CHAPTER 32

# Antibiotic Streamlining

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## LEARNING OBJECTIVES

- Discuss the importance of antibiotic streamlining.
- Recognize the presence of an infection.
- Describe the basics of interpreting microbiological testing.
- Recognize common bacteria, infection sites, and treatments.

## Introduction

*Antibiotic streamlining* is one of the most important methods pharmacists can use to encourage appropriate antibiotic use, limit the development of bacterial resistance, and improve patient care.

## Importance of Antibiotic Streamlining

Many antibiotics are used before an infection is confirmed. The use of antibiotics in this manner is referred to as *empiric therapy*. Empiric therapy is a "best guess" approach that takes into account the type of infection suspected and the patient's clinical status and medication allergies. Once diagnostic test results are received, empiric therapy may not be the best choice for treating the identified infecting organism(s). In this case, antibiotics may need to be changed to better target the infecting organism.

*Antibiotic streamlining* or *de-escalation* refers to the process of converting patients from a broad spectrum antibiotic, which covers several different types of disease-causing bacteria to a narrow spectrum antibiotic that targets a specific infecting organism.[1] The streamlining process involves monitoring the patient's clinical response and microbiology culture and sensitivity (C&S) data. The results of this data are then used to evaluate the patient's existing antibiotic therapy. If appropriate, a recommendation to streamline therapy may be made. Usually, it involves changing or reducing the number of antibiotics, but occasionally it may require discontinuing therapy completely if no infection is established.

Benefits associated with antibiotic streamlining include the following:

- Reducing secondary infections such as candidiasis, *Clostridium difficile*–associated diarrhea (CDAD), or vancomycin-resistant *Enterococcus* (VRE)
- Decreasing morbidity and mortality; appropriate therapy early in the infection can improve patient outcome[2]
- Supporting the institution's infection control processes
- Minimizing antimicrobial resistance
- Minimizing toxicity and adverse effects
- Reducing healthcare expenditures

Table 32-1 provides examples of interventions involving antibiotic streamlining.

## Presence of an Infection

The human body responds to infection by triggering a cascade of reactions to fight the invading organisms. Typically, these reactions will trigger certain physiologic responses that lead to a change in the patient's vital signs and clinical status, thereby producing signs and symptoms of infection.

### *Signs of an Infection*

By definition, *signs* are defined as something that can be measured or observed, and symptoms are based on the patient's verbal report. In the context of infection, measurable signs of infection are included in Table 32-2.

### *Stages of Infection*

Response to infection can be very individualized. However, there are generally three stages of infection.[3]

**Stage I** is referred to as an *early infection* and typically occurs during the first few days of the illness. The patient may be clinically unstable and have leukocytosis or neutropenia. Vital signs may be abnormal and diagnostic exams suggest an infection is present. Usually, there is uncertainty as to the specific organism causing the infection, so cultures are obtained and a preliminary result may or may not be available. The latter can be influenced by previous or current antibiotics that may have been administered.

**Stage II** of an infection usually occurs from days 4 to 6. If the correct therapy is being provided, the patient should begin to stabilize. A movement of the WBC count back into the normal range

**TABLE 32-1. Examples of Antibiotic Streamlining**

| Sample Intervention | Outcomes/Benefits |
|---|---|
| Converting from imipenem/cilastatin to cefazolin in a patient with a urinary tract infection caused by a strain of *Escherichia coli* that is susceptible to cephalosporins | • Prevents the development of antimicrobial resistance<br>• Reduces the likelihood that the patient will develop secondary infections from broad spectrum antibiotic use |
| Discontinuing therapy for a patient who was originally started on antibiotics in the emergency department for respiratory distress and was subsequently diagnosed with congestive heart failure exacerbation | • Minimizes adverse drug reactions<br>• Reduces the chance that bacteria normally present in the body will develop resistance and cause a new infection |
| Discontinuing metronidazole when the patient is receiving piperacillin/tazobactam for a wound infection (and does not have a confirmed or suspected CDAD infection) | • Avoids duplicate therapy<br>• Minimizes adverse drug reactions |
| Discontinuing vancomycin in a nursing home patient who is colonized with methicillin-resistant *Staphylococcus aureus* (MRSA) but displays no sign of active infection | • Avoids the unnecessary treatment of colonization in a patient who has no active signs of infection |

CDAD = *Clostridium difficile*–associated diarrhea.

**TABLE 32-2. Signs of an Infection**

| Sign | Description |
|---|---|
| Fever | • Body temperature above 38°C (100.4°F)<br>• Not all patients will present with a fever<br>• Elderly patients may actually present with hypothermia, which is defined as a temperature <36°C (96.8°F) |
| Hypotension | • Systolic blood pressure <90 mm Hg<br>• The cause may be dehydration or sepsis<br>• Patients with less severe infection or underlying hypertension may not develop hypotension |
| Tachycardia | • Heart rate above 100 beats per minute<br>• Some patients may have underlying tachycardia due to cardiac sources or secondary to medication |
| Tachypnea | • Rapid breathing of >20 breaths per minute or a $PaCO_2$ of <32 mm Hg (for patients on mechanical ventilation)<br>• Patients with infection tend to become acidotic and rapid breathing increases pH in attempt to return it to the normal range<br>• Patients with underlying respiratory diseases (such as chronic obstructive pulmonary disease) may have a low baseline respiratory rate and their compensatory response in breathing may not result in high respiratory rate |
| White blood cells (WBCs) | • Abnormal WBC count<br>• WBC counts may begin to trend upward past the normal range, usually 4,000 to 12,000 cells/$mm^3$ (this is known as *leukocytosis*)<br>• There may also be a *left shift*, which is an increase in immature neutrophils (also known as *bands*)<br>• Some medications, such as steroids, can also cause leukocytosis<br>• Chemotherapy patients may have the opposite effect and have extremely low neutrophils (a type of WBC), which is usually expressed through the term *neutropenia*<br>• Patients with neutropenia are at high risk for developing an infection |
| Procalcitonin (PCT) | • A biological marker that increases in response to certain bacterial infections and has been shown to be useful in guiding antibiotic therapy<br>• Normal PCT levels in a person without infection are usually below 0.5 ng/mL<br>• Existing literature has demonstrated that utilization of PCT to guide antibiotic therapy is associated with a reduction in antibiotic use with no overall effect on clinical outcomes or length of stay in the ICU or hospital<br>• PCT is not a stand-alone test and should not replace clinical judgment and evaluation of patients<br>• Additional tests are needed to confirm infection |
| Positive culture | • Isolation of the causative organism(s) from a specimen can confirm infection |

ICU = intensive care unit.

may be seen, fever may no longer be present, and other vital signs may return to normal. The causative organism(s) are usually identified by this stage.

**Stage III** of an infection occurs from day 7 forward. If the appropriate therapy has been received, the patient's vital signs and WBC count have returned to normal, fever is resolved, and repeat diagnostic exams are normal or improving. Although antibiotic streamlining can occur anytime, the best opportunity is in Stage I or early Stage II.

### *Normal Flora*

In a healthy human, the internal tissues (e.g., blood, brain, muscle, bone, and other internal organs) are normally free of microorganisms. On the other hand, the surface tissues (e.g., skin and mucous membranes) are constantly in contact with environmental organisms and become readily colonized by certain microbial species. The mixture of organisms regularly found at any anatomical site is referred to as the *normal flora.*

The normal flora of humans is complex and consists of more than 200 species of bacteria and yeasts. The makeup of the normal flora depends on various factors, including genetics, age, sex, stress, nutrition, and diet of the individual. Table 32-3 lists examples of some of the bacterial species that occur as normal flora of humans.

