

**Chapter 35: Antimicrobials**

**Penicillins**

All penicillins have a basic structure composed of a beta-lactam ring and a thiazolidine ring. The third component, the side chain, varies and determines the antibacterial spectrum of the drug. Penicillins are bactericidal drugs that interfere with cell wall synthesis in growing bacteria. The penicillins can be classified on the basis of similar spectra. Penicillins are excreted into the urine. They reach adequate levels in the CSF, brain, and eye only in the presence of inflammation. The most frequent untoward effect is hypersensitivity that may be as serious as anaphylaxis. Central nervous toxicity may result from massive doses, especially in the presence of renal failure.

*Natural Penicillins*

1. Penicillin G (Pfizerpen, Pentids, SK-Penicillin).
  - a. Procaine (Wycillin, Crystacillin, Duracillin).
  - b. Benzathine (Bicillin).
2. Penicillin V (Pen-Vee K, Pfizerpen, Uticillin, V-Cillin K, Veetids, Betapen-VK).

Penicillin G remains the drug of choice for all infections caused by sensitive organisms, including Streptococcus (except enterococcus), pneumococcus, Neisseria meningitidis, N. gonorrhoeae, anaerobes (except most Bacteroides fragilis), syphilis, Leptospira, Listeria monocytogenes, Clostridia species, anthrax bacillus and Actinomyces. Crystalline penicillin G is given intravenously. Delayed absorption forms (procaine and benzathine) are given intramuscularly. Penicillin V has a spectrum similar to penicillin G, but has better absorption after oral administration. It usually is substituted for penicillin G when oral therapy is indicated.

**Semisynthetic (Penicillinase-Resistant) Penicillins**

1. Methicillin (Staphcillin, Celbenin).
2. Nafcillin (Unipen, Nafcil).
3. Oxacillin (Prostaphlin, Bactocil).
4. Dicloxacillin (Dynapen, Pathocil, Veracillin).

These drugs are resistant to staphylococcal penicillinase, and their only indication is in the treatment of infections caused by penicillin G-resistant staphylococci. Side effects include those listed for penicillins as well as interstitial nephritis (methicillin), neutropenia (high-dose oxacillin), and hepatitis (oxacillin). For serious infections these drugs should be

given intravenously in doses of 9-12 g daily.

Of this group, dicloxacillin reaches the highest levels after oral administration. Staphylococci that are "tolerant" and resistant to the semisynthetic penicillins are being reported with increased frequency.

### **Aminopenicillins**

1. Ampicillin: (Amcill, Omnipen, Polycillin, Penbritin, Pensyn, Principen, Totacillin).
2. Amoxicillin: (Amoxil, Larotid, Polymox, Robamox, Trimox, Wymox).

These L-aminobenzyl penicillin derivatives were the first broad-spectrum penicillins. They have activity against many gram-negative organisms, but are not resistant to penicillinase. Ampicillin has more activity than penicillin G against enterococci and gram-negative rods including Haemophilus influenzae, Shigella, Salmonella, many Escherichia coli, and Proteus mirabilis. It is slightly less active than penicillin G against group A streptococci and pneumococci. Amoxicillin has a spectrum almost identical to ampicillin, but reaches higher peak blood levels after an oral dose. The most frequent side effects are hypersensitivity rash and gastrointestinal upset with oral administration.

### **Antipseudomonas Penicillins**

1. Carbenicillin (Geopen, Pyopen).
  - a. Indanyl carbenicillin (Geocillin).
2. Ticarcillin (Ticar).
3. Piperacillin (Avocin).
4. Mezlocillin (Baypen, Mezlin).

These drugs are active against organisms sensitive to ampicillin and against indole-positive Proteus, some Enterobacter species, most anaerobic gram-negative bacteria, and, most important, most strains of Pseudomonas aeruginosa.

Carbenicillin and ticarcillin must be used intravenously in daily doses of 24-30 g and 18 g, respectively. Both contain large amounts of sodium in the doses listed and can cause fluid overload. Both interfere with platelet function, but not platelet numbers, and may cause neutropenia with prolonged use. These drugs should be used with aminoglycosides in the treatment of severe pseudomonas infections. Indanyl carbenicillin is indicated only for the oral treatment of pseudomonas urinary tract infections; it does not reach adequate tissue levels in any other system.

