CHAPTER 8

TREATMENT ALGORITHMS FOR INFECTIOUS DISEASES

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Abstract

Infectious disease management is predicated on algorithms that integrate pathogen identification with host-specific factors. The algorithm for bacterial infections is stratified by the site of infection; community-acquired pneumonia (CAP) management is guided by CURB-65/PSI scores, dictating outpatient (e.g., macrolide, doxycycline) versus inpatient (e.g., ceftriaxone plus macrolide) therapy. Uncomplicated UTIs are treated with short-course antibiotics (e.g., nitrofurantoin), while skin infections are bifurcated into non-purulent (cellulitis) and purulent (abscess) algorithms. Viral infection algorithms are often time-sensitive. Influenza treatment with neuraminidase inhibitors is most effective within 48 hours of onset. Human Immunodeficiency Virus (HIV) follows a "treat-all" algorithm, initiating antiretroviral therapy (ART) with a 2- or 3-drug regimen immediately upon diagnosis. Fungal infection algorithms differentiate between prophylaxis, empiric, and definitive therapy, with echinocandins being first-line for suspected invasive candidiasis in critically ill patients. Parasitic disease algorithms, such as for malaria, are strictly species- and region-dependent, utilizing artemisinin-based combination therapies (ACTs) for uncomplicated *P. falciparum*. Antimicrobial stewardship principles, including de-escalation based on culture data, are integral to all algorithms.

Keywords: *Infectious Disease Algorithms, Antimicrobial Stewardship, Community-Acquired Pneumonia, HIV/ART, Sepsis, Empiric Therapy*

Learning Objectives

After completion of the chapter, the learners should be able to:

- Identify first-line antibiotic choices for common bacterial infections like acute otitis media and uncomplicated cystitis.
- Explain the algorithm for empiric antibiotic selection and the importance of de-escalation based on culture and sensitivity results.
- Formulate a treatment algorithm for a patient with influenza, including antiviral indications and supportive care.
- Differentiate the treatment algorithms for superficial fungal infections (e.g., tinea pedis) versus invasive systemic fungal infections (e.g., candidemia).
- Justify the choice of a specific antimalarial prophylactic regimen based on travel destination and drug resistance.

COMMON BACTERIAL INFECTIONS

Bacterial infections are managed via algorithms that balance the need for rapid, empiric therapy against the risk of antimicrobial resistance. The algorithm is typically stratified by the site of infection and host risk factors.

Community-Acquired Pneumonia (CAP)

CAP is an acute infection of the pulmonary parenchyma acquired outside of a hospital setting.

Pathophysiology

The pathophysiology of Community-Acquired Pneumonia (CAP) begins with the failure of host respiratory defenses (e.g., mucociliary escalator, cough reflex, alveolar macrophages) to clear an invading pathogen, most commonly *Streptococcus pneumoniae*. Following microaspiration or inhalation, the bacteria proliferate in the alveoli. This triggers a potent host inflammatory response, leading to the recruitment of neutrophils and the release of pro-inflammatory cytokines. The alveoli fill with an inflammatory exudate, red blood cells, and fibrin, a process known as consolidation. This consolidation of lung parenchyma, visible on chest X-ray, creates a physiologic shunt (perfusion without ventilation), which impairs gas exchange and leads to hypoxemia. Systemic symptoms (fever,

chills, malaise) are driven by the systemic cytokine release.

Diagnosis

The diagnostic algorithm requires the presence of a new pulmonary infiltrate on chest radiograph combined with clinical signs of infection (e.g., fever, cough, purulent sputum, leukocytosis). Microbiological workup (sputum, blood cultures) is generally reserved for patients with severe disease.

Differential Diagnosis

The differential includes acute bronchitis (no infiltrate), heart failure (which can present with congestion and dyspnea), pulmonary embolism (can be pleuritic), and non-infectious pneumonitis.

Treatment Algorithm

The primary algorithm branch point is **site-of-care determination**, guided by a clinical risk score like **CURB-65** (Confusion, Urea > 7, Respiratory rate ≥ 30, Blood pressure < 90/60, age ≥ 65) or the Pneumonia Severity Index (PSI).

