Overview

- Antibiotics that affect the cell wall are bactericidal. This group of antibiotics includes penicillins, cephalosporins, carbapenems, and monobactams.

MEDICATION CLASSIFICATION: PENICILLINS

- Select Prototype Medication: penicillin G potassium (Pfizerpen) – a narrow-spectrum medication for IM or IV use
- Other Medications
  - Narrow-spectrum
    - Penicillin G benzathine (Bicillin) for IM use
    - Penicillin V (Veetids) for oral use
  - Broad-spectrum
    - Amoxicillin-clavulanate (Augmentin) for oral use
    - Ampicillin (Principen) for oral or IV use
  - Antistaphylococcal
    - Nafcillin (Unipen) for IM or IV use
  - Antipseudomonas
    - Ticarcillin-clavulanate (Timentin) for IV use
    - Piperacillin tazobactam (Zosyn) for IV use

Purpose

- Expected Pharmacological Action – Penicillins destroy bacteria by weakening the bacterial cell wall.
- Therapeutic Uses
  - Penicillins are the medication of choice for gram-positive cocci such as *Streptococcus pneumoniae* (pneumonia and meningitis), *Streptococcus viridans* (infectious endocarditis), and *Streptococcus pyogenes* (pharyngitis).
  - Penicillins are the medication of first choice for meningitis caused by gram-negative cocci *Neisseria meningitides*.
  - Penicillins are the medication of choice for the treatment of syphilis caused by *Spirochete treponema pallidum*.
  - Extended-spectrum penicillin (piperacillin, ticarcillin) is effective against organisms such as *Pseudomonas aeruginosa, Enterobacter species, Proteus, Bacteroides fragilis*, and *Klebsiella*.
  - Penicillins are used as prophylaxis against bacterial endocarditis in at-risk clients prior to dental and other procedures.
Complications

<table>
<thead>
<tr>
<th>ADVERSE EFFECTS</th>
<th>NURSING INTERVENTIONS/CLIENT EDUCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>› Allergies/anaphylaxis</td>
<td>› Interview clients for prior allergy.</td>
</tr>
<tr>
<td></td>
<td>› Advise clients to wear an allergy identification bracelet.</td>
</tr>
<tr>
<td></td>
<td>› Observe clients for 30 min following administration of parenteral penicillin.</td>
</tr>
<tr>
<td>› Renal impairment</td>
<td>› Monitor kidney function.</td>
</tr>
<tr>
<td></td>
<td>› Monitor I&amp;O.</td>
</tr>
<tr>
<td>› Hyperkalemia/dysrhythmias (high doses of penicillin G potassium)</td>
<td>› Monitor the cardiac status and electrolyte levels.</td>
</tr>
<tr>
<td>› Hypernatremia (IV ticarcillin)</td>
<td></td>
</tr>
</tbody>
</table>

Contraindications/Precautions

- Penicillins are contraindicated for clients who have a severe history of allergies to penicillin, cephalosporin, and/or imipenem.
- Use cautiously in clients who have or are at risk for kidney dysfunction (clients who are acutely ill, older adults, or young children).
- Clients who are allergic to one penicillin should be considered cross-allergic to other penicillins and at risk for a cross allergy to cephalosporin.

Interactions

<table>
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<tr>
<th>MEDICATION/FOOD INTERACTIONS</th>
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</thead>
<tbody>
<tr>
<td>› Penicillin inactivates aminoglycosides when mixed in the same IV solution.</td>
<td>› Do not mix penicillin and aminoglycosides in the same IV solution.</td>
</tr>
<tr>
<td>› Probenecid (Probalan) delays excretion of penicillin.</td>
<td>› Probenecid may be added to penicillin therapy to prolong action.</td>
</tr>
</tbody>
</table>

Nursing Administration

- Instruct clients that penicillin V, amoxicillin, and amoxicillin-clavulanate may be taken with meals. All others should be taken with a full glass of water 1 hr before meals or 2 hr after.
- Instruct clients to report any signs of an allergic response such as skin rash, itching, and/or hives.
- IM injection should be performed cautiously to avoid injection into a nerve or an artery.
- Advise clients to complete the entire course of therapy regardless of presence of symptoms.
MEDICATION CLASSIFICATION: CEPHALOSPORINS

- Select Prototype Medication: cephalexin (Keflex) – 1st generation
- Other Medications
  - 1st generation – cefazolin (Ancef)
  - 2nd generation – cefaclor (Ceclor), cefotetan (Cefotan)
  - 3rd generation – ceftriaxone (Rocephin), cefotaxime (Claforan)
  - 4th generation – cefepime (Maxipime)