Piperacillin and mezlocillin are newer agents with extended spectra. Piperacillin has greater activity than any other penicillin against Pseudomonas aeruginosa. Mezlocillin is more active than carbenicillin against enterococci, Klebsiella species, and B. fragilis.

## **Cephalosporins**

These semisynthetic antibiotics are bactericidal and act like penicillins to inhibit cell wall synthesis. There are a wide variety of these agents with a range of absorption, tissue penetration, and spectrum of antibacterial activity. The first-generation cephalosporins have primarily gram-positive and limited gram-negative activity. The second-generation have more extensive gram-negative as well as anaerobic bacterial coverage. Third-generation cephalosporins are active against some strains of *Pseudomonas*.

Cephalosporins are acetylated to some extent in the body. Active and inactive metabolites are excreted in the urine.

### **Toxicity and Side Effects**

1. Hypersensitivity reactions are the most common complication of cephalosporin therapy. The incidence of cross-reactivity with penicillin hypersensitivity is less than 10%, and cephalosporins can be given with caution to penicillin-hypersensitive patients.

2. Hematologic: A positive direct Coombs' test occurs in some patients receiving cephalothin.

3. Elevated SGOT occurs rarely in association with cephalosporin therapy and usually is not of clinical significance.

4. Neutropenia is occasionally noted, particularly with the newer cephalosporins.

### **Cephalothin (Keflin)**

This drug is effective for gram-positive infections including penicillinase-producing staphylococci. It is also active against some gram-negative organisms such as *Klebsiella*, *Proteus mirabilis*, and *E. coli*.

### **Cefazolin (Kefzol, Ansef)**

This drug has a longer half-life and less pain with intramuscular injection than cephalothin. Its spectrum of activity is identical.

### **Cephalexin (Keflex)**

Cephalexin is absorbed orally, but is less active against many staphylococci and some anaerobes. It should not be used to treat serious deep tissue infections. Note: This drug is not as effective as penicillin for most oral-pharyngeal bacteria.

### **Cephaloglycin (Kafocin)**

This is another oral cephalosporin with less absorption than cephalexin, and little clinical usefulness.

### **Cephapirin (Cefadyl)**

Cephapirin is pharmacologically equivalent to cephalothin.

### **Cephradine (Velosef, Anspor)**

Cephradine is similar to cephalexin, but with both oral and parenteral administration.

### **Cefaclor (Ceclor)**

This is an oral cephalosporin with some activity against *Haemophilus influenzae*. It should not be used for serious deep tissue infections.

### **Cefamandole (Mandol)**

Cefamandole is a second-generation cephalosporin with expanded gram-negative spectrum including some *Enterobacter* and *Serratia*, as well as some activity against *Bacteroides fragilis*.

### **Cefoxitin (Mefoxin)**

Cefoxitin is actually a cephamycin rather than a cephalosporin. It has an extended gram-negative spectrum and is more active than cefamandole against *B. fragilis*. However, it is less active against many staphylococci and streptococci.

### **Cefotaxime (Claforan)**

This is a third-generation cephalosporin with a broad range of activity for gram-negative organisms including some strains of *Pseudomonas* and *B. fragilis*. It is less active than cephalothin for *Staphylococcus*.

### **Moxalactam (Moxam)**

A third-generation cephalosporin with extended range of activity including some strains of *Pseudomonas*, it is also highly active for *N. gonorrhoeae*. It may be drug of choice for gram-negative meningitis.

### **Aminoglycosides**

These are bactericidal agents that interfere with protein synthesis of the 30S subunit of bacterial ribosomes, causing misreading of the genetic code.

These drugs are not absorbed from the gastrointestinal tract. They are excreted primarily unchanged as active drug in the urine. Dosage must be decreased with renal failure.

Concentrations of drugs of about one-third of serum levels are achieved in tissue, sputum, and saliva. CSF penetrance is poor.

Aminoglycosides are active against many gram-negative bacteria, staphylococci, and mycobacteria. They are not active against anaerobes or streptococci.

### **Ototoxicity and Side Effects**

1. Ototoxicity: Irreversible cochlear and vestibular damage are common. Deafness occurs more commonly with kanamycin and neomycin, while vestibular dysfunction is more common with gentamicin and tobramycin. This toxicity is potentiated by preexisting renal disease, high serum drug levels, and sometimes with prolonged drug usage.

