Chapter 34

Drugs for Bacterial Infections

Pathogens

- Organisms that can cause disease
- Must bypass the body's defenses
  - Bacteria, viruses
  - Fungi; intracellular organisms
  - Multicellular animals

Pathogenicity and Virulence

- Pathogenicity: ability of organism to cause infection
- Virulence: measure of disease-producing potential
  - Highly virulent pathogen can cause disease when present in small numbers

Media Directory

Slide 43  Penicillin Animation
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Pathogens (continued)

- Cause disease in two ways
  - Divide rapidly to overcome body defenses
  - Disrupt normal cell function
- Secrete toxins
  - Disrupt normal cell function

Methods of Describing Bacteria

- Basic Shapes
  - Bacilli—rod shape
  - Cocci—spherical shape
  - Spirilla—spiral shape
Methods of Describing Bacteria (continued)

- Ability to use oxygen
  - Aerobic—with O₂
  - Anaerobic—without O₂
- Staining Characteristics
  - Gram positive
  - Gram negative

Anti-infective Drugs

- Known as antibacterial, antimicrobial, antibiotic
- Classified by
  - Chemical structures (e.g., aminoglycoside, fluoroquinolone)
  - Mechanism of action (e.g., cell-wall inhibitor, folic-acid inhibitor)

Actions of Anti-infective Drugs

- Affect target organism’s structure, metabolism, or life cycle
- Goal is to eliminate pathogen
  - Bactericidal—kill bacteria
  - Bacteriostatic—slow growth of bacteria

Acquired Resistance

- Occurs when pathogen acquires gene for bacterial resistance
  - Through mutation
    - Antibiotics destroy sensitive bacteria
    - Insensitive (mutated) bacteria remain
  - Mutations random, occur during cell division
  - Mutated bacteria multiply
  - Antibiotics do not create mutations
  - By another microbe
    - Bacteria passed to others
Widespread Use of Antibiotics

- Resistance not caused by but is worsened by overprescription of antibiotics
  - Results in loss of antibiotic effectiveness
- Only prescribe when necessary
- Long-time use increases resistant strains

(continued)

- Nosocomial infections often resistant
- Prophylactic use sometimes appropriate
- Nurse should instruct client to take full dose

Role of the Nurse

- Monitor client’s condition
- Provide client education
- Obtain medical, surgical, and drug history
- Assess lifestyle and dietary habits
- Obtain description of symptomology and current therapies

(continued)

- After parenteral administration, observe closely for possible allergic reactions
- Monitor for superinfections
  - Replace natural colon flora with probiotic supplements or cultured dairy products

Figure 34.2 Acquired resistance.
Role of the Nurse (continued)

- Teach clients to
  - Wear medic-alert bracelets if allergic to antibiotics
  - Report symptoms of allergic reaction
  - Not stop taking drug until complete prescription has been taken

Drug Therapy with Penicillins

- Assess previous drug reactions to penicillin
- Avoid cephalosporins if client has history of severe penicillin allergy
- Monitor for hyperkalemia and hypernatremia
- Monitor cardiac status, including ECG changes

Cephalosporin Therapy

- Assess for presence or history of bleeding disorders
  - Cephalosporins may reduce prothrombin levels
- Assess renal and hepatic function
- Avoid alcohol
  - Some cephalosporins cause disulfiram (Antabuse)-like reaction with alcohol

Tetracycline Therapy

- Contraindicated for clients who are pregnant or lactating
  - Effect on linear skeletal growth of fetus and child
- Contraindicated in children less than 8 years of age
  - Permanent mottling and discoloration of teeth

Tetracycline Therapy (continued)

- Photosensitivity may result
- Do not take with milk products, iron supplements, magnesium-containing laxatives, or antacids
**Macrolide Therapy**

- Assess for presence of respiratory infection
- Examine client for history of cardiac disorders
- Monitor hepatic enzymes with certain macrolides, such as erythromycin estolate
- Multiple drug-drug interactions occur with macrolides

**Aminoglycoside Therapy**

- Monitor for ototoxicity and nephrotoxicity
- Hearing loss may occur after therapy has been completed
- Neuromuscular function may also be impaired
- Increase fluid intake, unless otherwise contraindicated, to promote excretion

**Fluoroquinolone Therapy**

- Monitor white blood count
- Monitor clients with liver and renal dysfunction
- Teach that drugs may cause dizziness and lightheadedness
  - Advise against driving or performing hazardous tasks during drug therapy

**Fluoroquinolone Therapy (continued)**

- Norfloxacin (Noroxin) may cause photophobia
- Teach that drug may affect tendons, especially in children

