. To eliminate intraluminal encysted organisms
 - Paromomycin: 25–30 mg/kg/day po tid for 7 days

GIARDIASIS

- Treatment of choice: tinidazole po 2 g single dose
- Alternative agents: Nitazoxanide 500 mg po bid for 3d. Metronidazole 250 mg po tid for 5d

PARASITIC INFESTATIONS

ANGIOSTRONGYLIASIS

- Supportive and corticosteroids

ASCARIASIS (*A. LUMBRICOIDES*)

- Treatment of choice: mebendazole 100 mg po bid for 3 days
- Alternative treatments: pyrantel pamoate 11 mg/kg or albendazole 400 mg once

CUTANEOUS LARVA MIGRANS

- Treatment of choice: ivermectin 200 µg/kg po qd for 1–2 days
- Alternative treatments: albendazole 400 mg po qd for 3 days

CYSTICERCOSIS (*TAENIA SOLIUM*)

- Treatment of choice: albendazole 15 mg/kg/day po bid for 10–14 days
- Alternative treatments: praziquantel 50 mg/kg/day po tid for 10–14 days
- Concurrent steroids for CNS disease

DRACUNCULIASIS (GUINEA WORM DISEASE)

- Metronidazole 250 mg po tid for 10 days plus worm removal

ECHINOCOCCOSIS (HYDATID CYST)

- Treatment of choice: perioperative albendazole followed by surgery
- Alternative treatments: albendazole 400 mg po bid for 1–6 months

ENTEROBIASIS (PINWORM)

- Pyrantel pamoate 11 mg/kg po once
- Albendazole 400 mg po once
- Mebendazole 100 mg po once
- Repeat after 2 weeks

HOOK WORM (ANCYLOSTOMIASIS)

- Albendazole 400 mg po once or
- Mebendazole 100 mg po bid for 3 days or
- Pyrantel pamoate 11 mg/kg po for 3 days

LYMPHATIC FILARIASIS (*W. BANCROFTI*, *B. MALAYI*, *B. TIMORI*)

- Diethylcarbamazine 6 mg/kg po once

LOAISIS (*M. STREPTOCERCA*, *O. VOLVULUS*, *D. MEDINENSIS*)

- Diethylcarbamazine 8 to 10 mg/kg/day po tid for 21 days

TROPICAL PULMONARY EOSINOPHILIA

- Diethylcarbamazine 6 mg/kg/day po tid for 14–21 days

TRYPANOSOMA CRUZI (CHAGAS DISEASE)

- Benznidazole for acute infection only: 5 to 7 mg/kg/day po bid for 60 days

ONCHOCERCIASIS (RIVER BLINDNESS)

- Ivermectin 150 µg/kg po once; repeat every 6–12 months

FLUKE INFECTIONS

- Liver flukes (*Clonorchis sinensis*), intestinal flukes (*Fasciolopsis buski*): praziquantel 25 mg/kg/d po tid for 1 day
- Lung fluke (*Paragonimus westermani*): praziquantel 25 mg/kg/day po tid for 2 days
- Sheep liver fluke: triclabendazole 10 mg/kg po once

SCHISTOSOMIASIS

- *S. mansoni*, *S. haematobium*: praziquantel 40 mg/kg/d po in bid × 1 day
- *S. japonicum*, *S. mekongi*: praziquantel 60 mg/kg/d po in tid × 1 day

STRONGYLOIDIASIS

- Treatment of choice: ivermectin 200 µg/kg/d po for 2 d. If immunocompromised 200 µg/kg/d po for 2 days and repeat at 2 weeks
- Alternative treatments: albendazole 400 mg po qd for 3–7 days.