2. Nephrotoxicity: Damage to renal proximal tubular cells may cause reversible azotemia. This toxicity is associated with high serum peak-and-through drug levels, preexisting renal disease and, elderly patients.

3. Neuromuscular blockade: Neomycin, streptomycin, and kanamycin may cause a curarelike neuromuscular blockade which is potentiated by anesthesia and especially common with the peritoneal route of antibiotic administration.

4. Hypersensitivity: Rashes and drug fever are rarely seen with aminoglycosides.

### **Streptomycin**

Streptomycin is used primarily to treat tuberculosis, and combined with penicillin for enterococcal endocarditis. Its most serious toxicity is vertigo from vestibular damage. This is related to both total dose and peak serum dose.

### **Kanamycin**

Kanamycin is used almost exclusively as an oral bowel-sterilizing agent before bowel surgery.

### **Gentamicin**

Gentamicin is the agent of choice for many gram-negative bacterial infections, and is combined with penicillin or semi-synthetic penicillin to treat staphylococcal and enterococcal endocarditis. It may cause eighth nerve damage when administered as otic drops when the tympanic membrane is ruptured.

### **Tobramycin**

Tobramycin has a similar spectrum of activity to gentamicin. It is the preferred agent for pseudomonas infection, and has a synergy with carbenicillin for Pseudomonas. The incidence of ototoxicity is the same as for gentamicin. Some investigators claim less nephrotoxicity, but others disagree.

## **Amikacin**

Amikacin has a similar spectrum of activity to gentamicin and tobramycin. It is sometimes active against hospital-acquired resistant gram-negative bacteria. It has a higher incidence of cochlear damage and the same degree of nephrotoxicity as gentamicin. This drug should be reserved for bacteria resistant to gentamicin and tobramycin.

## **Neomycin**

Neomycin is used for topical administration only. It usually is combined with polymyxin B and bacitracin in creams and sprays such as Neosporin ointment. Its activity is against staphylococci and most gram-negative bacteria except *Pseudomonas*. As a topical agent it may be systemically absorbed to cause progressive nerve deafness. It also may cause deafness when instilled in the otic canal with a perforated tympanic membrane.

## **Sisomicin and Netilmicin**

These drugs were developed for serious gram-negative infections. Amikacin, however, usually is more active against gentamicin-resistant strains. These agents are therefore rarely indicated.

## **Bacitracin**

Bacitracin is for topical use only. It is active against most gram-positive organisms including staphylococci and streptococci. Gram-negative bacteria are resistant. It is a topical agent not absorbed systemically like neomycin.

## **Chloramphenicol**

Chloramphenicol is a bacteriostatic agent that inhibits protein synthesis by reversibly binding to the 50S bacterial ribosome, preventing peptide bond formation. Chloramphenicol has a broad spectrum of activity. It is active against most gram-positive and gram-negative aerobic bacteria with the exceptions of *Pseudomonas aeruginosa* and many *Enterobacter*, *Serratia*, and indole-positive *Proteus* species. It has excellent activity against anaerobic bacteria, rickettsiae, and mycoplasmas. The excellent penetration of chloramphenicol into the CSF makes it the initial drug of choice in most cases of meningitis. It also achieves therapeutic levels in other body tissues and fluids, including the aqueous humor. Chloramphenicol is metabolized in the liver, and dosage adjustment is not required in renal failure.

## **Toxicity and Side Effects**

### **Bone Marrow**

The toxicity of chloramphenicol is manifest primarily in the bone marrow and is of two types. The first, aplastic anemia, is a rare idiosyncratic response and not dose related. This type of toxicity, generally irreversible and fatal, rarely occurs with parenteral chloramphenicol.

The second type of toxicity is the more common dose-related bone marrow suppression. This produces anemia, leukopenia, and/or thrombocytopenia. These effects are reversible when the drug is discontinued.

### **Gray Baby Syndrome**

Premature and newborn infants who receive large doses of chloramphenicol can develop circulatory collapse with a high mortality. The drug should not be given in late pregnancy or during breast-feeding.

### **Hypersensitivity**

Rashes and drug fever are rarely noted.