**Sulfonamide Therapy**

- Assess for anemia or other hematological disorders
- Assess renal function; sulfonamides may increase risk for crystalluria

**Sulfonamide Therapy**

- Contraindicated in clients with history of hypersensitivity to sulfonamides
  - Can induce skin abnormality called Stevens-Johnson syndrome
- Teach client how to decrease effects of photosensitivity
Antituberculosis Therapy

• Contraindicated for clients with history of alcohol abuse, AIDS, liver disease, or kidney disease
• Use caution for certain clients
  – Those with renal dysfunction
  – Those who are pregnant or lactating
  – Those with history of convulsive disorders

Antituberculosis Therapy (continued)

• Assess for gouty arthritis
• Some antituberculosis drugs interact with oral contraceptives
  – Use alternate form of birth control.
• If taking isoniazid, avoid foods containing tyramine

Selection of an Antibiotic

• Careful selection of correct antibiotic essential
  – Use of culture and sensitivity testing
  – For effective pharmacotherapy; to limit adverse effects

Selection of an Antibiotic (continued)

• Broad-spectrum antibiotics
  – Effective for wide variety of bacteria
• Narrow-spectrum antibiotics
  – Effective for narrow group of bacteria

Culture and Sensitivity Testing

• Examination of specimen for microorganisms
• Grown in lab and identified
• Tested for sensitivity to different antibiotics

Culture and Sensitivity Testing (continued)

• Bacteria may take several days to identify
• Viruses may take several weeks to identify
• Broad-spectrum antibiotics may be started before lab culture completed
Multidrug Therapy

- Affected by antagonism—combining two drugs may decrease efficacy of each
- Use of multiple antibiotics increases risk of resistance.
- Multidrug therapy can be used
  - When multi-organisms cause infection
  - For treatment of tuberculosis
  - For treatment of HIV

Superinfections

- Occur when too many host flora are killed by an antibiotic
  - Host flora prevent growth of pathogenic organisms

Superinfections

- Pathogenic microorganisms have chance to multiply
  - Opportunistic—take advantage of suppressed immune system
  - Signs and symptoms include diarrhea, bladder pain, painful urination, or abnormal vaginal discharge

Host Factors Influence Choice of Antibiotics

- Immune system status
- Local conditions at infection site
- Allergic reactions

Host Factors Influence Choice of Antibiotics (continued)

- Age
- Pregnancy status
- Genetics

Penicillin

- Prototype drug: penicillin G (Pentids)
- Mechanism of action: to kill bacteria by disrupting their cell walls
- Primary use: as drug of choice against streptococci, pneumococci, and staphylococci organisms that do not produce penicillinase
  - Also medication of choice for gonorrhea and syphilis
- Adverse effects: diarrhea, nausea, vomiting, superinfections, anaphylaxis
Penicillin Animation

Cephalosporin

- **Prototype drug:** cefotaxime (Claforan)
- **Mechanism of action:** to act with broad-spectrum activity against gram-negative organisms
- **Primary use:** for serious infections of lower respiratory tract, central nervous system, genitourinary system, bones, blood, and joints
- **Adverse effects:** hypersensitivity, anaphylaxis, diarrhea, vomiting, nausea, pain at injection site

Tetracycline

- **Prototype drug:** tetracycline HCL (Achromycin, others)
- **Mechanism of action:** effective against broad range of gram-positive and -negative organisms
- **Primary use:** chlamydiae, rickettsiae, and mycoplasma
- **Adverse effects:** superinfections, nausea, vomiting, epigastric burning, diarrhea, discoloration of teeth, photosensitivity

Macrolide

- **Prototype drug:** erythromycin (E-Mycin, Erythrocin)
- **Mechanism of action:** to act as spectrum similar to that of penicillins
  - Also to be effective against gram-positive bacteria
- **Primary use:** for *Bordetella pertussis* (whooping cough) and *Corynebacterium diphtheriae*, most gram-positive bacteria

Macrolide (continued)

- **Adverse effects:** nausea, abdominal cramping, and vomiting
  - Most severe is hepatotoxicity.