- **Algorithm 1: Outpatient (CURB-65 score 0-1)**
    - **No Comorbidities/Risk Factors:** Monotherapy with amoxicillin, doxycycline, or a macrolide (if local resistance is low).
    - **With Comorbidities (e.g., Heart/Lung/Liver/Renal disease, Diabetes, Asplenia):** Combination therapy with amoxicillin/clavulanate OR a cephalosporin *plus* a macrolide OR doxycycline; OR monotherapy with a respiratory fluoroquinolone (e.g., levofloxacin).
- **Algorithm 2: Inpatient - Non-Severe (CURB-65 score 2)**
    - **Standard:** IV beta-lactam (e.g., ceftriaxone) *plus* a macrolide (e.g., azithromycin).
    - **Alternative:** Respiratory fluoroquinolone monotherapy.
- **Algorithm 3: Inpatient - Severe (CURB-65 score 3-5; ICU admission)**

- **Standard:** IV beta-lactam *plus* a macrolide.
- **Risk for *Pseudomonas*:** Antipseudomonal beta-lactam (e.g., piperacillin-tazobactam) *plus* an anti-pseudomonal fluoroquinolone.
- **Risk for MRSA:** Add vancomycin or linezolid. The algorithm dictates de-escalation once sensitivities are known and a total duration of 5-7 days for most cases.

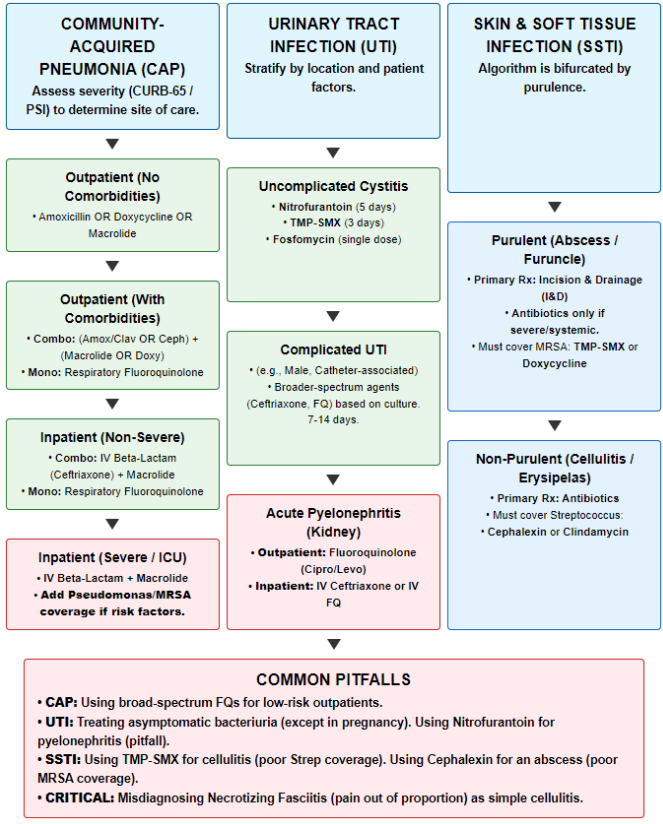

Figure 8.1: Common Bacterial Infections

Table 8.1: First-Line Outpatient Algorithms for Common Bacterial Infections

Infection	Likely Pathogen(s)	First-Line Algorithm (Healthy Adult)
Community-Acquired Pneumonia (CAP)	*S. pneumoniae, H. flu*	**Amoxicillin** OR **Doxycycline** OR Macrolide (if local resistance < 25%).
Uncomplicated UTI (Cystitis)	*E. coli*	**Nitrofurantoin** OR **TMP-SMX** OR Fosfomycin.
Cellulitis (Non-purulent)	*Strep. pyogenes*	**Penicillin VK** OR **Cephalexin** OR Clindamycin (if PCN-allergic).
SSTI (Purulent / Abscess)	*S. aureus* (MRSA risk)	**I&D** (Incision & Drainage) + (TMP-SMX OR Doxycycline).

Monitoring and Follow-Up

Clinical monitoring is paramount. The main parameters include vital signs (respiratory rate, oxygen saturation, heart rate, temperature), work of breathing, and mental status. Inpatients require daily assessment, while outpatients should have a follow-up (e.g., phone or clinic) in 48-72 hours. Failure to improve by 72 hours suggests treatment failure, which could be due to a resistant pathogen, a non-bacterial cause, or a complication (e.g., empyema, lung abscess).