### **Lincomycin (Lincocin) and Clindamycin (Cleocin)**

These antibiotics act to inhibit bacterial protein synthesis at the 50S subunit. They are well absorbed orally, tolerated parenterally, and metabolized by the liver. High concentrations are achieved in most body tissues and the saliva. Cerebral spinal fluid concentrations are low. Doses should be reduced with liver failure. They are active against most gram-positive organisms including penicillinase producing staphylococci. Clindamycin is a first-line agent for infections with *B. fragilis*.

### **Toxicity and Side Effects**

1. Pseudomembranous colitis: This life-threatening complication is due to overgrowth of *Clostridium difficile* in the bowel flora. It is more common when these antibiotics are administered orally. This complication is not, however, unique to these drugs and occurs following administration of most other classes of antibiotics.

2. Nausea, vomiting, and diarrhea: Relatively common side effects which often precede pseudomembranous colitis.

3. Hypersensitivity: Drug fever and skin rash occur commonly with clindamycin.

4. Elevated SGOT is occasionally noted, but of little clinical significance.

### **Erythromycin**

Erythromycin is the most important of the macrolide antibiotics. It is generally considered to be bacteriostatic, but can be bactericidal at higher concentrations. Erythromycin binds reversibly to the 50S ribosomal subunit in bacterial cells and interferes with chain elongation in protein synthesis. It has a broad spectrum of activity against bacteria, treponemas, and mycoplasmas. It is the agent of choice in *Mycoplasma pneumoniae* infections, Legionnaires' disease, diphtheria, and pertussis. It also is important in treating pneumococcal pneumonia, syphilis, gonorrhea, and group A streptococcal infections in penicillin-allergic patients.

Erythromycin is excreted in bile and, to a lesser extent, in urine. Most appears to be inactivated by metabolic degradation in the liver. Erythromycin achieves therapeutic levels in body tissues and fluid other than the brain and CSF.

### **Toxicity and Side Effects**

Erythromycin causes few untoward reactions. Side effects include dose-related gastrointestinal distress, thrombophlebitis with intravenous use, and occasional allergic reactions. Hepatotoxicity may result from use of the estolate preparation. Large intravenous doses (more than 3 g/day) may cause transient hearing loss.

### **Tetracyclines**

This group of broad-spectrum bacteriostatic agents are generally administered orally. Tetracyclines bind reversibly to 30S ribosomes in bacterial cells and block the transfer RNA. They are active against many gram-positive and gram-negative bacteria excluding most *Enterococcus* and *Proteus*, *Pseudomonas*, and *Klebsiella* species. *Rickettsiae*, *Chlamydiae*, and *Mycoplasmas* also are susceptible to tetracyclines.

The tetracyclines are divided into three pharmacologically distinct groups: (1) short-acting: tetracycline, chlortetracycline, oxytetracycline; (2) intermediate: demeclocycline; (3) long-acting: doxycycline and minocycline.

All the tetracyclines are excreted primarily by the kidneys and are, with the exception of doxycycline, contraindicated in renal failure. Absorption of these compounds from the gastrointestinal tract is hindered by milk and calcium, magnesium, and aluminium-containing drugs. Tetracycline achieves adequate levels in most tissues and body fluids except the CSF. However, only minocycline reaches high enough levels in the saliva to cure meningococcal carriers.

### **Toxicity and Side Effects**

Important toxicities and side effects include hypersensitivity reactions, photosensitivity reactions, gastrointestinal upset, hepatotoxicity, azotemia, vertigo (minocycline), and superinfection. Because they often cause discoloration of forming tooth enamel, tetracyclines are rarely indicated in pregnant women and children under age 8.

### **Vancomycin**

Vancomycin is a bactericidal antibiotic that inhibits bacterial wall synthesis via a different mechanism than penicillins and cephalosporins. The drug is not absorbed orally. It is excreted unchanged by the kidneys. Dosage must be decreased with renal failure. Therapeutic levels are achieved in most body tissues except the CSF.

Vancomycin is active against most gram-positive organisms including enterococci, and is drug of choice for most methicillin-resistant staphylococcal infections. It also is used orally to suppress bowel flora and to treat antibiotic-induced pseudomembranous colitis.