Aminoglycoside

- **Prototype drug:** gentamicin (Garamycin)
- **Mechanism of action:** to act as broad-spectrum, bacteriocidal antibiotic
Aminoglycoside (continued)

- **Primary use:** for serious urinary, respiratory, nervous, or GI infections
  - Often used in combination with other antibiotics
  - Used parenterally or as drops (Genoptic) for eye infections
- **Adverse effects:** ototoxicity and nephrotoxicity

Fluoroquinolone

- **Prototype drug:** ciprofloxacin (Cipro)
- **Mechanism of action:** to inhibit bacterial DNA gyrase
  - Affects bacterial replication and DNA repair
- **Primary use:** for respiratory infections, bone and joint infections, GI infections, ophthalmic infections, sinusitis, and prostatitis
- **Adverse effects:** nausea, vomiting, diarrhea, phototoxicity, headache, dizziness

Ciprofloxacin Animation

- Click here to view an animation on the topic of ciprofloxacin.

Sulfonamide

- **Prototype drug:** trimethoprim-sulfamethoxazole (Bactrim, Septra)
- **Mechanism of action:** to kill bacteria by inhibiting bacterial metabolism of folic acid
- **Primary use:** for urinary tract infections, *Pneumocystis carinii* pneumonia, shigella infections of small bowel, and acute episodes of chronic bronchitis
- **Adverse effects:** skin rashes, nausea, vomiting, agranulocytosis or thrombocytopenia

Miscellaneous

- **Clindamycin (Cleocin):** for oral infections caused by bacteroides
  - Associated with pseudomembranous colitis
  - Metronidazole (Flagyl): used to treat *H. pylori* infections of stomach

Miscellaneous (continued)

- **Vancomycin (Vancocin):** effective for MRSA infections
- **Adverse effects:** ototoxicity, nephrotoxicity, red man syndrome
Miscellaneous—new

- Oxazolidinones: linezolid (Zyvox)—as effective as vancomycin against MRSA
- Cyclic lipopeptides: daptomycin (Cubicin)—used to treat serious skin infections
- Carbapenems: imipenem (Primaxin) have some of the broadest spectrums

Miscellaneous—new

- Carbapenems: imipenem (Primaxin) have some of the broadest spectrums
- Ketolides: telithromycin (Ketek)—used for respiratory infections
- Glycylcyclines: tigecycline (Tygacil)—used for drug-resistant abdominal infections and complicated skin infections

Penicillins

- Most effective against gram-positive bacteria
- Kill bacteria by disrupting cell wall with beta-lactam ring
- Beta-lactamase or penicillinase is enzyme allowing bacteria to be resistant

Penicillins (continued)

- New penicillins are penicillinase-resistant
  - Examples: oxacillin and cloxacillin
- Combination drugs with beta-lactamase inhibitors
  - Examples: clavulanate, sulbactam, tazobactam

Penicillin—Adverse Effects

- One of safest classes of antibiotic
- Allergy most common adverse effect
- If client allergic to penicillin, avoid cephalosporins
  - Possibility of cross-hypersensitivity
Penicillin—Adverse Effects (continued)

• Other adverse effects
  – Skin rash; decreased RBC, WBC, or platelet counts

Cephalosporins

• Similar in structure and function to penicillins
• Have beta-lactam ring; are bacteriocidal
• Widely prescribed anti-infective class
• More than 20 cephalosporins available

Cephalosporins (continued)

• Cross-sensitivity with penicillins (5–10% of population)
• Classified by generations
• Generations of cephalosporins
  – First (oldest): bacteria producing beta-lactamase are resistant
  – Second: more potent, broader spectrum, more resistant to beta-lactamase
  – Third: longer duration of action, even broader spectrum, resistant to beta-lactamase
  – Fourth: effective against organisms that are resistant to earlier generations
  – Third and fourth capable of entering CSF

Tetracyclines

• Some of broadest spectrums of any antibiotic class
• Large number of resistant bacterial strains
• Drugs of choice for only a few diseases
  – Rocky Mountain spotted fever
  – Typhus, cholera, Lyme disease
  – Peptic ulcers caused by H. pylori
  – Chlamydial infections
• Inhibit bacterial protein synthesis with bacteriostatic effect

Tetracyclines—Adverse Effects

• Bind with calcium and iron to decrease absorption by up to 50%
  – Do not take with milk.
• Photosensitivity
• Permanent yellow-brown tooth discoloration in children
• Risk for superinfection is high
• Pregnancy Category D
Macrolides

- Safe alternatives to penicillin
- Effective against most gram-positive and gram-negative bacteria
- Inhibit protein synthesis by binding to bacterial ribosome
- Bacteriostatic at low doses and bacteriocidal at high doses

Macrolides

- Drug of choice for whooping cough, Legionnaire’s disease
  - Also infections caused by streptococcus, H. influenzae, Mycoplasma pneumoniae, chlamydia
- Broad spectrum, so superinfections may occur
- Otherwise, no serious side effects
- No contraindications except previous