**TABLE 32-3. Normal Flora in the Human Body**

| Body Site | Normal Flora |
|---|---|
| Skin | • Diphtheroids (e.g., *Corynebacterium* spp.)<br>• *Propionibacterium*<br>• Staphylococci (especially *Staphylococcus epidermidis*) |
| Gastrointestinal tract | • *Bacteroides* spp.<br>• *Clostridium* spp. (some species)<br>• Diphtheroids<br>• Enterobacteriaceae (e.g., *E. coli, Klebsiella* spp.)<br>• *Enterococcus*<br>• *Candida* spp. (usually *C. albicans*) |
| Upper respiratory tract | • *Haemophilus* spp.<br>• *Neiserria* spp.<br>• Viridans streptococci<br>• *Streptococcus pneumoniae*<br>• Staphylococci<br>• Diphtheroids |
| Genital tract | • *Corynebacterium* spp.<br>• Enterobacteriaceae<br>• *Lactobacillus* spp.<br>• *Mycoplasma* spp.<br>• Staphylococci<br>• Streptococci<br>• *Candida* spp. (usually *C. albicans*) |

### *Colonization Versus Infection*

Knowing the difference between colonization and infection is very important in determining whether or not therapy is warranted. The human body can have a symbiotic relationship with certain types of bacteria and fungi. In the absence of clinical symptoms, this relationship is referred to as *colonization.* When a host's immune system is compromised, or is introduced to variant strains or foreign pathogens, then infection occurs. Questions should be asked to determine whether or not treatment is necessary (see Table 32-4).

### *Signs and Symptoms of Common Infections*

In addition to the signs listed in Table 32-2, there are additional clinical signs and symptoms for common infections found in the acute care setting (see Table 32-5). It is important to recognize these signs and symptoms in any patient who has a presumed or documented infection.

## Interpreting Microbiology Information

### *General Guidelines for Microbiological Testing*

Knowing how the microbiology laboratory does its testing can help when interpreting C&S results. For each culture, there is usually a preliminary report, as well as a final report that is posted in the patient's chart. A culture with no growth is considered to be a *negative culture*. A culture with growth identified is called a *positive culture*.

**TABLE 32-4. To Treat or Not to Treat?**

| Question | Answer |
|---|---|
| Is the positive culture from a normally sterile site? | • A sterile site is an area of the body where bacterial or fungal organisms are not likely to be found<br>• Examples include blood, spinal fluid, and internal organs<br>• A positive culture from these sites may be highly suggestive of an infection, unless contamination of the specimen is suspected<br>• A positive culture should always be evaluated in conjunction with clinical symptoms and other diagnostic results |
| Is the positive culture from a nonsterile site? | • A positive culture from a nonsterile site may or may not be indicative of an infection and needs to be reviewed in the context of the patient's clinical presentation<br>• Pulmonary secretions and sputum cultures represent the biggest challenges in treating a patient for infection<br>• Sputum is not considered to be a sterile body fluid<br>• Cultures that are obtained from the patient coughing up sputum or tracheal secretions from the upper part of an endotracheal tube (ET) may be contaminated with oral flora and are typically not optimal for use in diagnosing infection<br>• These cultures may falsely grow bacteria and fungus that are not the true infecting pathogens<br>• Sputum samples obtained from a bronchoscopy (deep into the lungs) are more accurate in terms of diagnosis |
| What risk factors are present that predispose the patient to developing an infection? | • Infections can occur when the host's immune system or natural defenses are compromised<br>• Burn patients are at high risk for developing systemic candidiasis because their damaged skin serves as portal of entry into the blood for bacteria and fungus<br>• Neutropenic cancer patients and HIV positive patients are also at high risk for infections, due to their compromised immune systems<br>• In these patients, bacteria or fungus may not grow from all cultures; therefore, the majority of therapy will be empiric |
| Is the pathogen in question normally present in healthy individuals? | • A pathogen that is typically present in the human body may represent the patient's normal flora |
| Does the patient have other signs and symptoms of infection present? | • Refer to the previous section on clinical signs and symptoms of infection for more information |

HIV = human immunodeficiency virus.

**TABLE 32-5. Signs and Symptoms of Common Types of Infections**

| Type of Infection (system involved) | Signs | Symptoms |
|---|---|---|
| Gastroenteritis (gastrointestinal tract) | • Positive culture specifically for *Shigella*, *Salmonella*, *Camphylobacter,* or *E. coli*<br>• Electrolyte disturbances | • Profuse diarrhea<br>• Abdominal pain<br>• Nausea<br>• Vomiting and/or dehydration |
| Meningitis (central nervous system) | • Cerebrospinal fluid findings (look for glucose, total protein, WBCs, and Gram stain results)<br>• Positive Kernig's or Brudzinski's sign | • Photophobia<br>• Headache<br>• Stiffness of the neck<br>• Rigidity<br>• Seizures<br>• Nausea<br>• Vomiting and/or blurred vision<br>• In young children, symptoms may include irritability, altered sleep patterns, vomiting, high-pitched crying, and decreased oral intake |
| Peritonitis (gastrointestinal) | • Few or no bowel sounds<br>• CT scan | • Severe abdominal pain<br>• Rebound tenderness<br>• Nausea<br>• Vomiting<br>• Diarrhea and/or abdominal swelling |
| Pneumonia (pulmonary) | • Increased sputum production<br>• Decreased breath sounds<br>• Inspiratory "crackles"<br>• Abnormal chest x-ray | • Chest pain and productive cough<br>• A nonproductive cough may still be present in infection<br>• Other disease states (e.g., congestive heart failure exacerbation or chronic bronchitis) or certain medications (e.g., angiotensin-converting enzyme inhibitors) may also cause cough |
| Urinary tract infection (UTI)—urogenital | • Urinalysis results<br>• Changes in BUN and serum creatinine | • Pyuria (burning) on urination<br>• Discolored urine and/or increased frequency of urination<br>• Patients with a more severe form of infection (pyelonephritis) may complain of severe lower back pain |
| Wound (integument/skin) | • Measurement of ulcer width and/or depth<br>• Visible break in skin that is producing puss or is discolored from normal skin tone | • Warmth<br>• Redness<br>• Swelling and/or pain |

BUN = blood urea nitrogen; CT = computerized tomography; WBC = white blood cell.

Antimicrobial susceptibilities are not reported for every drug and are based on national laboratory standards and expert rule systems that are built into automated testing systems. Only appropriate drug-microorganism combinations are reported. For example, ciprofloxacin susceptibility will not be reported for a positive *Streptococcus pneumoniae* culture. Ciprofloxacin is never the drug of choice to treat *S. pneumoniae* because of the ease in which resistance can develop.

Individual hospital testing practices may vary, but generally susceptibility testing is performed on all routine bacterial cultures that are deemed to be positive. However, in most hospitals susceptibility testing is not routinely performed on the following:

- Anaerobes
- Yeast/molds
- *Lactobacillus* spp.
- Diphtheroid/*Corynebacteria* spp.
- *Neisseria* spp. and *Moraxella* spp.
- Some species of viridans streptococci
- Organisms that are rare, unusual, or do not have standardized methods of testing
- Cultures with growth that may be reported with normal flora statements:
  - Normal respiratory flora
  - Normal skin flora
  - Normal genital/vaginal flora
  - Normal oral flora
  - Normal upper respiratory flora
  - No *Salmonella*, *Shigella*, or *Campylobacter* isolated
- Cultures with growth that may be reported as contaminated or insignificant:
  - Polymicrobic growth—skin flora
  - Polymicrobic growth—fecal flora
  - Random urine cultures with less than 10,000 CFU/mL

Positive cultures are typically reported to the facility's infection control program for some significant pathogens including the following:

- MRSA (methicillin [oxacillin] resistant *Staphylococcus aureus*)
- VRE (vancomycin-resistant *Enterococcus*)
- ESBL (extended-spectrum beta-lactamase) producer
- CRE (carbapenems-resistant Enterobacteriaceae)
- Multidrug-resistant gram-negative bacteria (e.g., *P. aeruginosa*, *A. baumanii*)
- Positive smears for acid-fast bacilli (AFB) (e.g., *M. tuberculosis*)
- Positive *Clostridium difficile* toxin A/B tests
- Positive respiratory syncytial virus (RSV) test
- Positive influenza A/B test

## *Elements of a Culture and Sensitivity Report*

Pharmacists who are involved in the antibiotic streamlining process must understand how to interpret a C&S report. It is important to note that these reports may vary from institution to institution but should have similar information recorded on the final reports. Figure 32-1 shows a C&S report with the key components identified.