TAPEWORM INTESTINAL INFECTIONS (*TAENIA SAGINATA*)

- Praziquantel 5–10 mg/kg po for 1 day

TRICHINELLOSIS (ROUNDWORM)

- Treatment of choice: steroids for severe symptoms plus mebendazole 200–400 mg po tid for 3 days, then 400–500 mg po tid for 10 days
- Alternative treatments: albendazole 400 mg po bid for 10–14 days

TRICHURIASIS (WHIPWORM)

- Treatment of choice: mebendazole 100 mg po bid for 3 days or albendazole 400 mg po qd for 3 days
- Alternative treatments: ivermectin 200 Mg/kg/day po for 3 days

ALBENDAZOLE

Class: antinematodal agents, benzimidazole

Brand name: Albenza

Manufacturer: GlaxoSmithKline, generic

Dosages:

- Ancylostomiasis and necatoriasis: 400 mg po as a single dose
- Ascariasis: 400 mg po as a single dose
- Clonorchiasis: 10 mg/kg po qd for 7 days
- Cutaneous larva migrans: 400 mg po qd for 3 days
- *Echinococcus granulosus* infection, hydatid disease: 60 kg or greater, 400 mg po bid for three 28-day cycles
- Enterobiasis: 400 mg po as a single dose; repeat in 2 weeks
- Enterocolitis, eosinophilic – infection by *Ancylostoma caninum*: 400 mg po as a single dose
- Infection by Gnathostoma: 400 mg po bid for 21 days
- Infection by Microsporidia: intestinal due to *E. intestinalis*, 400 mg po bid for 21 days

Contraindications:

- Hypersensitivity to albendazole or benzimidazole products
- Pregnancy
- Use with caution in impaired liver function

Adverse effects:

- Gastrointestinal: abdominal pain, nausea, vomiting, hepatotoxicity
- Neurologic: headache
- Renal: acute renal failure (rare)
- Hematologic: agranulocytosis, granulocytopenia, leukopenia, pancytopenia, thrombocytopenia (rare)

Drug interactions:

- Increased risk of albendazole toxicity with praziquantel and dexamethasone

Pregnancy category: C

Lactation: safe

Relative cost: \$\$\$

MEBENDAZOLE

Class: antinematodal agents, benzimidazole

Brand name: Emverm

Manufacturer: Impax Laboratories, Inc.

Dosages:

- Ancylostomiasis and necatoriasis: 100 mg po bid for 3 days
- Ascariasis: 100 mg po bid for 3 days
- Enterobiasis: 100 mg po once
- Trichuriasis: 100 mg po bid for 3 days
- *treatment may be repeated in 3 weeks in all above conditions

Contraindications/cautions:

- Hypersensitivity to mebendazole products
- Caution if prolonged use

Adverse effects:

- Gastrointestinal: abdominal pain, diarrhea, hepatitis
- Neurologic: headache, seizure
- Dermatologic: rash, angioedema
- Hematologic: neutropenia, agranulocytosis

Drug interactions: No significant drug interactions

Pregnancy category: C

Lactation: safe
Relative cost: \$\$\$

IVERMECTIN

Class: antinematodal agents
Brand name: Stromectol
Manufacturer: Merck & Co., Inc.

Dosages:

- Infection by *Onchocerca volvulus*: 150 µg/kg, single oral dose; retreatment interval between 3 and 12 months. Give on empty stomach
- Intestinal strongyloidiasis: 200 µg/kg, single oral dose

Contraindications/cautions:

- Hypersensitivity to ivermectin or components
- Pregnancy
- Asthma

Adverse effects:

- Gastrointestinal: disease of gastrointestinal tract, nausea, vomiting, diarrhea
- Neurologic: dizziness, headache
- Dermatologic: pruritus

Drug interactions: no significant drug interactions

Pregnancy category: C

Lactation: safety unknown

Relative cost: \$\$ (generic available: \$\$)

PRAZIQUANTEL

Class: antitrematodal agents
Brand name: Biltricide
Manufacturer: Bayer

Indications:

- Schistosomiasis: 20 mg/kg po tid for 1 day
- Clonorchiasis: 25 mg/kg po tid for 1 day
- Tapeworms: 5–25 mg/kg po once
- Intestinal flukes: 25 mg/kg po tid for 1 day

Contraindications/cautions:

- Hypersensitivity to praziquantel
- Ocular cysticercosis
- History of seizures

Adverse effects:

- Gastrointestinal: abdominal pain
- Cardiovascular: cardiac dysrhythmia, heart block
- Neurologic: dizziness, headache, seizure
- Other: malaise

Drug interactions:

- Chloroquine may decrease praziquantel levels
- Combination may increase albendazole levels

Pregnancy category: B

Lactation: Avoid breastfeeding for 3 days after last dose

Relative cost: \$\$\$

THIABENDAZOLE: NO LONGER AVAILABLE IN THE USA

Class: antinematodal agents, benzimidazole

Brand name: Mintezol

Manufacturer: Merck & Co., Inc.

Dosages:

- Ascariasis: (not first-line therapy): 50 mg/kg/d q12 h po for 2 days
- Cutaneous larva migrans – for 2 days
- Visceral larva migrans – for 7 days
- Trichinosis – for 2–3 days
- Dracunculosis – for 3 days

Contraindications/cautions:

- Hypersensitivity to thiabendazole products
- Prophylactic treatment of pinworm infestation

Adverse effects:

- Gastrointestinal: nausea, vomiting, anorexia, diarrhea, hepatotoxicity
- Neurologic: central nervous system finding, dizziness, drowsiness
- Dermatologic: erythema multiforme, Stevens-Johnson syndrome

Drug interactions:

- Combination may increase theophylline levels and risk of toxicity

Pregnancy category: C

Lactation: safety unknown

Relative cost: \$

PYRANTEL PAMOATE

Class: antinematodal agents

Brand name: Ascarel, Pamix, Pin-X

Manufacturer: generic

Dosages:

- Enterobiasis: 11 mg/kg (up to maximum 1 gm) po once
- Ascariasis: 11 mg/kg (up to maximum 1 gm) po once

Contraindications/cautions:

- Hypersensitivity to drug
- Pregnancy
- Liver disease

Adverse effects:

- Gastrointestinal: abdominal discomfort, nausea, vomiting
- Neurologic: dizziness, headache, somnolence

Drug interactions: no major drug interactions

Pregnancy category: generally regarded as unsafe

Lactation: safety unknown

Relative cost: \$ (generic available: \$)

TINIDAZOLE

Class: imidazole derivative antibiotics

Brand name: Tindamax

Manufacturer: Mission Pharmacal Company

Dosages:

- Intestinal amebiasis: 2000 mg po qd for 3 days
- Amebic liver abscess: 2000 mg po qd for 3–5 days
- Giardiasis: 2000 mg po once. Give with food

Contraindications/cautions:

- Hypersensitivity to drug or components
- Caution in impaired liver function
- Caution in disulfiram use, alcohol use, CNS disorder, blood dyscrasia

Adverse effects:

- Gastrointestinal: candidiasis, nausea, vomiting
- Neurologic: seizures, peripheral neuropathy
- Pulmonary: bronchospasm
- Hematologic: thrombocytopenia
- Dermatologic: Stevens-Johnson syndrome, erythema multiforme
- Other: menorrhagia

Drug interactions:

- Disulfiram like reaction with alcohol, lopinavir/ritonavir, tipronavir, diazoxide, ethanol
- May increase levels of lithium, phenytoin, cyclosporine, tacrolimus

Pregnancy category: C

Lactation: avoid/ breastfeeding during treatment and for 72 h after discontinuation. No human data available to assess risk of infant harm

Relative cost: \$\$\$ (Generic available: \$\$)

PAROMOMYCIN

Class: aminoglycoside antibiotics

Brand name: Humatin

Manufacturer: King Pharmaceuticals, Inc.