Aminoglycosides

- Narrow-spectrum drugs, bacteriocidal
- Reserved for serious systemic infections caused by aerobic gram-negative bacteria
  - E. coli, serrattia, proteus, klebsiella, and pseudomonas
- Inhibit bacterial protein synthesis

Aminoglycosides (continued)

- More toxic than most antibiotics
- Have potential to cause serious adverse effects
  - Ototoxicity, nephrotoxicity, neuromuscular blockade
- Note difference in spelling “mycin” and “micin”—reflects origins of drug

Fluoroquinolones

- Are bacteriocidal and affect DNA synthesis by inhibiting two bacterial enzymes
- All have activity against gram-negative pathogens
- Newer drugs in class have activity against gram-positive microbes.
- Now four generations
  - Used for infections of respiratory system, GI and GU tracts, skin and soft tissue infections

Fluoroquinolones—Adverse Effects

- Do not take with multivitamins or minerals such as calcium, magnesium, iron, or zinc ions
  - Can decrease absorption by up to 90%
- Most serious adverse effects are dysrhythmias and liver failure
Fluoroquinolones—
Adverse Effects (continued)

• CNS disturbances affect 1–8% of clients
• Do not use in children and pregnant or lactating women

Sulfonamides

• Are bacteriostatic and act by inhibiting folic acid
• Are broad spectrum
• Widespread use leads to resistance.
• Used in a combination to treat UTIs
• Also used to treat Pneumocystis carinii and shigella
• Anti-inflammatory properties can help with rheumatoid arthritis and ulcerative colitis

Adverse Effects

• Generally safe
• Serious adverse effects
  – Crystal development in urine, hypersensitivity reactions
  – Nausea, vomiting, potentially fatal blood abnormalities

Miscellaneous Antibacterials

• Some cannot be grouped into classes, or class is too small
• Many miscellaneous drugs have critical importance, and many are new

Tuberculosis

• Caused by Mycobacterium tuberculosis
  – Cell wall resistant to anti-infectives
• Body’s immune response attempts to isolate pathogen by walling it off
• Tuberculosis may remain dormant in walled-off areas called tubercles
• Decreased immune system can give tuberculosis opportunity to become active

Long-Term Therapy

• 6–12 months of drug therapy
  – Needed to reach isolated pathogens in tubercles
• Therapy must be continued even if no symptoms
• Clients with multidrug-resistant infections require therapy for 24 months
Multidrug Therapy

- 2–4 antibiotics administered concurrently
- Different combinations used during course of therapy
  - Necessary because mycobacterium grows slowly and is commonly resistant
  - Therapy initiated with first-choice drugs
  - When resistance develops, second-choice drugs used
    - More toxic
    - Less effective than first-choice drugs

Chemoprophylaxis

- Antituberculosis drugs used to prevent disease in high-risk populations
  - Close contacts and family members of recently infected tuberculosis clients
  - Clients with AIDS
  - Clients who are HIV-positive or are receiving immunosuppressant drugs

Clients Receiving Antibacterial Therapy

- Assessment
  - Obtain complete health history—allergies, drugs, drug interactions
  - Obtain specimens for culture and sensitivity before initiating therapy
  - Perform infection-focused physical examination—vital signs, WBC count, sedimentation rate

Clients Receiving Antibacterial Therapy (continued)

- Nursing diagnoses
  - Infection; risk for injury
  - Deficient knowledge, related to disease process, transmission, and drug therapy
  - Noncompliance, related to therapeutic regimen

Clients Receiving Antibacterial Therapy (continued)

- Planning—client will
  - Report reduction in symptoms related to diagnosis
  - Have negative results for laboratory and diagnostic tests
  - Demonstrate understanding of drug’s action

Clients Receiving Antibacterial Therapy (continued)

- Planning—client will (continued)
  - Report side effects
    - Rash, shortness of breath, swelling
    - Fever, stomatitis, loose stools
    - Vaginal discharge, cough
  - Complete full course of antibiotic therapy and follow-up care
Clients Receiving Antibacterial Therapy (continued)

- Implementation (continued)
  - Determine food and beverage interactions
  - Monitor IV site for signs of tissue irritation, severe pain, extravasation
  - Monitor for side effects, renal function, symptoms of ototoxicity, compliance with antibiotic therapy

- Evaluation—client
  - Reports reduction in symptoms; has improved laboratory results
  - Accurately states drug’s action and side effects
  - Accurately states signs and symptoms to be reported
  - Completes full course of therapy and complies with follow-up care