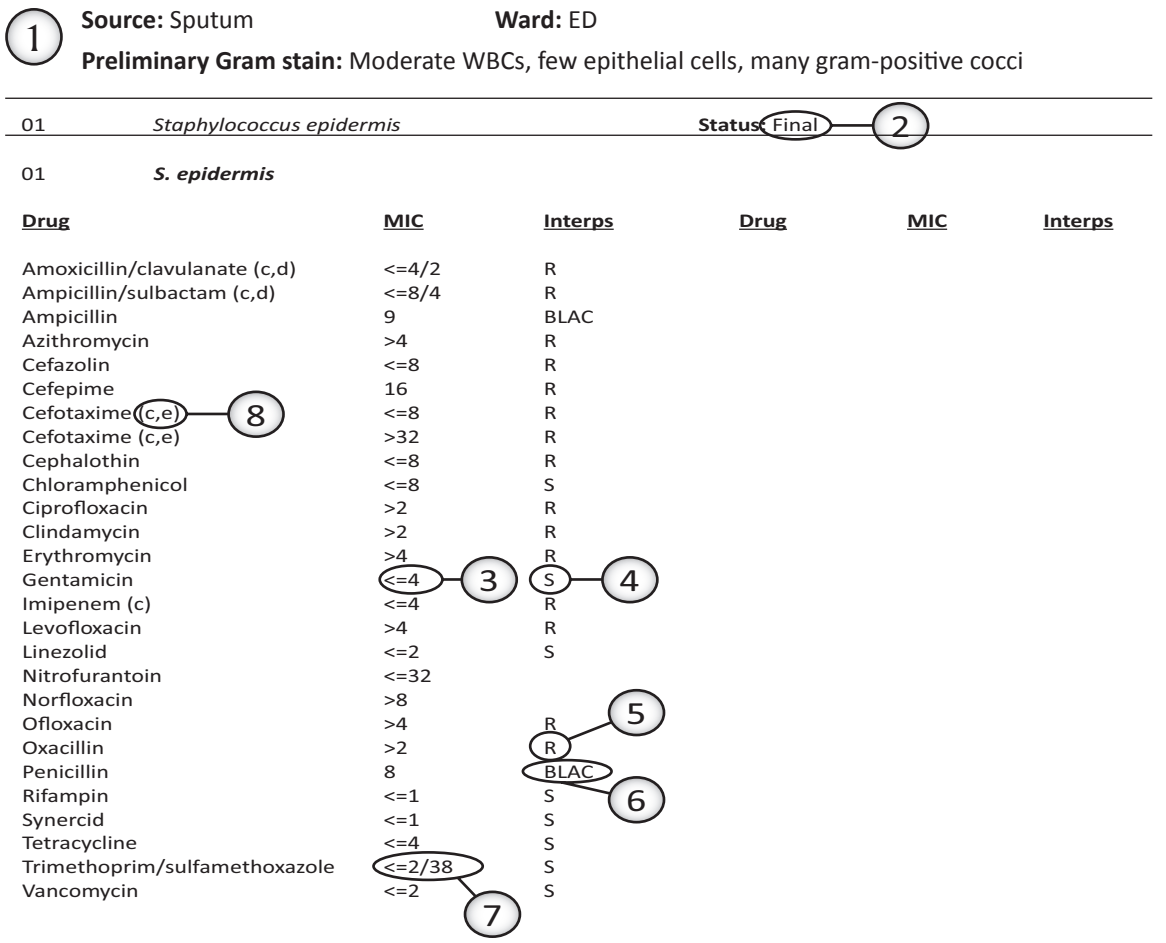
## *Limitations of Microbiological Testing*

Testing a bacteria, virus, or fungi for susceptibility to an anti-infective in a nonphysiologic environment, such as in a test tube, is known as *in vitro testing*. One limitation of in vitro testing is that it only represents the susceptibility of the pathogen to a given anti-infective at a single point in time and does not take into account the different conditions that exist within the body (known as *in vivo*).

When infection is present, other factors may influence the ability of an anti-infective agent to eradicate a pathogen, such as the patient's immune status (e.g., neutropenic versus non-neutropenic) or the behavior of the microbe in the patient. When evaluating a positive culture in the context of the reported bacterial susceptibilities, keep in mind that some exceptions exist in which an in vitro test result does not necessarily predict a therapeutic response in vivo. Therefore, the respective antibiotic should not be used. Some examples are included in Table 32-6.

## *Advances in Microbiological Testing*

Traditional methods for organism identification such as Gram stain, bacterial culture, and biochemical tests (e.g., coagulase, DNase, and latex agglutination assays) may deliver final C&S results anywhere from 48 to 96 hours after specimen collection. On the other hand, rapid molecular identification methods can deliver results within 1 to 2 hours from the time a blood culture




## *Culture and Sensitivity Report Key*

1. Denotes the original Gram stain information—Many times, semiquantitative information will be provided about the quality of the specimen before the final pathogen is known. In sputum cultures, there may be comments such as "heavy growth, many WBCs, many red blood cells (RBCs), many or few epithelial cells, etc." A quantitative bacterial count (e.g., >100,000 CFU/mL) is typically provided when it is a urine specimen but may also be provided for other specimens on request.
2. Indicates that this is the final report—Sometimes, if the C&S has not been confirmed, it will list a status of *pending*.
3. Represents the minimum inhibitory concentration (MIC) for the drug listed—In this case, the MIC is ≤4 mcg/mL, which means susceptible based on national laboratory guidelines. The susceptibility definition varies based on the organism and the antibiotic being tested.
4. Location of the susceptibility results—In this case, S = **s**usceptible, I = **i**ntermediate, and R = **r**esistant.
5. Because this strain of *S. epidermidis* is oxacillin resistant, it is classified as MRSE or methicillin-resistant *S. epidermidis*.
6. BLAC—This indicates that this strain of *S. epidermidis* produces beta-lactamase.
7. When two MICs are listed, this means that the MIC is different for each drug in the combination product. In this case, the MIC for trimethoprim is ≤2 mcg/mL, whereas the MIC for sulfamethoxazole is ≤38 mcg/mL.
8. These letters refer to supplemental comments on the report (not shown).

