Exploring Antibiotics

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Antibiotics

- A form of chemotherapy used to treat infections
- Effective against bacteria
- Not effective against viruses
- One of the most significant medical advances of the 20th century
Bacteria Characteristics

• Single cell organisms
• Characterized in the laboratory by:
  – Shape: cocci (round), bacilli (rods), chains, spirals
  – Gram Stain: positive, negative
• Can also be classified as:
  – Aerobic – which need oxygen to survive
  – Anaerobic – which survive without oxygen
Bacteria – Gram Stain

Gram Stain Positive (purple)

Gram Stain Negative (pink/red)
Bacteria - shape

Gram positive
Many are cocci, “round bacteria”
• Examples: Streptococci, Staphylococci, Enterococci
• Clostridium difficile (C. diff) is an anaerobic, Gram positive rod

Gram negative
Most are bacilli, “rod-shaped bacteria”
• Examples: E. coli, Klebsiella, Enterobacter, Proteus, Pseudomonas, Acinetobacter
Describing antibiotics

• **Spectrum of action**
  – Narrow-spectrum target a few specific bacteria
  – Broad-spectrum can kill a wide variety of bacteria

• **Classification**
  – Penicillins, Cephalosporins, Fluoroquinolones, Aminoglycosides, Monobactams, Carbapenems, Macrolides, and others
How do antibiotics work with the immune system?

• Antibiotics do not take the place of the immune system – they help the immune system
  – Bacteria reproducing faster than immune system can activate itself
  – Bacteria are rapidly producing toxins that cause damage before the immune system alone can eliminate them
  – Immune system is weakened and needs help killing bacteria
**Bactericidal** antibiotics kill bacteria
**Bacteriostatic** antibiotics do not kill bacteria but instead prevent the growth of bacteria.
How do antibiotics work?

Antibiotics stop the bacteria’s ability to stay intact or reproduce making it vulnerable to the body’s immune system

- Block protein formation: macrolides, tetracycline, aminoglycosides
- Inhibit cell wall formation: beta lactams, vancomycin, bacitracin
- Interfere with DNA formation: quinolones, rifampin
- Prevent folic acid synthesis: sulfonamides, trimethoprim
How are antibiotics used?

• To treat a known infection

• Prophylactic treatment - treatment with antibiotics to prevent an infection (e.g., prior to specific surgeries)

• Empiric therapy – treatment of an infection before specific culture information has been obtained
Tools to help choose antibiotics

• **Direct examination**
  – Lab prepares or stains the specimen to allow for identification of the infecting organism

• **Cultures**
  – Isolate and grow the microorganism in the lab

• **Sensitivities**
  – Once the microorganism is cultured antibiotic susceptibility can be determined

• **Antibiograms**
  – Summary of antibiotic susceptibility and resistance for a setting such as a hospital or nursing home
Pulling it all together
Antibiotics: Beta Lactam classes

• **Penicillin, methicillin, amoxicillin and ampicillin**
  – Extended spectrum agents: piperacillin, ticarcillin
  – Can be to help overcome bacterial resistance
    ▪ Amoxicillin + Clavulanate = Augmentin
    ▪ Ampicillin + Sulbactam = Unasyn
    ▪ Piperacillin + Tazobactam = Zosyn

• **Cephalosporins**
  – More gram positive activity: Cephalexin, Cefazolin
  – More gram negative activity: Ceftriaxone, Ceftazidime, Cefepime
  – New broader spectrum, including MRSA: Ceftaroline
Antibiotics: Carbapenems

• Extremely broad-spectrum, among the most powerful antibiotics we currently have available

• Spectrum includes *Streptococci*, susceptible *Staphylococci, Enterobactericeae, Pseudomonas, Acinetobacter sp.*, and anaerobic bacteria

<table>
<thead>
<tr>
<th>Drug</th>
<th>Route of Administration</th>
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<tbody>
<tr>
<td>Imipenem</td>
<td>IV</td>
</tr>
<tr>
<td>Meropenem</td>
<td>IV</td>
</tr>
<tr>
<td>Ertapenem</td>
<td>IM, IV</td>
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<td>Doripenem</td>
<td>IV</td>
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Antibiotics: Gram positive agents

• **Vancomycin**
  – Treats methicillin-resistant *Staphylococcus aureus* (MRSA)
  – Oral form NOT absorbed from gut; only used to treat *C. difficile*
  – IV form gets good systemic levels - used for all other infections

• **Daptomycin**
  – Covers resistant gram-positive organisms: MRSA and VRE
  – Only available as IV formula

• **Linezolid**
  – Covers MRSA and VRE
  – Both oral and IV forms available and get good systemic levels
Antibiotics: Gram negative agents

Fluoroquinolones (Oral and IV forms)

• Ciprofloxacin: Mostly gram negative activity
  – Commonly used for UTI treatment

• Levofloxacin/Moxifloxacin: Broader activity
  – Also used for treating UTIs and infections from gram-negative bacteria
  – Also covers *Streptococcus pneumoniae* and other respiratory bacteria
Antibiotics: Gram negative agents

Aminoglycosides (only IV)

- Examples: Gentamicin, Tobramycin, Amikacin
- Excellent gram negative drugs – especially for urinary tract
- Limited use because of toxicity (kidney, hearing/balance)
Antibiotics: Miscellaneous

• **Trimethoprim/Sulfamethoxazole (Bactrim)**
  – Mainly given in oral form – must watch renal function
  – Narrow spectrum – activity against both Gram negative and Gram positive bacteria
  – Commonly used to treat UTIs
  – Also used for MRSA skin infections

• **Azithromycin**
  – Commonly given in oral dose pack called “Z-pack”
  – Considered narrow spectrum, used for respiratory/sinus infections

• **Metronidazole (Flagyl) (oral and IV form)**
  – A primary treatment for *C. difficile* infections
  – Oral form can cause nausea and stomach upset
Key points

• Antibiotics are a powerful treatment against infections due to bacteria
• Choosing antibiotics wisely requires taking into account a number of factors regarding the targeted bacteria and the individual being treated
• Antibiotics are not a substitute for the immune system
• There are a number of tools that should be used to guide antibiotic selection