Purpose

- Expected Pharmacological Action
  - Cephalosporins are beta-lactam antibiotics, similar to penicillins that destroy bacterial cell walls causing destruction of micro-organisms.
  - Cephalosporins are grouped into four generations. Each subsequent generation of cephalosporins is:
    - More likely to reach cerebrospinal fluid.
    - Less likely to be destroyed by beta-lactamase.
    - More effective against gram-negative organisms and anaerobes.
- Therapeutic Uses
  - Cephalosporins are broad-spectrum bactericidal medications with a high therapeutic index that treat urinary tract infections, postoperative infections, pelvic infections, and meningitis.

Complications

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</thead>
<tbody>
<tr>
<td>› Allergic/hypersensitivity/anaphylaxis</td>
<td>› If indications of allergy appear (urticaria, rash, hypotension, and/or dyspnea) stop cephalosporin immediately, and notify the provider.</td>
</tr>
<tr>
<td>› Possible cross-sensitivity to penicillin</td>
<td>› Question client carefully regarding past history of allergy to a penicillin or other cephalosporin, and notify the provider if present.</td>
</tr>
</tbody>
</table>
| › Bleeding tendencies with use of cefotetan and ceftriaxone | › Avoid use in clients who have bleeding disorders and those taking anticoagulants.  
  |                                                              | › Observe clients for signs of bleeding.                                      |
|                                                | › Monitor prothrombin time and bleeding time. Abnormal levels can require discontinuation of medication. |
|                                                | › Administer parenteral vitamin K.                                           |
| › Thrombophlebitis with IV infusion            | › Rotate injection sites.                                                 |
|                                                | › Administer as a diluted intermittent infusion or, if a bolus dose is prescribed, administer slowly over 3 to 5 min and in a dilute solution. |
| › Pain with IM injection                       | › Administer IM injection deep in large muscle mass.                      |
| › Antibiotic-associated pseudomembranous colitis | › Observe clients for diarrhea and notify the provider.      |
|                                                | › Medication should be discontinued.                                       |
Contraindications/Precautions

- Cephalosporins should not be given to clients who have a history of severe allergic reactions to penicillins.
- Use cautiously in clients who have renal impairment or bleeding tendencies.

Interactions

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<tr>
<td>› Disulfiram reaction (intolerance to alcohol) occurs with combined use of cefotetan, cefazolin, cefoperazone, and alcohol.</td>
<td>› Instruct clients not to consume alcohol while taking these cephalosporins.</td>
</tr>
<tr>
<td>› Probenecid delays renal excretion.</td>
<td>› Monitor I&amp;O.</td>
</tr>
</tbody>
</table>

Nursing Administration

- Instruct clients to complete the prescribed course of therapy, even though symptoms can resolve before the full course of antimicrobial treatment is completed.
- Advise clients to take oral cephalosporins with food.
- Instruct clients to store oral cephalosporin suspensions in a refrigerator.

MEDICATION CLASSIFICATION: CARBAPENEMS

- Select Prototype Medication: imipenem-cilastatin (Primaxin)
- Other Medications: meropenem (Merrem IV)

Purpose

- Expected Pharmacological Action – Carbapenems are beta-lactam antibiotics that destroy bacterial cell walls, causing destruction of micro-organisms.
- Therapeutic Uses
  - Broad antimicrobial spectrum is effective for serious infections such as pneumonia, peritonitis, and urinary tract infections caused by gram-positive cocci, gram-negative cocci, and anaerobic bacteria.
  - Resistance develops when imipenem is used alone to treat *Pseudomonas aeruginosa*. A combination of antipseudomonal medications should be used to treat this micro-organism.
Complications

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</tr>
</thead>
<tbody>
<tr>
<td>&gt; Allergy/hypersensitivity</td>
<td>&gt; Monitor clients for indications of allergic reactions, such as rashes or pruritus.</td>
</tr>
<tr>
<td>&gt; Possible cross-sensitivity to penicillin or cephalosporins</td>
<td>&gt; Question clients carefully regarding past history of allergy to a penicillin or other cephalosporin and notify provider if present.</td>
</tr>
<tr>
<td>&gt; Gastrointestinal symptoms (nausea, vomiting, diarrhea)</td>
<td>&gt; Observe clients for manifestations and notify the provider if they occur.</td>
</tr>
<tr>
<td>&gt; Suprainfection</td>
<td>&gt; Monitor I&amp;O.</td>
</tr>
<tr>
<td>&gt; Monitor for indications of colitis (diarrhea, oral thrush, and/or vaginal yeast infection).</td>
<td></td>
</tr>
</tbody>
</table>