**FIGURE 32-1.** Anatomy of a Culture and Susceptibility Report

**TABLE 32-6. Examples of Microbiological Testing Limitations**

| Example | Comments |
|---|---|
| An ESBL-producing organism (usually *E. coli* or *Klebsiella* spp.) that is susceptible to cefoxitin | • Cefoxitin is stable to breakdown by ESBLs in vitro; however, there have been clinical failures reported and it should not be used for treatment<br>• Other antibiotics that should not be used to treat a documented ESBL infection include any cephalosporin, such as cefepime, extended-spectrum penicillins, and aztreonam<br>• In some cases, fluoroquinolones may have in vitro activity<br>• Clinical failure can also occur with these agents<br>• The primary treatment of choice for an infection caused by an ESBL-producing organism is typically a carbapenem |
| An MRSA susceptible to sulfamethoxazole/trimethoprim | • It is very common for an MRSA strain to be listed as susceptible to sulfamethoxazole/trimethoprim on the C&S report<br>• The site of infection should be considered in this case, along with whether or not the strain is community acquired (typically resistant to beta-lactams only) or hospital acquired (typically resistant to multiple classes of antibiotics)<br>• For example, this antibiotic may be appropriate to treat a community-acquired MRSA skin and soft tissue infection but would not be the ideal treatment choice for an ICU patient with MRSA bacteremia |
| An *Enterococcus* spp. that is susceptible to cephalosporins | • Cephalosporins may appear to be effective against these organisms based on laboratory results, but clinically they are not effective in treating enterococcal infections<br>• The combination of trimethoprim/sulfamethoxazole also may appear effective against these organisms in the laboratory but will not be effective in a patient<br>• In general, susceptibility testing for these organisms can be misleading<br>• Infections due to *Enterococcus* are commonly treated with ampicillin or vancomycin, often combined with gentamicin |
| Aminoglycosides and synergy | • Specifically applies to *Enterococcus* bacteria<br>• The lab may report synergy testing for gentamicin and streptomycin<br>• Ampicillin, penicillin, and vancomycin and an aminoglycoside can be an effective, synergistic combination especially in enterococcal endocarditis<br>• Gentamicin was also commonly used in conjunction with vancomycin or another beta-lactams for the treatment of MRSA endocarditis, but this practice has fallen out of favor (see new MRSA guidelines) |

ESBL = extended-spectrum beta-lactamase; ICU = intensive care unit; MRSA = methicillin-resistant *Staphylococcus aureus*.

becomes positive. Today, several assays that employ various technical approaches (e.g., polymerase chain reaction [PCR], loop-mediated isothermal application, bacteriophage amplification, and fluorescence in situ hybridization using peptide nucleic acid probes [PNA-FISH]) are available to help with early identification of bacteria, yeast, and viruses.[4] Despite this potential advantage, implementation of rapid diagnostic testing alone has not always resulted in a positive impact in patient outcomes. The literature indicates that implementation of rapid molecular identification tests within healthcare institutions should be coupled with antibiotic stewardship activities to optimize outcomes. Clinicians should be trained and educated to report, interpret, and respond to these results in a timely manner to ensure a significant reduction in the time to initiating effective antimicrobial therapy, as well as potential decreased mortality and decreased hospital costs.

Features to consider when selecting a rapid molecular diagnostics platform include the following:

- Cost of equipment and maintenance requirements
  - One-time fee versus lease
  - Licensing and software updates
  - Cost per test
- Lab space requirements
- Technical complexity, training requirements, and competencies
- Inclusivity of panel
  - Gram-positive, gram-negative, antifungal, anaerobes, resistance genes
  - FDA-approved indications
- Personnel requirements
  - Technician time
  - Clinician availability (physicians, pharmacists, etc.)
- Time to result
  - Batching capabilities
  - Turnaround time
- Sensitivity and specificity
- Reimbursement (inpatient versus outpatient)

# Common Bacteria, Their Infection Sites, and Treatment

Understanding the different bacteria that can cause infection and the medications that treat infections with these organisms is imperative in antibiotic streamlining. One factor that increases the complexity of this process is the number of antibiotics that can be used to treat these organisms. Table 32-7 lists common bacteria involved in infection and antibiotics that may be used in treatment.

## *Patient-Specific Factors*

It is important to be aware of patient-specific or "host" factors that can either change the way a patient responds to a medication or that can influence the medication selection. After a patient has been identified for antibiotic streamlining, patient-specific factors should be taken into consideration before an alternative therapy is recommended. These factors are listed in Table 32-8.

## *Combination Antibiotic Therapy*

Combining two or more antibiotics may be necessary when treating certain types of infections. When combined, some antibiotics work synergistically to treat certain types of infections. Others are combined because a broader spectrum of coverage is needed in polymicrobial infections. For example, gentamicin is typically added to a beta-lactam antibiotic for the treatment of gram-positive endocarditis. Rifampin may be added to oxacillin or vancomycin to reduce the number of *S. aureus* colonies. Infections caused by *Pseudomonas aeruginosa* can be treated with a two-drug combination that includes an antipseudomonal beta-lactam (e.g., piperacillin/tazobactam) plus either an aminoglycoside, ciprofloxacin, or levofloxacin.

Combination therapy has also been used to treat multidrug-resistant *Acinetobacter baumannii* and carbapenem-resistant Enterobacteriaceae (CRE) in healthcare facilities in the United States and globally. Although optimal therapy for these highly resistant infections has not been well defined, regimens usually include combinations of a polymyxin and a secondary agent (e.g., tigecycline, minocycline, aminoglycosides, or carbapenems). Older agents like nitrofurantoin and fosfomycin have also been utilized for CRE infections localized in the urinary tract.

## *Duplicate Therapy*

There are combinations of drugs that *may* represent unnecessary overlap in antimicrobial spectra and may require an intervention (see Table 32-9). Keep in mind that this is not a "hard and fast" rule in all situations

**TABLE 32-7. Common Bacteria and Antibiotic Treatment Options**

| Bacteria | Selected Antibiotics with Activity Against This Bacteria[a,b] | Types of Infections Caused by This Bacteria |
|---|---|---|
| **Gram positive** | | |
| *Enterococcus* spp. | *Vancomycin susceptible*<br>• Amoxicillin[c]<br>• Ampicillin[c]<br>• Nitrofurantoin (urine isolates only)<br>• Penicillin<br>• Vancomycin<br>• Gentamicin or streptomycin have activity in combination with a beta-lactam<br>*VRE*<br>• Daptomycin<br>• Linezolid | • Peritonitis<br>• Pelvic infections<br>• UTI<br>• Pyelonephritis<br>• Endocarditis<br>• Bacteremia<br>• Complicated skin and soft-tissue infections (CSSI) |
| *Staphylococcus aureus* | *Methicillin susceptible*<br>• Amoxicillin[c]<br>• Ampicillin[c]<br>• Cefazolin<br>• Clindamycin<br>• Dicloxacillin<br>• Doxycycline<br>• Minocycline<br>• Nafcillin<br>• Oxacillin<br>• Trimethoprim/sulfamethoxazole<br>• Rifampin or gentamicin may be used in combination with a second drug<br>*MRSA*<br>• Daptomycin<br>• Linezolid<br>• Ceftaroline<br>• Tigecycline<br>• Vancomycin | • Endocarditis<br>• Bacteremia<br>• Meningitis<br>• Pneumonia<br>• CSSI<br>• Osteomyelitis |

so if you are unsure, it is best to check with another clinician prior to making an intervention. For example, piperacillin/tazobactam with intravenous metronidazole to treat a CSSI would generally be duplicate therapy. However, piperacillin/tazobactam together with oral metronidazole for *C. difficile* infection would be appropriate.