### **Toxicity and Side Effects**

1. Ototoxicity: Reversible and irreversible deafness may occur with high serum levels, particularly in elderly patients.
2. Nephrotoxicity: Vancomycin may cause azotemia, particularly when combined with other nephrotoxic drugs such as aminoglycosides.
3. Hypersensitivity: Skin rashes, urticaria, drug fever, and eosinophilia are common.

### **Sulfonamides and Trimethoprim**

Sulfonamides are synthetic antimicrobials which are generally bacteriostatic. They interfere with folic acid production in bacteria. They inhibit a broad range of gram-positive and gram-negative bacteria as well as Actinomyces, chlamydiae, Toxoplasma, and some Plasmodidae.

Trimethoprim also inhibits bacterial folic acid production. It blocks the enzymatic reaction that is directly after the step blocked by sulfonamides. Trimethoprim most commonly is used in fixed combination with sulfamethoxazole for the treatment of urinary tract infections, chronic bronchitis, bacterial gastroenteritis, and infections caused by Pneumocystis carinii.

Both trimethoprim and sulfonamides are excreted in the urine as free drugs and as metabolites.

### **Toxicity and Side Effects**

Gastrointestinal upset, rash, headache, fever, aplastic anemia, leukopenia, thrombocytopenia, and hemolytic anemia in glucose 6-phosphate dehydrogenase (G-6-PD)-deficient individuals are the most common untoward effects.

### **Metronidazole**

A metronidazole compound that has long been used orally in the treatment of infections caused by anaerobic protozoa such as amebiasis and giardiasis, has recently been released in intravenous form for the treatment of selected anaerobic bacterial infections. It has no activity against aerobic or facultative anaerobic bacteria and should not be used alone for the treatment of mixed aerobic/anaerobic infections such as those caused by mouth flora. The mechanism of action of metronidazole has not been fully described. The primary route of excretion is renal with a major proportion excreted as inactive metabolites. Therapeutic levels of the drug are reached in the CSF and brain abscess cavities.

### **Toxicity and Side Effects**

These include gastrointestinal intolerance, neutropenia, and peripheral neuropathy. Metronidazole has been found to be carcinogenic in high doses in laboratory animals. This effect has not been demonstrated in humans.

A summary of antimicrobial susceptibility profiles for gram-negative rods is given in Table 35-1; for gram-positive cocci in Table 35-2; gram-positive rods Table 35-3; and gram-negative cocci Table 35-4 at the end of this chapter.

## **Antituberculous Agents**

### **Isoniazid**

Isoniazid (INH) is a synthetic agent which, by inhibiting the cell wall synthesis of *Mycobacterium tuberculosis*, is bactericidal against actively growing organisms.

The major toxicity associated with isoniazid is hepatitis. INH hepatitis can be fatal if not recognized early. The incidence increases with age and with preexisting liver disease.

### **Ethambutol**

This is a tuberculostatic agent that probably acts as an antimetabolite by inhibiting mycobacterial RNA synthesis. Because resistant strains rapidly develop during therapy, ethambutol must be used in combination therapy.

The main complication of ethambutol therapy is retrobulbar neuritis. If the drug is discontinued soon after the onset of symptoms, the condition usually reverses.

### **Rifampin**

Although primarily used in the treatment of tuberculosis, rifampin has a broad spectrum of activity against gram-positive and gram-negative bacteria. Because it reaches high levels in the saliva, it is used for prophylaxis of meningococcal-exposed patients and carriers of the organism. Rifampin is bactericidal against *M. tuberculosis* by inhibiting RNA synthesis.

The major untoward reaction is hepatotoxicity that may be potentiated by INH. It causes the urine and body secretions to have an orange color.

## **Antifungal Agents**

### **Amphotericin**

Amphotericin is the drug of choice for most systemic fungal infections including candidiasis, histoplasmosis, cryptococcosis, coccidiomycosis, sporotrichosis, aspergillosis, and blastomycosis. It is a polyene which binds to ergosterol in the plasma membrane of the fungus, thus altering the permeability of the cell. After an initial 1 mg test dose, amphotericin is given intravenously in gradually increasing daily doses up to 1 mg/kg/day (maximum 50 mg). For severe systemic diseases a total dosage of 1-2 g is administered.