Procalcitonin (PCT) is a useful laboratory biomarker; a low PCT is highly suggestive *against* a typical bacterial pneumonia, and serial PCT levels can be used to guide the safe discontinuation of antibiotics. A follow-up chest X-ray is *not* necessary for most patients who are clinically improving, as radiographic findings can lag behind clinical recovery by 4-6 weeks.

Long-Term Management / Secondary Prevention

The most effective secondary prevention strategies are vaccination and risk factor modification. Patients should be counseled on and receive both the **annual influenza vaccine** (as influenza is a major predisposing factor for bacterial pneumonia) and the **pneumococcal vaccine** (e.g., PCV20 or PCV15/PPSV23, based on age and comorbidities). **Smoking cessation** is critical, as smoking paralyzes the mucociliary escalator and is the strongest modifiable risk factor for CAP.

Patient Counseling Points

1. **Adherence:** "You must take the *entire* course of your antibiotics, even if you start to feel better after a few days. Stopping early can allow the infection to return or lead to antibiotic resistance."
2. **Expected Course:** "It is normal to cough for several weeks, even after the infection is gone. Your energy will also take time to return. The X-ray will take 4-6 weeks to clear."
3. **Warning Signs:** "You should start to feel slowly better in 48-72 hours. If you suddenly feel worse, or if you have new shortness of breath, chest pain, or high fever, you must seek care immediately."
4. **Prevention:** "The two best ways to prevent this from happening again are to get your flu shot every year, your pneumonia shot, and, if you smoke, to quit."

Common Pitfalls

A critical pitfall is miscalculating severity and under-treating a high-risk patient in the outpatient setting. Another is the overuse of broad-spectrum agents (fluoroquinolones, MRSA/Pseudomonas coverage) in low-risk patients, which drives resistance. Finally, failing to switch from IV to PO (oral) therapy when a patient is clinically stable is a common error.

Urinary Tract Infections (UTI)

UTIs are stratified into uncomplicated (cystitis), complicated (e.g., male, pregnant, catheter-associated), and pyelonephritis

(kidney infection).

Pathophysiology

The pathophysiology of UTIs is typically an ascending infection. The process begins with colonization of the periurethral area by uropathogens (most commonly uropathogenic *E. coli*, or UPEC) from the gut. These bacteria possess "virulence factors," such as P-fimbriae (pili), which allow them to adhere to and ascend the urothelium of the urethra into the bladder, causing **cystitis**. The host responds with an inflammatory cascade, causing the typical symptoms of dysuria, frequency, and urgency. If the bacteria continue to ascend the ureters to the kidneys, **pyelonephritis** develops. This is a severe, invasive infection of the renal parenchyma, causing inflammation, tissue damage, and a systemic response (fever, chills, CVA tenderness).

Diagnosis

Diagnosis is based on symptoms (dysuria, frequency, urgency) and confirmed by urinalysis (pyuria, bacteriuria) and urine culture.

Differential Diagnosis

Differentials include vaginitis (yeast, BV), urethritis (e.g., STI like *Chlamydia* or *Gonorrhea*), and non-infectious interstitial cystitis.

Treatment Algorithm

- **Algorithm 1: Uncomplicated Cystitis (Non-pregnant female)**
    - **First-Line:** Nitrofurantoin 100 mg BID for 5 days OR Trimethoprim-sulfamethoxazole (TMP-SMX) DS BID for 3 days (if local resistance < 20%).
    - **Second-Line:** Fosfomycin 3g single dose. Fluoroquinolones are to be avoided.
- **Algorithm 2: Complicated UTI (e.g., Male, Obstruction, Catheter)**
    - Requires broader-spectrum agents based on

urine culture (e.g., ceftriaxone, fluoroquinolone) and a longer duration (7-14 days).

- **Algorithm 3: Acute Pyelonephritis**
    - **Outpatient (Mild, able to tolerate PO):** Ciprofloxacin or levofloxacin for 5-7 days.
    - **Inpatient (Severe, septic, unable to tolerate PO):** IV ceftriaxone or an IV fluoroquinolone. Therapy is tailored to culture results.

Monitoring and Follow-Up

For uncomplicated cystitis, monitoring is clinical. Symptoms should resolve within 24-48 hours of starting antibiotics. For pyelonephritis, monitoring involves tracking symptom resolution (fever, CVA tenderness) and laboratory markers (WBC, serum creatinine). Inpatients should improve within 48-72 hours; failure to do so warrants a renal CT scan to look for complications like a perinephric abscess or an obstructing kidney stone. A "test of cure" (follow-up urine culture) is *not* needed for uncomplicated cystitis but is recommended for pyelonephritis and in all pregnant patients.