Clients Receiving Antituberculosis Agents (continued)

- Nursing diagnoses
  - Risk for infection
  - Risk for injury, related to side effects of medication
  - Deficient knowledge, related to drug therapy and spread of infection
  - Noncompliance, related to therapeutic regimen
Clients Receiving Antituberculosis Agents (continued)

- Planning—client will
  - Report reduction in tuberculosis symptoms
  - Have negative results for laboratory and diagnostic tests
  - Demonstrate understanding of drug’s action
  - Report adverse effects
  - Complete full course of therapy and comply with follow-up care

- Implementation
  - Monitor for hepatic and neurologic side effects
  - Collect sputum specimens
  - Monitor for dietary compliance when client is taking isoniazid

- Clients Receiving Antituberculosis Agents (continued)

  - Monitor for side effects specific to antituberculosis drugs
  - Establish infection-control measures
  - Establish therapeutic environment
  - Monitor client’s ability and motivation to comply with therapeutic regimen

- Evaluation—client
  - Reports reduction in tuberculosis symptoms; has negative lab results
  - Accurately states drug’s action and side effects
  - Accurately states signs and symptoms to be reported
  - Completes full course of therapy and complies with follow-up care

Penicillins

Table 34.2 Penicillins

Table 34.2b Penicillins
Cephalosporins

Table 34.3 Cephalosporins

Tetracyclines

Table 34.4 Tetracyclines

Macrolides

Table 34.5 Macrolides

Aminoglycosides

Table 34.6 Aminoglycosides

Fluoroquinolones

Table 34.7 Fluoroquinolones
### Sulfonamides

**Table 34.8 Sulfonamides**

1. **Sulfadiazine**
2. **Sulfaguanidine**
3. **Sulfamerazine**
4. **Sulfamethizole**
5. **Sulfamerazone**
6. **Sulfamethoxazole**
7. **Sulfadimidine**
8. **Sulfamerazine**
9. **Sulfadimethoxine**
10. **Sulfathiazole**

### Selected Miscellaneous Antibacterials

**Table 34.9 Selected Miscellaneous Antibacterials**

1. **Polymyxin B**
2. **Polymyxin E (colistin)**
3. **Tobramycin**
4. **Netilmicin**
5. **Gentamicin**
6. **Amikacin**
7. **Kanamycin**
8. **Spectinomycin**
9. **Tetracyclines**
10. **Nitrofurantoin**
11. **Furosemide**
12. **Hydrochlorothiazide**

### Selected Miscellaneous Antibacterials

**Table 34.9b Selected Miscellaneous Antibacterials**

1. **Polymyxin B**
2. **Polymyxin E (colistin)**
3. **Tobramycin**
4. **Netilmicin**
5. **Gentamicin**
6. **Amikacin**
7. **Kanamycin**
8. **Spectinomycin**
9. **Tetracyclines**
10. **Nitrofurantoin**
11. **Furosemide**
12. **Hydrochlorothiazide**

### Selected Miscellaneous Antibacterials

**Table 34.9c Selected Miscellaneous Antibacterials**

1. **Polymyxin B**
2. **Polymyxin E (colistin)**
3. **Tobramycin**
4. **Netilmicin**
5. **Gentamicin**
6. **Amikacin**
7. **Kanamycin**
8. **Spectinomycin**
9. **Tetracyclines**
10. **Nitrofurantoin**
11. **Furosemide**
12. **Hydrochlorothiazide**

### Selected Miscellaneous Antibacterials

**Table 34.9d Selected Miscellaneous Antibacterials**

1. **Polymyxin B**
2. **Polymyxin E (colistin)**
3. **Tobramycin**
4. **Netilmicin**
5. **Gentamicin**
6. **Amikacin**
7. **Kanamycin**
8. **Spectinomycin**
9. **Tetracyclines**
10. **Nitrofurantoin**
11. **Furosemide**
12. **Hydrochlorothiazide**

### Antituberculosis drugs

**Table 34.10 Antituberculosis drugs**

1. **Isoniazid**
2. **Rifampin**
3. **Ethambutol**
4. **Pyrazinamide**
5. **Streptomycin**
6. **Para-aminosalicylic acid (PAS)**
7. **Isoniazid and rifampin**
8. **Rifampin and isoniazid**
9. **Ethambutol and isoniazid**
10. **Streptomycin and isoniazid**
11. **Para-aminosalicylic acid (PAS) and isoniazid**
12. **Rifampin and pyrazinamide**
| Table 34.10b Antituberculosis drugs |

| Table 34.10c Antituberculosis drugs |