Interactions

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</thead>
<tbody>
<tr>
<td>&gt; Imipenem-cilastatin can reduce blood levels of valproic acid (Depakote). Breakthrough seizures are possible.</td>
<td>&gt; Avoid using together. If concurrent use is unavoidable, monitor for increased seizure activity.</td>
</tr>
</tbody>
</table>

Contraindications/Precautions

- Imipenem-cilastatin is a Pregnancy Risk Category C medication.
- Use cautiously in clients who have renal impairment.

Nursing Administration

- Instruct clients to complete the prescribed course of antimicrobial therapy, even though manifestations may resolve before the full course is completed.

**MEDICATION CLASSIFICATION: OTHER INHIBITORS**

- Select Prototype Medications
  - Vancomycin (Vancocin)
  - Aztreonam (Azactam): classified as a monobactam
  - Fosfomycin (Monurol)

Purpose

- Expected Pharmacological Action – This group of antibiotics destroys bacterial cell walls, causing destruction of micro-organisms.
- Therapeutic Uses
  - They are the antimicrobials of choice for:
    - Serious infections caused by methicillin-resistant *Staphylococcus aureus*, *E. coli*, or *Staphylococcus epidermidis*.
    - Antibiotic-associated pseudomembranous colitis caused by *Clostridium difficile*.
Complications

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<th>ADVERSE EFFECTS</th>
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<tbody>
<tr>
<td>› Ototoxicity</td>
<td>› Assess for indications of hearing loss.</td>
</tr>
<tr>
<td></td>
<td>› Instruct clients to notify the provider if changes in hearing acuity develop.</td>
</tr>
<tr>
<td></td>
<td>› Monitor vancomycin levels.</td>
</tr>
<tr>
<td>› Infusion reactions (rashes, flushing, tachycardia, and hypotension, sometimes called “red man syndrome”)</td>
<td>› Administer vancomycin slowly over 60 min.</td>
</tr>
<tr>
<td>› IV injection site thrombophlebitis</td>
<td>› Rotate injection sites.</td>
</tr>
<tr>
<td></td>
<td>› Monitor the infusion site for redness, swelling, and inflammation.</td>
</tr>
<tr>
<td>› Renal toxicity</td>
<td>› Monitor I&amp;O and kidney function tests.</td>
</tr>
<tr>
<td></td>
<td>› Monitor vancomycin trough levels.</td>
</tr>
</tbody>
</table>

Interactions

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<tbody>
<tr>
<td>› Increased risk for ototoxicity when vancomycin is used concurrently with another medication that also produces ototoxicity (loop diuretics and aminoglycoside antibiotics)</td>
<td>› Assess for hearing loss.</td>
</tr>
</tbody>
</table>

Contraindications/Precautions

- Contraindicated for clients who have allergy to corn/corn products or previous allergy to vancomycin.
- Use cautiously in clients who have renal impairment, hearing impairment, or older adults.

Nursing Administration

- Monitor vancomycin trough levels routinely after blood levels have reached a steady state. Peak levels may also be prescribed.
- IV dose may be adjusted based on creatinine clearance levels if renal insufficiency is present.

Nursing Evaluation of Medication Effectiveness

- Depending on therapeutic intent, effectiveness may be evidenced by:
  - Reduction of clinical manifestations such as fever, pain, inflammation, and adventitious breath sounds
  - Resolution of infection
APPLICATION EXERCISES

1. A nurse is caring for a client in an acute care setting who was admitted with a cerebral spinal fluid (CSF) infection caused by a highly gram-negative bacteria. Which of the following cephalosporin IV antibiotics should the nurse expect to be effective in treating this infection?

   A. Cefaclor (Ceclor)
   B. Cefazolin (Ancef)
   C. Cefepime (Maxipime)
   D. Cephalexin (Keflex)

2. A nurse in an outpatient facility is preparing to administer nafcillin (Unipen) IM to an adult client who has an infection. Which of the following actions should the nurse plan to take? (Select all that apply.)