Infusions of amphotericin may be accompanied by chills, fever, nausea, vomiting, hypotension, headache, and anorexia. Many of these symptoms can be prevented by premedication with antipyretics and small dosages of intravenous hydrocortisone. The most important toxicity is renal. Azotemia occurs to some degree in almost all patients treated, and

the dosage may have to be adjusted to serum creatinine. Amphotericin also may suppress bone marrow erythropoiesis and cause anemia.

### **Flucytosine (5-Fluorocytosine)**

This is a fluorinated cytosine which interferes with DNA synthesis after being incorporated by the fungal cell into pyrimidine metabolism. It is a well-absorbed oral agent usually used with amphotericin B in the treatment of infections caused by *Candida* and *Cryptococcus*. Drug resistance develops rapidly when 5-FC is used alone. Toxicity is low, but bone marrow suppression does occur and is more common when 5-FC is used with amphotericin B or in azotemic patients.

### **Ketoconazole**

Ketoconazole is a new oral imidazole currently being used for long-term therapy of patients with chronic fungal infections. It appears to be effective in the treatment of chronic mucocutaneous candidiasis and usually has little toxicity even after months of use.

Like the other imidazoles, ketoconazole damages the plasma membranes of fungi.

### **Culture Media**

**Blood Agar (BA).** Nutrient agar plus 3-5% sheep or other blood. It is a general medium that supports the growth of most pathogens. Bacteria produce different, and often characteristic, hemolytic patterns on blood agar.

**Chocolate agar (CA).** Blood agar that has been heated at 70-80°C to disrupt the red blood cells. This releases Factor X (hemin), a nutrient required by some fastidious organisms such as *Haemophilus influenzae* and *Neisseria gonorrhoeae*. Factor V (NAD) is usually added.

**Trypicase soy broth (TSB).** A nutrient broth that supports the growth of most aerobes and facultative anaerobes.

**Thioglycollate broth (thio).** A nutrient broth that has an oxidation-reduction potential that supports the growth of obligate anaerobes.

**Eosin-methylene blue agar (EMB), desoxycholate agar (DCA), MacConkey agar (MCA).** Selective media for the growth of the Enterobacteriaceae, *Pseudomonas*, and certain other gram-negative rods. Lactose is the only carbohydrate, and colonies that utilize it ('lactose fermenters') appear red.

**Thayer-Martin agar (TM).** Chocolate agar that contains antibiotics to inhibit normal throat and genital flora. It is a selective medium for gonococcus and meningococcus.

**Xylose-lysine-desoxycholate agar (XLD) and Salmonella-Shigella agar (SS).** Inhibits Enterobacteriaceae and promotes growth of *Salmonella* and *Shigella* species. *Salmonella* colonies are often black, indicating H<sub>2</sub>S production.

Müller-Hinton agar. A beef infusion agar used for antibiotic disc sensitivity testing.

Sabouraud dextrose agar (SAB). Supports the growth of and selects for fungi. Low pH inhibits bacterial growth.

Transport medium. Charcoal agar. Keeps the specimen (swab) moist, but does not promote bacterial growth.

Viral culture medium. Tissue culture fluid which should be held at 4°C after inoculation.

#### Table 35-1. Gram-Negative Rods

##### Acinetobacter

Gentamicin

B

Used to be called Mima-Herellea A.

##### Bacteroides

###### B. fragilis

Clindamycin

Chloramphenicol

Metronidazole

Carbenicillin (high-dose)

(Cefoxitin)

(Cefamandole)

Some authorities question efficacy of new cephalosporins.

##### Other species

Penicillin

Tetracycline

Cephalosporin

Oral-pharyngeal flora usually penicillin-sensitive.

##### Brucella

Tetracycline

Streptomycin

Sulfa

##### Campylobacter

Erythromycin

Tetracycline

Gentamicin

Common cause of infectious diarrhea. Used to be called

**Vibrio**

fetus.

##### E. coli

Ampicillin

Cephalosporin  
Gentamicin  
TMP-SMX

Most community acquired are ampicillin sensitive.

Enterobacter

Gentamicin  
B (Cefamandole)  
A

Haemophilus influenzae

Ampicillin  
Chloramphenicol  
TMP-SMX  
Cefamandole

Increasing ampicillin resistance requires lab sensitivity.

Klebsiella

Cephalosporin  
Gentamicin

Legionella pneumophila

Erythromycin  
Legionnaires' disease.