Dosages:

- Intestinal amebiasis: 25–35 mg/kg/day po divided in tid for 5–10 days
- Hepatic encephalopathy: 1000 mg po qid for 5–6 days
- Cryptosporidial diarrhea in HIV: 1500–3000 mg po divided 3–6 times per day. Alternative: 1000 mg po bid × 12 weeks in combination with azithromycin 600 mg po qd for 4 weeks. Give with food

Contraindications/cautions:

- Hypersensitivity to drug or components
- Use with caution in impaired renal function
- Use with caution in intestinal obstruction, inflammatory bowel disease, neurotoxic agents, ototoxic agents, dehydration, neuromuscular disease, auditory or vestibular dysfunction

Adverse effects:

- Gastrointestinal: malabsorption syndrome (prolonged use), enterocolitis, nausea, abdominal cramps, diarrhea
- Other: nephrotoxicity, ototoxicity, neurotoxicity

Drug interactions:

- Increased risk of nephrotoxicity with acyclovir, aminoglycoside, cyclosporine, flucytosine, foscarnet, ganciclovir, mitomycin, penicillamine, sirolimus, vancomycin

Pregnancy category: C

Lactation: probably safe

Relative cost: \$\$\$ (generic available: \$\$\$)

IODOQUINOL

Class: antifungals

Brand name: Yodoxin

Manufacturer: Glenwood, LLC

Dosage:

- Intestinal amebiasis: 650 mg po tid for 20 days. Give after meals, repeat treatments should be performed in 2–3-week intervals

Contraindications/cautions:

- Hypersensitivity to drug or components
- Hypersensitivity to iodine
- Use with caution in hepatic dysfunction
- Use with caution in thyroid disease

Adverse effects:

- Gastrointestinal: nausea, vomiting, abdominal pain
- Dermatologic: pruritus, skin discoloration
- Other: optic neuritis, peripheral neuropathy, headache

Drug interactions:

- Inadequate immunologic response to concomitant live oral typhoid vaccine
- May decrease levels of mycophenolate mofetil

Pregnancy category: C

Lactation: safety unknown

Relative cost: \$\$\$\$

DIETHYLCARBAMAZINE

Class: antihelminthics

Brand name: Hetrazan

Manufacturer: Wyeth

Dosage:

- Loiasis: 8 to 10 mg/kg/day po tid for 21 days
- Lymphatic filariasis: 6 mg/kg/day po qd or tid for 12 days

Contraindications/cautions:

- Hypersensitivity to drug or components

Adverse effects:

- Neurologic: encephalopathy
- Gastrointestinal: nausea

Drug interactions:

- Inadequate studies

Pregnancy category: X

Lactation: breast milk excretion unknown

Relative cost: \$\$\$

BENZNIDAZOLE

Class: agents for leishmaniasis and trypanosomiasis

Brand name: Rochagan

Manufacturer: Brazilian Government (not commercially available in the USA)

Dosage:

- Chagas disease: 5 to 7 mg/kg/day po bid for 60 days

Contraindications/cautions:

- Hypersensitivity to drug or components

Adverse effects:

- Neurologic: convulsions, seizures, peripheral neuropathy

Drug interactions:

- Enhance toxic effect of disulfiram

Pregnancy: avoid using during pregnancy; possible risk of fetal harm

Lactation: breastfeeding during therapy not recommended

Relative cost: \$

TRICLABENDAZOLE

Class: benzimidazole antihelminthics

Brand name: Egaten

Manufacturer: Novartis

Dosage:

- Fascioliasis: 10 mg/kg po q12h for 2 doses

Contraindications/cautions:

- Hypersensitivity to drug or components

Adverse effects:

- Gastrointestinal: self-limited biliary obstruction, abdominal cramping

Drug interactions:

- No known interactions

Pregnancy category: B

Lactation: safety unknown

Relative cost: \$\$\$

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