   ____ A. Select a 25-gauge, ½-inch needle for the injection.
   ____ B. Administer the medication deeply into the ventrogluteal muscle.
   ____ C. Ask the client about allergy to penicillin before administering the medication.
   ____ D. Monitor the client for 30 min following the injection.
   ____ E. Tell the client to expect a temporary rash to occur following the injection.

3. A nurse is preparing to administer cefotaxime (Claforan) IV to a client who has a severe infection and has been receiving cefotaxime for the past week. Which of the following findings indicates a potentially serious adverse reaction to this medication and should be reported to the provider?

   A. Diaphoresis
   B. Epistaxis
   C. Diarrhea
   D. Alopecia

4. A nurse is taking a medication history for a hospitalized client who is to receive imipenem-cilastatin IV to treat an infection. Which of the following medications taken by the client places the client at risk for medication interaction?

   A. Regular insulin (Humulin R)
   B. Furosemide (Lasix)
   C. Valproic acid (Depakote)
   D. Ferrous sulfate (Feosol)
5. A nurse is preparing to administer ceftriaxone (Rocephin) 0.5 g IM to a client in a long-term care facility. Available is ceftriaxone diluted to 350 mg/mL. How many mL should the nurse administer? (Round the answer to the nearest tenth.)

6. A nurse in an acute care facility is administering vancomycin (Vancocin) IV to a client who has a serious wound infection. What should the nurse teach the client about this medication? Use the ATI Active Learning Template: Medication to complete this item to include the following:

A. Therapeutic Use: Identify for vancomycin in this client.

B. Adverse Effects: Identify two the client should watch for.

C. Diagnostic Tests: Describe two diagnostic tests to monitor for this client.

D. Nursing Actions: Describe two nursing actions for client taking vancomycin.
APPLICATION EXERCISES KEY

1. A. INCORRECT: Cefaclor, a second-generation cephalosporin, is unlikely to be effective against a highly gram-negative bacterial infection in the CSF.

   B. INCORRECT: Cefazolin, a first-generation cephalosporin, is unlikely to be effective against a highly gram-negative bacterial infection in the CSF.

   C. CORRECT: Cefepime, a fourth-generation cephalosporin, is more likely to be effective against this infection than the other medications, which are from the first or second generation. Medications from each progressive generation of cephalosporin are more effective against gram-negative bacteria, more resistant to being destroyed by beta-lactamase, and more able to penetrate the CSF.

   D. INCORRECT: Cephalexin, a first-generation cephalosporin, is unlikely to be effective against a highly gram-negative bacterial infection in the CSF.

2. A. INCORRECT: A 25-gauge, ½-inch needle is too small and short for an IM injection of nafcillin to an adult client. Although the needle size/length should be chosen for each specific client, an example of a correctly sized IM needle for an adult would be 19- to 22-gauge and 1½ inches.

   B. CORRECT: It is important to administer nafcillin IM into a deep muscle mass, such as the ventrogluteal site.

   C. CORRECT: It is important to ask the client about allergy to penicillin or other antibiotics before administering nafcillin. In general, a documented allergy to another penicillin or to a cephalosporin is a contraindication for administering nafcillin.

   D. CORRECT: When administering a parenteral penicillin or other antibiotic, it is important to monitor the client for 30 min for an allergic reaction.

   E. INCORRECT: A rash is not an expected reaction after nafcillin administration. A rash may be a manifestation of allergy to the medication.

3. A. INCORRECT: Diaphoresis is not an adverse effect of cefotaxime.

   B. INCORRECT: Epistaxis is not an adverse effect of cefotaxime.

   C. CORRECT: Diarrhea is caused by cefotaxime and other cephalosporins and should be reported to the provider. Severe diarrhea may indicate the client has developed antibiotic-associated pseudomembranous colitis, which could be life-threatening.

   D. INCORRECT: Alopecia is not an adverse effect of cefotaxime.
4. A. INCORRECT: Regular insulin, an antidiabetic medication, does not interact with imipenem-cilastatin.

B. INCORRECT: Furosemide, a loop diuretic, does not interact with imipenem-cilastatin.

C. CORRECT: Imipenem-cilastatin decreases blood levels of valproic acid, an antiseizure medication, putting the client at risk for increased seizure activity. Combination of these two medications should be avoided. If they must be taken concurrently, the nurse should monitor the client for seizures.