Morganella morganii

Gentamicin  
B

Used to be called Proteus morganii A.

Pasteurella

Streptomycin  
Tetracycline  
Sulfa

Proteus mirabilis

Ampicillin  
Cephalosporin  
Gentamicin  
TMP-SMX

Proteus vulgaris and P. rettgeri

Gentamicin  
(Cefoxitin)

Usually hospital acquired, often antibiotic resistant A.

Providencia

Gentamicin

(Cefoxitin)  
A

Pseudomonas

Tobramycin  
Carbenicillin (high doses)  
Amikacin

Tobramycin more active than gentamicin. Most authorities **doubt**  
efficacy of new cephalosporins A.

Salmonella

Ampicillin  
Chloramphenicol  
TMP-SMX

TMP-SMX recommended for carrier state.

Serratia

Gentamicin  
(Cefoxitin)  
A

Shigella

TMP-SMX  
Ampicillin  
Chloramphenicol

Many strains now chloramphenicol resistant.

A Usually hospital acquired (nosocomial) and resistant to many antibiotics.

B Sensitivity pattern varies widely. Amikacin, TMP-SMX, second- or third-generation cephalosporins may be used depending on sensitivity.

& Gentamicin and tobramycin usually have identical sensitivities. Gentamicin is selected as aminoglycoside of choice of lower cost.

&& New cephalosporins in parenthesis are active in vitro. Clear clinical advantage over aminoglycosides, TMP-SMX, and narrow-spectrum cephalosporins is doubtful.

#### Table 35-2. Gram-Positive Cocci

Pneumococcus

Penicillin  
Cephalosporin  
Erythromycin

Increased penicillin resistance requires lab sensitivity.

Streptococcus viridans

Penicillin  
Cephalosporin

Some authorities combine penicillin and aminoglycoside for endocarditis.

Microaerophilic streptococci and anaerobic streptococci (Peptostreptococcus)

Penicillin

Cephalosporin

Erythromycin

Normal mouth and GI flora.

Beta-hemolytic streptococcus groups A, B, C, G

Penicillin

Cephalosporin

Erythromycin

Group D streptococcus (Strep. bovis)

Penicillin

Cephalosporin

Erythromycin

Endocarditis associated with colonic carcinoma.

Strep. fecalis (Enterococcus)

Ampicillin

Vancomycin

Penicillin and aminoglycoside for treatment of endocarditis.

Staphylococcus aureus Non-penicillinase producing

Penicillin

Cephalosporin

Vancomycin

Vancomycin treatment of choice for methicillin-resistant Staph. aureus.

Staphylococcus aureus Penicillinase producing

Methicillin

Oxacillin

Vancomycin

Cephalosporin

Cephalexin, cefoxitin not recommended for staphylococcus infection.

Staphylococcus epidermidis (coagulase-negative)

Cephalosporin

(Penicillin)

Vancomycin

Most hospital-acquired Staph. epidermidis are penicillin resistant.

Actinomycosis

Penicillin

Tetracycline

Sulfa

Often requires prolonged treatment.

Bacillus sp.

B. subtilis

Penicillin

Cephalosporin

Usually lab contaminant.

B. anthracis

Penicillin

Cephalosporin

Clostridium

C. perfringens

Penicillin

Cephalosporin

C. tetani

Penicillin

Cephalosporin

C. difficile

Vancomycin

Cause of antibiotic-induced pseudomembranous colitis.

Corynebacterium

Penicillin

Erythromycin

Cephalosporin

Listeria

Penicillin

Ampicillin

Cephalosporin

Associated with neoplasms and immunosuppressive therapy.

Table 35-4. Gram-Negative Cocci

Gonococcus

Penicillin

Ampicillin

Tetracycline

Spectinomycin

Increasing penicillin resistance requires lab sensitivity.



Meningococcus

Penicillin

Chloramphenicol

Rifampin drug of choice for prophylaxis.

Spirochetes

T. pallidum (syphilis)

Penicillin

Tetracycline

Erythromycin

Neurosyphilis requires parenteral treatment for 10-14 days.

Mycoplasma

Tetracycline

Erythromycin

Chlamydiae

Tetracycline

Sulfa

Chloramphenicol

Rickettsiae

Tetracycline

Chloramphenicol.