**TABLE 32-7. Common Bacteria and Antibiotic Treatment Options (continued)**

| Bacteria | Selected Antibiotics with Activity Against This Bacteria[a,b] | Types of Infections Caused by This Bacteria |
|---|---|---|
| *Staphylococcus epidermidis* (in most cases, this will be methicillin resistant) | *Methicillin susceptible*<br>• Dicloxacillin<br>• Nafcillin<br>• Oxacillin<br>• Ampicillin[c]<br>*MRSE*<br>• Daptomycin<br>• Linezolid<br>• Vancomycin | • Endocarditis<br>• Bacteremia<br>• CSSI |
| *Streptococcus pneumoniae* (penicillin susceptible) | • Amoxicillin[c]<br>• Azithromycin<br>• Ceftriaxone<br>• Cefotaxime<br>• Clarithromycin<br>• Doxycycline<br>• Gemifloxacin<br>• Levofloxacin<br>• Moxifloxacin<br>• Penicillin<br>• Sulfamethoxazole/trimethoprim | • Meningitis<br>• Otitis media<br>• Pharyngitis<br>• Pneumonia<br>• Sinusitis |
| *Streptococcus pyogenes* | • Amoxicillin[c]<br>• Ampicillin[c]<br>• Penicillin | • Pharyngitis<br>• Skin and soft tissue infections (SSTI)<br>• Necrotizing fasciitis (rare) |
| *Listeria monocytogenes* (gram-positive rod) | • Ampicillin (+/– gentamicin)<br>• Sulfamethoxazole/trimethoprim | • Meningitis (pediatric and elderly population) |
| **Gram negative** | | |
| *Acinetobacter baumannii* | • Varies<br>• Refer to individual C&S or hospital susceptibility patterns | • Bacteremia<br>• Pneumonia<br>• CSSI *(Note: Usually hospital acquired; implicated in ICU outbreaks)* |

**TABLE 32-7. Common Bacteria and Antibiotic Treatment Options (continued)**

| Bacteria | Selected Antibiotics with Activity Against This Bacteria[a,b] | Types of Infections Caused by This Bacteria |
|---|---|---|
| *Citrobacter freundii* (part of the genera Enterobacteriaceae) | • Aztreonam<br>• Ciprofloxacin<br>• Ertapenem<br>• Gentamicin<br>• Imipenem/cilastatin<br>• Levofloxacin<br>• Meropenem<br>• Piperacillin[c]<br>• Ticarcillin[c]<br>• Tobramycin | • Bacteremia<br>• Pneumonia<br>• Intra-abdominal infections<br>• CSSI<br>• UTI *(Note: Usually hospital acquired)* |
| *Enterobacter cloacae* (part of the genera Enterobacteriaceae) | • Aztreonam<br>• Ciprofloxacin<br>• Ertapenem<br>• Gentamicin<br>• Imipenem/cilastatin<br>• Levofloxacin<br>• Meropenem<br>• Piperacillin[c]<br>• Ticarcillin[c]<br>• Tobramycin | • Bacteremia<br>• Pneumonia<br>• CSSI<br>• UTI *(Note: Usually hospital acquired)* |
| *Escherichia coli* (part of the genera Enterobacteriaceae) | • Amoxicillin[c]<br>• Ampicillin[c]<br>• Aztreonam<br>• Cefazolin<br>• Cefotaxime<br>• Ceftriaxone<br>• Ciprofloxacin<br>• Gentamicin<br>• Levofloxacin<br>• Moxifloxacin (nonurinary infections)<br>• Piperacillin[c]<br>• Sulfamethoxazole/trimethoprim<br>• Ticarcillin[c]<br>• Tobramycin | • Gastroenteritis<br>• Intra-abdominal infections<br>• UTI<br>• Genitourinary<br>• Bacteremia<br>• CSSI |

**TABLE 32-7. Common Bacteria and Antibiotic Treatment Options (continued)**

| Bacteria | Selected Antibiotics with Activity Against This Bacteria[a,b] | Types of Infections Caused by This Bacteria |
|---|---|---|
| *Haemophilus influenzae* | • Amoxicillin[c]<br>• Azithromycin<br>• Cefotaxime<br>• Ceftriaxone<br>• Clarithromycin<br>• Doxycycline<br>• Gemifloxacin<br>• Levofloxacin<br>• Moxifloxacin<br>• Sulfamethoxazole/trimethoprim | • Meningitis<br>• Pharyngitis<br>• Pneumonia<br>• Sinusitis |
| *Klebsiella pneumoniae* (part of the genera Enterobacteriaceae) | • Amoxicillin[c]<br>• Azithromycin<br>• Cefotaxime<br>• Ceftriaxone<br>• Clarithromycin<br>• Gemifloxacin<br>• Levofloxacin<br>• Moxifloxacin<br>• Sulfamethoxazole/trimethoprim | • Pneumonia<br>• UTI<br>• CSSI<br>• Bacteremia |
| *Legionella pneumophila* | • Azithromycin<br>• Clarithromycin<br>• Gemifloxacin<br>• Levofloxacin<br>• Moxifloxacin | • Pneumonia (also called *Legionnaires' disease*) |
| *Moraxella catarrhalis* | • Amoxicillin/clavulanate<br>• Azithromycin<br>• Cefotaxime<br>• Ceftriaxone<br>• Clarithromycin<br>• Gemifloxacin<br>• Levofloxacin<br>• Moxifloxacin<br>• Sulfamethoxazole/trimethoprim | • Pharyngitis<br>• Pneumonia (community acquired)<br>• Sinusitis |

**TABLE 32-7. Common Bacteria and Antibiotic Treatment Options (continued)**

| Bacteria | Selected Antibiotics with Activity Against This Bacteria[a,b] | Types of Infections Caused by This Bacteria |
|---|---|---|
| *Neisseria gonorrhoeae* | • Cefotaxime<br>• Cefixime<br>• Cefpodoxime<br>• Ceftriaxone<br>• Ciprofloxacin<br>• Levofloxacin | • Pelvic inflammatory disease<br>• Urethritis<br>• Oral and anal infections |
| *Neisseria meningitidis* | • Cefotaxime<br>• Ceftriaxone<br>• Cefuroxime<br>• Penicillin | • Meningitis |
| *Proteus mirabilis* (part of the genera Enterobacteriaceae) | • Amoxicillin[c]<br>• Ampicillin[c]<br>• Aztreonam<br>• Cefazolin<br>• Cefotaxime<br>• Ceftriaxone<br>• Ciprofloxacin<br>• Gentamicin<br>• Levofloxacin<br>• Moxifloxacin (nonurinary infections)<br>• Piperacillin[c]<br>• Sulfamethoxazole/trimethoprim<br>• Ticarcillin[c]<br>• Tobramycin | • Intra-abdominal<br>• Pneumonia<br>• UTI<br>• CSSI<br>• Bacteremia<br>• Prosthetic device infections |
| *Pseudomonas aeruginosa* | • Amikacin<br>• Aztreonam<br>• Cefepime<br>• Ceftazidime<br>• Ciprofloxacin<br>• Imipenem/cilastatin<br>• Levofloxacin<br>• Meropenem<br>• Piperacillin[c]<br>• Tobramycin *(Note: Combination therapy required for nonurinary infections)* | • CSSI<br>• Osteomyelitis<br>• Bacteremia<br>• Pneumonia<br>• UTI<br>• Prostatitis<br>• Intra-abdominal *(Note: Usually hospital acquired)* |

**TABLE 32-7. Common Bacteria and Antibiotic Treatment Options (continued)**

| Bacteria | Selected Antibiotics with Activity Against This Bacteria[a,b] | Types of Infections Caused by This Bacteria |
|---|---|---|
| *Serratia marcescens* (part of the genera Enterobacteriaceae) | • Aztreonam<br>• Cefepime<br>• Cefotaxime<br>• Ceftazidime<br>• Ceftriaxone<br>• Ciprofloxacin<br>• Ertapenem<br>• Gentamicin<br>• Imipenem/cilastatin<br>• Levofloxacin<br>• Tobramycin | • Pneumonia<br>• UTI<br>• Catheter-related infections<br>• Bacteremia<br>• CSSI |
| **Miscellaneous** | | |
| *Chlamydophila pneumoniae* | • Azithromycin<br>• Clarithromycin<br>• Doxycycline<br>• Gemifloxacin<br>• Levofloxacin<br>• Moxifloxacin | • Pneumonia<br>• Sinusitis<br>• Otitis media |
| *Mycoplasma pneumoniae* | • Azithromycin<br>• Clarithromycin<br>• Doxycycline<br>• Gemifloxacin<br>• Levofloxacin<br>• Moxifloxacin | • Pneumonia (also called *walking pneumonia*) |

**TABLE 32-7. Common Bacteria and Antibiotic Treatment Options (continued)**

| Bacteria | Selected Antibiotics with Activity Against This Bacteria[a,b] | Types of Infections Caused by This Bacteria |
|---|---|---|
| **Anaerobes**[d] | | |
| *Bacteroides fragilis* | • Metronidazole | • Intra-abdominal<br>• Pelvic<br>• CSSI |
| *Clostridium difficile* | • Metronidazole<br>• Vancomycin<br>• Fidaxomicin | • Pseudomembranous colitis |
| *Clostridium perfringens* | • Penicillin G<br>• Clindamycin | • Intra-abdominal<br>• Necrotizing skin infections |

C&S = culture and sensitivity; CSSI = complicated skin and soft tissue infection; ICU = intensive care unit; MRSA = methicillin-resistant *Staphylococcus aureus*; MRSE = methicillin-resistant *Staphylococcus epidermidis*; UTI = urinary tract infection; VRE = vancomycin-resistant *Enterococcus*.