D. INCORRECT: Ferrous sulfate does not interact with imipenem-cilastatin.

NCLEX® Connection: Pharmacological and Parenteral Therapies, Adverse Effects/Contraindications/Side Effects/Interactions

5. **1.4 mL**

### Using Ratio and Proportion

<table>
<thead>
<tr>
<th>STEP 1: What is the unit of measurement to calculate?</th>
<th>STEP 5: What is the quantity of the dose available?</th>
</tr>
</thead>
<tbody>
<tr>
<td>mL</td>
<td>1 mL</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STEP 2: What is the dose needed?</th>
<th>STEP 6: Set up an equation and solve for X.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose needed = Desired</td>
<td>Have _ Dose available = Have _ Desired</td>
</tr>
<tr>
<td>0.5 g</td>
<td>Quantity = X</td>
</tr>
<tr>
<td>350 mg/mL</td>
<td>350 mg = 500 mg</td>
</tr>
<tr>
<td>1 mL</td>
<td>X mL</td>
</tr>
</tbody>
</table>

**STEP 4: Should the nurse convert the units of measurement?**

Yes (g ≠ mg)

1 g = 1,000 mg
0.5 g = 500 mg

**STEP 5:**

- **X = 1.4285**
- **Round if necessary.**
- **1.4285 = 1.4**

**STEP 8:** Reassess to determine whether the amount to give makes sense.

If there is 350 mg/mL and the prescribed amount is 0.5 g (500 mg), it makes sense to give 1.4 mL. The nurse should administer ceftriaxone injection 1.4 mL IM.

### Using Desired Over Have

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>mL</td>
<td>1 mL</td>
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<tr>
<td>Dose needed = Desired</td>
<td>Desired _ Quantity = Have</td>
</tr>
<tr>
<td>0.5 g</td>
<td>500 mg _ 350 mg</td>
</tr>
<tr>
<td>1 mL</td>
<td>X mL</td>
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Using Dimensional Analysis

<table>
<thead>
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<th>STEP 7: Round if necessary.</th>
</tr>
</thead>
<tbody>
<tr>
<td>mL</td>
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<td>1.4285 = 1.4</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>STEP 2: What quantity of the dose available?</th>
<th>STEP 6: Set up an equation of factors and solve for X.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mL</td>
<td>X = \frac{\text{Quantity}}{\text{Conversion (Have)}} \times \frac{\text{Conversion (Desired)}}{\text{Desired}}</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STEP 3: What is the dose available? Dose available = Have</th>
<th>STEP 4: What is the dose needed? Dose needed = Desired</th>
</tr>
</thead>
<tbody>
<tr>
<td>350 mg/mL</td>
<td>0.5 g</td>
</tr>
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</table>

\[ X = \frac{1 \text{ mL}}{350 \text{ mg}} \times \frac{1,000 \text{ mg}}{1 \text{ g}} \times 0.5 \text{ g} \]

\[ X = 1.4285 \]

STEP 8: Reassess to determine whether the amount to give makes sense.

If there is 350 mg/mL and the prescribed amount is 0.5 g (500 mg), it makes sense to give 1.4 mL.

The nurse should administer ceftriaxone injection 1.4 mL IM.

NCLEX® Connection: Pharmacological and Parenteral Therapies, Dosage Calculation

6. Using the ATI Active Learning Template: Medication

A. Therapeutic Use
   - Vancomycin is an antibiotic that kills bacteria by disrupting their cell wall. The IV form treats serious infections caused by gram-positive bacteria, such as methicillin-resistant *Staphylococcus aureus*, *E. Coli*, or *Staphylococcus epidermidis*.

B. Adverse Effects
   - Infusion reaction, sometimes called “red man syndrome,” which causes a flushed face/neck, tachycardia, and hypotension
   - Ototoxicity, manifested by hearing loss
   - Renal toxicity manifested by acute renal failure
   - Thrombophlebitis at the IV site

C. Diagnostic Tests
   - Renal function tests and trough vancomycin levels in order to determine if toxicity is occurring
   - Peak vancomycin levels
   - WBC to determine if the infection is being successfully treated

D. Nursing Interventions
   - Infuse vancomycin over at least 60 min/dose to prevent an infusion reaction.
   - Monitor the IV site for redness, pain, or other manifestations of thrombophlebitis.
   - Monitor the client’s I&O, and notify the provider for oliguria or other signs of acute renal injury.
   - Monitor the client for hearing loss.
   - Ask the client about allergy to antibiotics before administering the medication. Watch for allergic manifestations during and after the infusion.

NCLEX® Connection: Pharmacological and Parenteral Therapies, Medication Administration