Long-Term Management / Secondary Prevention

For patients with recurrent cystitis, prevention is crucial. Non-pharmacological strategies include counseling on post-coital voiding and adequate hydration. Pharmacological options for recurrent, well-documented infections include patient-initiated self-treatment, post-coital antibiotic prophylaxis, or, in severe cases, continuous low-dose antibiotic prophylaxis. Topical vaginal estrogen is a highly effective preventive measure for post-menopausal women with recurrent UTIs.

Patient Counseling Points

1. **Adherence:** "Finish the full antibiotic course. Even for a simple bladder infection, stopping early can lead to a more serious kidney infection (pyelonephritis)."
2. **Hydration:** "Drink plenty of water to help flush the bacteria from your system."
3. **Hygiene (for women):** "Always wipe from front to

back after using the toilet to prevent moving bacteria from the rectal area to the urethra."

4. **Pyelonephritis Warning Signs:** "A bladder infection (cystitis) is in your bladder. If you *ever* develop a fever, chills, or severe pain in your back or side, that means the infection may have moved to your kidneys, and you need to be seen by a doctor right away."

Common Pitfalls

The most common pitfall is treating "asymptomatic bacteriuria" (a positive urine culture with no symptoms) with antibiotics, which is a major driver of resistance and provides no benefit (exception: pregnancy). Another is using a 3-day course of TMP-SMX in an area with high resistance. Finally, using nitrofurantoin for pyelonephritis is a critical error, as it does not achieve adequate renal tissue concentrations.

Skin and Soft Tissue Infections (SSTI)

The SSTI algorithm is fundamentally bifurcated into purulent (abscess, furuncle) and non-purulent (cellulitis, erysipelas).

Treatment Algorithm

- **Algorithm 1: Purulent SSTI (High suspicion for *S. aureus* / MRSA)**
    - **Step 1:** The primary treatment is **incision and drainage (I&D)**.
    - **Step 2 (Antibiotics):** Antibiotics are *only* indicated if the abscess is severe, associated with systemic signs (fever), or the patient is immunocompromised.
    - **Step 3 (Drug Choice):** Empiric coverage for MRSA is required (e.g., TMP-SMX, doxycycline).
- **Algorithm 2: Non-Purulent SSTI (Cellulitis - High suspicion for *Streptococcus*)**
    - **Step 1:** The primary treatment is **antibiotics**.
    - **Step 2 (Drug Choice):** Therapy must target *Streptococcus* (e.g., cephalexin, clindamycin).

- **Step 3 (Severe):** IV therapy (e.g., cefazolin) is used for severe, rapidly progressing, or systemically ill patients.

Common Pitfalls

The most common pitfall is treating cellulitis with TMP-SMX, which has poor streptococcal coverage. The inverse error is treating a purulent abscess with cephalexin, which has poor MRSA coverage. A critical, "cannot-miss" pitfall is misdiagnosing necrotizing fasciitis as simple cellulitis; clinical signs (pain out of proportion, crepitus, hemorrhagic bullae) demand immediate surgical exploration.

Case Study

A 30-year-old male presents to urgent care with a 3-day history of a "spider bite" on his forearm. On exam, you see a 4 cm, tender, red, fluctuant (tense, fluid-filled) nodule with a small purulent center. He has a 100.5°F fever.

Discussion

This is a classic **Purulent Skin & Soft Tissue Infection (SSTI)**, or abscess. The algorithm for SSTIs is critically bifurcated: purulent vs. non-purulent.

- **Non-purulent (Cellulitis):** Assumed *Strep* species. Treat with antibiotics (e.g., Cephalexin).
- **Purulent (Abscess):** Assumed *Staph. aureus* (with high risk of MRSA). Primary treatment is drainage.

Treatment Algorithm:

1. **Diagnosis:** Purulent SSTI (Abscess) with systemic signs (fever).
2. **Algorithm Step 1 (Primary):** The algorithm mandates **Incision and Drainage (I&D)** as the definitive treatment.
3. **Algorithm Step 2 (Antibiotics):** Because the patient has systemic signs (fever) and a surrounding ring of cellulitis, antibiotics are indicated (I&D alone is often sufficient for small, simple abscesses).
4. **Therapy:** The antibiotic algorithm must cover community-acquired **MRSA**.