[a]Gilbert DN, Moellering RC, Eliopoulos GM, et al., eds. *The Sanford Guide to Antimicrobial Therapy.* 37th ed. Hyde Park, VT: Antimicrobial Therapy Inc; 2007.

[b]Based on in vitro or in vivo testing; assumes organism is pansensitive unless indicated. Listing of antibiotics is not all inclusive and order does not necessarily reflect treatment preference.

[c]May be used in combination with an enzyme inhibitor (e.g., clavulanate or tazobactam) depending on the organism.

[d]Anaerobic bacteria can also be classified as gram negative or gram positive.

**TABLE 32-8. Patient-Specific Factors**

| Factor | Comments |
|---|---|
| Age | • Neonates have different metabolic capabilities and may not be able to tolerate certain antimicrobials, such as sulfonamides and ceftriaxone<br>• Fluoroquinolones have also historically been avoided in pediatrics due to concerns about skeletal muscle toxicity identified in early animal studies |
| Medication allergies | • Penicillin and sulfonamide allergies are the most common |
| Hepatic function | • Patients with mild-to-severe hepatic dysfunction may not be able to metabolize medications appropriately<br>• Doses of some antibiotics must be reduced in liver disease or avoided in severe impairment (particularly some of the antifungals) |
| Pregnancy | • All medications should be evaluated for teratogenicity |
| Renal function | • Doses of medications should be adjusted based on patient's creatinine clearance<br>• In some cases, the medications may need to be avoided all together |
| Drug interactions | • Medication interactions should be reviewed before suggesting an alternative therapy |
| Site of action | • Certain types of infections require high concentrations of antibiotics to reach the site of infection<br>• For example, significantly higher doses of antibiotics are used to treat meningitis because they have to be able to cross the blood–brain barrier |

**TABLE 32-9. Duplicate Therapy**

| Antibiotic | Plus Second Antibiotic | General Category of Duplicate Coverage |
|---|---|---|
| Metronidazole | • Amoxicillin/clavulanate<br>• Ampicillin/sulbactam<br>• Cefoxitin<br>• Clindamycin<br>• Piperacillin/tazobactam<br>• Ertapenem<br>• Imipenem/cilastatin<br>• Meropenem<br>• Doripenem | • Anaerobic |
| Clindamycin | • Amoxicillin/clavulanate<br>• Ampicillin/sulbactam<br>• Cefoxitin | • Gram positive and anaerobes |
| Clindamycin | • Cefazolin<br>• Oxacillin<br>• Penicillin<br>• Amoxicillin<br>• Ampicillin<br>• Vancomycin | • Gram positive (but not anaerobes) |
| Cefazolin | • Ampicillin/sulbactam<br>• Clindamycin<br>• Dicloxacillin<br>• Oxacillin<br>• Penicillin<br>• Piperacillin/tazobactam<br>• Vancomycin<br>• Linezolid<br>• Daptomycin<br>• Other cephalosporins | • Gram positive<br>• Some gram negative (ampicillin/sulbactam, piperacillin/tazobactam, other cephalosporins) |
| Levofloxacin | • Amoxicillin/clavulanate<br>• Ceftazidime<br>• Cefepime<br>• Ceftriaxone<br>• Ciprofloxacin<br>• Ertapenem<br>• Imipenem/cilastatin<br>• Moxifloxacin<br>• Piperacillin/tazobactam | • Gram negative<br>• Gram positive |

**TABLE 32-9. Duplicate Therapy (continued)**

| Antibiotic | Plus Second Antibiotic | General Category of Duplicate Coverage |
|---|---|---|
| Oxacillin/nafcillin | • Cefazolin<br>• Clindamycin<br>• Dicloxacillin<br>• Linezolid<br>• Daptomycin<br>• Vancomycin | • Gram positive |

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# Competence Checklist

**Name:** _____ **Date:** _____

| Knowledge and Skills | Yes | No |
|---|---|---|
| Describes the benefits associated with antibiotic streamlining | | |
| Recognizes the most common signs associated with an infection | | |
| Identifies the three stages of infection | | |
| Identifies and interprets the primary components of the C&S report | | |
| Recognizes organisms that generally do not undergo additional susceptibility testing after identification | | |
| Explains the difference between colonization and infection | | |
| Defines normal flora and lists examples of organisms that make up the normal flora at specific body sites | | |
| Identifies antibiotics that can be used to treat bacterial pathogens commonly found in the healthcare setting | | |
| Recognizes patient-specific factors that can influence antimicrobial medication selection and considers these factors when making recommendations for antibiotic streamlining | | |
| Defines combination antibiotic therapy and describes its role in the treatment of infections | | |
| Monitors patients receiving antibiotic therapy for duplicate therapy; avoidance of drug–drug, drug–food, and drug–disease interactions; adverse drug reactions; and other medication-related problems | | |
| Recommends appropriate antibiotic streamlining regimens for patients receiving inappropriate or broad-spectrum antibiotics | | |
| Makes recommendations to manage adverse effects, and other medication-related problems to ensure positive therapeutic outcomes in patients receiving antibiotic therapy | | |
| NOTES | | |

_____ _____

Competence certified by Date

# Competency Assessment Exam

**Name:** _____ **Date:** _____

## *Use the following case report to select the best answers to questions 1 through 6.*

R. K. is a 64-year-old female who is admitted to the intensive care unit (ICU) from a nearby nursing home with a 5-day history of persistent fevers, chills, and difficulty breathing. Records from the facility state that she has had frequent bouts of coughing, which produce greenish-yellow sputum. She has received antibiotics for a presumed upper respiratory tract infection twice during the last 6 months. Her past medical history includes congestive obstructive pulmonary disease (COPD), diabetes, hypertension, and hypothyroidism. She was hospitalized last year for a severe COPD exacerbation, for which she remained intubated for 10 days. Her social history reveals that she was a smoker. She has an allergy to soy products and sulfa-containing medication.

Her temperature on arrival was 102.7°F, blood pressure was 89/52 mm Hg, heart rate was 124 beats/minute, and her respiratory rate was 28 breaths/minute. Her oxygen saturation is approximately 86% on 50% $FiO_2$ (facemask). A chest x-ray is obtained, and the results show bilateral infiltrates. The patient's WBC count was 19,800 cells/$mm^3$ (normal 4,000 to 11,000 cells/$mm^3$), and a left shift was noted. Her SCr was 1.2 mg/dL. All other labs were normal. Blood and sputum cultures were obtained, and the results are pending.

She is given a 1 liter IV bolus of 0.9% sodium chloride in the ED and started on vancomycin IV (1,250 mg IV once, then pharmacy to dose), piperacillin/tazobactam 3.375 g IV every 6 hours, and azithromycin 500 mg IV daily.

__ 1. Which of the following would be considered a *sign* of infection?
   a. Fatigue
   b. Frequent chills
   c. Difficulty breathing
   d. WBC count of 19,800 cells/$mm^3$

__ 2. Which stage of infection is the patient in?
   a. Stage I
   b. Stage II
   c. Stage III
   d. Stage IV

The next day the results of the blood and sputum cultures return. The blood culture report states that there was no growth in either sample. The sputum results show the following:

| **Source:** Sputum | **Ward:** ED | |
|---|---|---|
| **Preliminary Gram stain:** Moderate WBCs, few epithelial cells, many gram-positive cocci, few yeast | | |
| **Final report:** *Streptococcus pneumoniae* (selected susceptibility results) | | |
| **Drug Name** | **MIC (mcg/mL)** | **Interpretation** |
| Amoxicillin | ≤2 | S |
| Azithromycin | 1 | 1 |
| Cefotaxime | ≤1 | S |
| Ceftriaxone | ≤1 | S |
| Penicillin | ≥ 2 | R |

I = intermediate; R = resistant; S = susceptible.

__ 3. What do the numbers listed on this report reflect?
   a. Minimum invasive concentration
   b. Maximum inhibitory concentration
   c. Marginal inhibitory concentration
   d. Minimum inhibitory concentration

__ 4. Which of the following statements is true?
   a. *Streptococcus pneumoniae* is the likely organism causing the patient's infection.
   b. Azithromycin is the best choice of antibiotic to treat the patient's infection.
   c. Aztreonam has activity against this isolate of *Streptococcus pneumoniae*.
   d. Penicillin has activity against this isolate of *Streptococcus pneumoniae*.

__ 5. How can you streamline the patient's regimen based on this C&S report?
   a. Add tobramycin
   b. Stop all antibiotics
   c. Discontinue azithromycin but continue vancomycin and piperacillin/tazobactam
   d. Discontinue all antibiotics and start ceftriaxone

__ 6. Why did the lab refrain from conducting susceptibility testing on the yeast species that was reported on the Gram stain?
   a. It reflects colonization and not infection.
   b. It was an oversight by the laboratory.
   c. Yeast speciation cannot be conducted on sputum cultures.
   d. Yeast speciation cannot be conducted when a bacteria is present.

## *Use the following case report to select the best answers to questions 7 through 12.*

E. G. is a 35-year-old male admitted from home who presented with a 3-day history of worsening abdominal pain accompanied by nausea, diarrhea, and high fevers. His symptoms were sudden in onset and he noted that they began approximately 6 hours after eating at a local restaurant. On exam, the patient reveals abdominal distention and left lower quadrant abdominal tenderness. His past medical history includes gastroesophageal reflux disease (GERD), inflammatory bowel syndrome, diabetes (type I), and depression. Bowel sounds are present, and his stool is guaiac-negative. His temperature is 101.3°F, heart rate (HR) is 124 beats/minute, and blood pressure is 96/63 mm Hg. A CBC with differential shows a WBC count of 23,000 cells/$mm^3$ with 54% segmented neutrophils (normal 36% to 66%) and 17% bands (normal 0% to 8%). The physician starts E. G. on piperacillin/tazobactam, ciprofloxacin, and metronidazole after blood and stool cultures are obtained. The patient has no medication allergies. Later that day, the lab calls and states that there are gram-negative rods growing from his blood cultures and his *C. difficile* toxin assay is negative.

__ 7. What signs and symptoms are present to suggest that there is an infection present?
   a. Normal HR, elevated WBC count, normal temperature, type 2 diabetes mellitus
   b. Elevated HR, no left shift, elevated temperature, guaiac-negative stool
   c. Elevated HR, elevated WBC count, preliminary blood cultures are positive, diarrhea, and worsening abdominal pain
   d. Normal WBC count, a left shift, hypertension, abdominal pain

__ 8. Which of the following organisms is most likely to be a cause of the patient's gastroenteritis?
   a. Mycobacterium tuberculosis
   b. Methicillin-resistant *Staphylococcus epidermidis*
   c. *Acinetobacter baumannii*
   d. *Escherichia coli*

__ 9. Piperacillin/tazobactam and metronidazole both have activity against what type of organisms?
   a. Gram negative
   b. Anaerobic
   c. Aerobic
   d. Gram positive

__ 10. The next day the lab reports that there are gram-negative rods and *Enterococcus* spp. growing from the stool culture. Which of the following is true regarding the presence of the *Enterococcus*?
   a. It is likely the infecting organism causing the patient's illness.
   b. It represents normal flora.
   c. It represents a secondary infection.
   d. None of the above

__ 11. The patient's final blood culture results are reported and the gram-negative rod (identified in question 8) is reported to be susceptible to all antibiotics. What do you recommend?
   a. Continue current triple antibiotic therapy
   b. Replace clindamycin with metronidazole for better anaerobic coverage
   c. Discontinue metronidazole, ciprofloxacin, and piperacillin/tazobactam and streamline to the most narrow spectrum antibiotic that has activity specifically against the infecting organism
   d. Discontinue all three antibiotics and initiate daptomycin to provide the needed broad spectrum coverage

__ 12. What is the benefit of streamlining patient's antibiotic regimen?
   a. Increases morbidity and mortality
   b. Decreases morbidity and mortality
   c. Increases the likelihood that a secondary infection may develop
   d. Increases healthcare expenditures

## *Use the following case report to select the best answers to questions 13 through 17.*

R. C. is an 81-year-old man who presents to the ED with a large infected ulcer on his lower right heel. He does not recall how long the ulcer has been present but reports that it has become progressively painful over the last 2 days, and he now rates the pain as 9 out of 10 and is not able to walk without assistance. He reports yellow-green discharge from the wound. His past medical history includes uncontrolled type 2 diabetes mellitus, chronic renal insufficiency, and schizophrenia. He is currently taking lisinopril, metformin, olanzapine, and regular insulin with meals. He drinks approximately two beers per day and smokes occasionally. He has no known medication allergies.

His temperature on arrival was 100.9°F, blood pressure was 117/65 mm Hg, heart rate was 99 beats/minute, and his respiratory rate was 16 breaths/minute. Other pertinent labs include a WBC count of 18,800 cells/$mm^3$ and a serum creatinine of 2.8 mg/dL. The patient weighs 92 kg and is approximately 5 ft 8 in tall. He is started on ampicillin/sulbactam 3 g IV every 6 hours and gentamicin 80 mg IV every 8 hours. On physical examination, it is determined that the wound is invasive enough that R. C. will have to be admitted and undergo surgical debridement the following day. During surgery, a deep tissue specimen is obtained and sent to the lab for C&S testing.

__ 13. Which of the following statements is true regarding the general spectrum of activity of ampicillin/sulbactam?
   a. It is a broad spectrum antibiotic that has coverage against multiple bacteria but not anaerobes.
   b. It is a narrow spectrum agent and only has activity against gram-negative organisms.
   c. It has activity against gram-positive and gram-negative bacteria and anaerobes.
   d. It has synergistic activity against *P. aeruginosa* when combined with gentamicin.

__ 14. Which of the following is true regarding this patient's antibiotics based on the patient-specific factors presented in this case?
   a. The dose should be reduced because of the patient's age and schizophrenia.
   b. The dose should be reduced because the patient has diabetes.
   c. The dose should be reduced due to renal insufficiency and advanced age.
   d. Ampicillin/sulbactam should be discontinued due to medication allergies.

Following debridement, the cultures return and show the following:

| **Source:** Wound | **Ward:** 6W | |
|---|---|---|
| **Preliminary Gram stain:** Moderate WBCs, few epithelial cells, many gram-positive cocci | | |
| **Final report:** *Staphylococcus aureus*<br>*Staphylococcus epidermidis*<br>(selected susceptibility results) | | |
| **Drug Name** | ***S. aureus*** | ***S. epidermidis*** |
| Ampicillin/sulbactam | R | R |
| Azithromycin | R | R |
| Ceftriaxone | R | R |
| Levofloxacin | I | R |
| Oxacillin | S | S |
| Rifampin | S | S |
| Trimethoprim/sulfamethoxazole | S | S |
| Vancomycin | S | S |
| Daptomycin | S | S |

I = intermediate; R = resistant; S = susceptible.

__ 15. What would be a reasonable alternative to therapy based on the patient's culture results?

a. Discontinue both antibiotics and initiate daptomycin
b. Discontinue both antibiotics and initiate rifampin
c. Discontinue all antibiotics as this result reflects normal flora
d. Discontinue both antibiotics and initiate oxacillin

__ 16. B. B. is a 70-year-old female who presents to the ED with a chief complaint of dyspnea. She has a complex past medical history that includes type 2 diabetes mellitus, atrial fibrillation, congestive heart failure, chronic obstructive pulmonary disease, and a stroke 2 years ago. Her vital signs are noted to be stable with the exception of a heart rate of 118 beats/minute. She is admitted to the hospital and is placed on several medications including cefepime 2 g IV every 12 hours and azithromycin. Two days later, it is determined that her dyspnea was the result of a CHF exacerbation. Blood and sputum cultures that were obtained showed no growth, and the attending physician states in the progress notes that an infection has been ruled out. How can B. B.'s regimen be streamlined?

a. Discontinue antibiotics
b. Reduce the dose of cefepime to 1 g every 12 hours
c. Change the cefepime to ceftriaxone 1 g daily
d. Antibiotics should be continued until the patient is discharged from the hospital.

__ 17. R. N. is a 63-year-old female who has positive cultures for an ESBL-producing strain of *K. pneumoniae* from multiple sites. What would be the preferred treatment for her infection assuming she has no medication allergies and a creatinine clearance of 72 mL/min?

a. Cefoxitin
b. Meropenem
c. Ticarcillin/clavulanate
d. Cefepime

_____ _____

Competence certified by Date

# Answer Key

1. d. WBC counts may begin to trend upward past the normal range (usually 4,000 to 12,000 cells/$mm^3$) during infection. This is known as *leukocytosis*. Some medications, such as steroids, can also cause leucocytosis, so this should be ruled out.

2. a. Stage I is referred to an *early infection* and typically occurs during the first few days of the illness. The patient may be clinically unstable and have leukocytosis or neutropenia. Vital signs may be abnormal and diagnostic exams suggest an infection is present. Usually, there is uncertainty regarding the specific organism that is causing the infection, so cultures are obtained and a preliminary result may or may not be available. The latter can be influenced by previous or current antibiotics that may have been administered.

3. d. Minimum inhibitory concentration (MIC) represents the lowest concentration of antibiotics that prevents visible growth and are based on national laboratory guidelines. The susceptibility definition varies based on the organism and the antibiotic being tested. On a culture and sensitivity (C&S) report, there is a finite amount of antibiotics reported, because there is finite amount of space for susceptibility testing on the cards used by automated systems. Depending on how the system reports susceptibilities, there may or may not be an exact MIC. Rather, it may just be reported as less than or equal to the susceptibility breakpoint. MICs vary based on the organism–drug combination.

4. a. *Streptococcus pneumoniae* is the organism listed on the final report. Different cultures can take different amounts of time to finalize. Blood cultures are not final until 5 days after drawn but may show preliminary growth in 1 to 2 days, depending on the organism(s) present. Urine cultures are often finalized between 2 to 3 days. Until finalized, many systems will classify the report as *pending* or *preliminary*. Some organisms, such as certain types of fungi or mycobacterium, may take weeks or months to grow.

5. d. Antibiotic therapy is often initiated empirically before the infecting organism(s) and/or site of infection have been identified. Empiric antibiotic use is an appropriate way to target the suspected pathogen based on clinical signs and symptoms. Choices of empiric therapy can be guided based on the susceptibility and resistance patterns from the hospital's antibiogram. However, because the therapy is empiric, the results of the C&S report can provide the opportunity to change therapy to a drug that has a more narrow or targeted spectrum of activity. Based on the susceptibility results, ceftriaxone is the preferred agent. If no other infection is suspected or present, all other antimicrobials can be discontinued.

6. a. A positive culture from a nonsterile site may or may not be indicative of an infection and needs to be reviewed in the context of the patient's clinical presentation. Pulmonary secretions and sputum cultures represent the biggest challenges in treating a patient for infection. Sputum is not considered to be a sterile body fluid. Cultures that are obtained from the patient coughing up sputum or tracheal secretions from the upper part of an endotracheal tube (ET) may be contaminated with oral flora and are typically not optimal for use in diagnosing infection. These cultures may falsely grow bacteria and fungus that are not the true infecting pathogens. Sputum samples obtained from a bronchoscopy (deep into the lungs) are more accurate in terms of diagnosis.

7. c. Together, elevated HR, elevated WBC count, positive preliminary blood cultures, diarrhea, and worsening abdominal pain are signs and symptoms that suggest there may be an infection present.

8. d. *Shigella*, *Salmonella*, *Camphylobacter*, and *E. coli*, are common infecting organisms responsible for gastroenteritis.

9. b. Metronidazole, amoxicillin/clavulanate, ampicillin/sulbactam, cefoxitin, clindamycin, piperacillin/tazobactam, ertapenem, imipenem/cilastatin, and meropenem possess anaerobic activity. If available, confirm sensitivity with microbiology antibiogram report.

10. b. Bacterial species that occur as normal flora of human gastrointestinal tracts include the following:
    - *Bacteroides* spp.
    - *Clostridium* spp. (some species)
    - Diphtheroids
    - Enterobacteriaceae (e.g., *E. coli*, *Klebsiella* spp.)
    - *Enterococcus*
    - *Candida* spp. (usually *C. albicans*)

11. c. Antibiotic streamlining or *de-escalation* refers to the process of converting patients from broad spectrum antibiotics (i.e., metronidazole, ciprofloxacin, and piperacillin/tazobactam), which cover several different types of disease-causing bacteria to a narrow spectrum antibiotic that targets a specific infecting organism.

12. b. Benefits associated with antibiotic streamlining include the following:
    - Reducing secondary infections such candidiasis, CDAD, or VRE
    - Decreasing morbidity and mortality; appropriate therapy early in the infection can improve patient outcome
    - Supporting the institution's infection control processes
    - Minimizing antimicrobial resistance
    - Minimizing toxicity and adverse effects
    - Reducing healthcare expenditures

13. c. Ampicillin/sulbactam has activity against gram-positive and gram-negative bacteria and anaerobes.

14. c. Factors that should be taken into consideration before altering antimicrobial therapy include (but are not limited to) patient age, medication allergies, hepatic function, renal function, pregnancy status, potential drug interactions, and drug site of action.

15. d. Although ampicillin/sulbactam covers both organisms, it is a broad spectrum antibiotic and should be streamlined if a narrow spectrum agent is available. According to the susceptibility analysis, both organisms are susceptible to oxacillin. Gentamicin is not indicated and should be discontinued.

16. a. Once diagnostic test results have been received and it has been determined that the patient's symptoms are not likely due to infection, all antibiotics should be discontinued.

17. b. ESBL (extended-spectrum beta-lactamase) production confers resistance to all cephalosporins, including cefepime, extended-spectrum penicillins, and aztreonam. In some cases, fluoroquinolones may have in vitro activity. However, clinical failure can also occur with these agents. The primary treatment of choice for an infection caused by an ESBL-producing organism is typically a carbapenem.