Antibiotics are antibacterial substances produced by various species of microorganisms (bacteria, fungi, and actinomycetes) that suppress the growth of other microorganisms. Common usage of the term “antibiotics” often extends to include synthetic antimicrobial agents, such as sulfonamides and quinolones (Chambers, 2006). Antibiotics are classified based on chemical structure and proposed mechanism of action (Chambers, 2006).

Although treatment with antimicrobial agents has minimized the morbidity and mortality associated with urinary tract infections (UTIs) (Tanagho & McAninch, 2004), antimicrobials are among the most commonly used and misused of all drugs (Chambers, 2006). The consequence of the overuse of antibiotics has been the emergence of antibiotic-resistant pathogens. Reducing inappropriate antibiotic use is thought to be the best way to control resistance (Chambers, 2006).

The goal of therapy when using antibiotics is to eradicate the infection by selecting the appropriate antibiotics that would target specific bacterial susceptibility (Tanagho & McAninch, 2004). Choosing the appropriate antibiotic is not straightforward. Many antibiotics are available, and the lowest effective dose and length of therapy are not well defined. When choosing the antibiotic, the following items should be considered:

- Infecting pathogen (antibiotic susceptibility, single-organism vs. multiple-organism, pathogen vs. normal flora, community vs. hospital-acquired).
- Patient status (age, underlying disease, previous antibiotic therapy, current medications, outpatient vs. inpatient, pregnancy).
- Site of infection (kidney, bladder, prostate) (Tanagho & McAninch, 2004).

As with all antibiotic use, in vitro susceptibility tests via a urine culture should be performed prior to treatment.

Nitrofurantoin

Nitrofurantoin is a synthetic antibacterial agent used in the treatment of UTIs. Nitrofurantoin (Macrobid®) is administered orally with food to enhance tolerability and absorption. The usual dosage for treatment of uncomplicated UTIs is 50 mg four times daily or 100 mg formulation as dual-release capsules twice daily for seven days. For long-term suppression usage, the dosage should be decreased to 50 mg to 100 mg as a single evening dose (AHFS Drug Information, 2008).

The most frequent side effects of nitrofurantoin are nausea, flatulence, headache, and turning the urine dark yellow or brown in color. These side effects can be reduced or eliminated by reducing the dosage or administering with food. Less frequent side effects include vomiting, diarrhea, dizziness, vertigo, transient alopecia, rashes, and asthma attacks in patients with known history of asthma (AHFS Drug Information, 2008).

There have been reports of patients experiencing peripheral polyneuropathy who have taken nitrofurantoin, which may become severe and irreversible and potentially fatal. Initial symptoms of peripheral polyneuropathy include numbness and tingling of the lower extremities, which may progress to muscle weakness. Severe neuropathy is characterized by edema. The rate of recovery and severity of symptoms are not related to dosage or total amount of drug administered. Neuropathy occurs most frequently in patients with impaired renal function (AHFS Drug Information, 2008).

Acute, subacute, or chronic pulmonary hypersensitivity reactions occur occasionally with the use of nitrofurantoin. Acute reactions include sudden severe shortness of breath (dyspnea), chills, chest pain, fever, and cough, and usually develop within eight hours of initiation of therapy in patients previously sensitized or within three weeks of those who develop sensitivity during therapy. Subacute reac-

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Editor’s Note: Please see Dr. Rahn’s article (pp. 333-342) for an in-depth discussion of prevalence and pathophysiology of urinary tract infections. Presented here are the common antibiotics used to treat UTIs as discussed in Rahn’s article, including nitrofurantoin, trimethoprim/sulfamethoxazole, ciprofloxacin hydrochloride, and levofloxacin.
Cipro® is a fluoroquinolone that has broad-spectrum antibacterial action. It prevents bacterial DNA replication, repair, transcription, and recombination. The oral dosage of ciprofloxacin hydrochloride for an uncomplicated UTI is regular-strength 250 mg twice daily or 500 mg daily of extended release with meals for three days. For a complicated UTI, extend the dosage for 7 to 14 days (AHFS Drug Information, 2008).

The most common side effects are nausea, diarrhea, and vomiting. This tends to be mild and transient. Some patients may experience abnormal liver function test results and a rash. The initial studies on ciprofloxacin hydrochloride did not find an increase in C-diﬀiﬃce; however, market studies since its release have shown an increase (AHFS Drug Information, 2008).

A common side effect is arthralgia (pain in the joints). Market studies have shown a severe side effect to be ruptures of tendons after use of quinolones. The FDA has required new warning labels about the ruptures. Patients receiving corticosteroids and geriatric patients are at a greater risk for tendon ruptures (AHFS Drug Information, 2008).

Quinolones have been shown to increase central nervous system (CNS) stimulation and should be used with caution in patients with a history of CNS disorders. If given to a patient with a history of seizures, the patient should be warned to report any increase in seizure activity immediately (AHFS Drug Information, 2008).

Use with caution in patients who are taking anticoagulation therapy in the form of warfarin. The use of quinolones with warfarin may increase prothrombin time and put the patient at risk for bleeding (AHFS Drug Information, 2008).

**Trimethoprim/Sulfamethoxazole**

Sulfamethoxazole (Gantanol®) is an antibacterial sulfonamide that prevents the formation of dihydrofolate acid, a bacterial compound necessary for survival. Trimethoprim (Trimax®, Proloprim®, Prinisol®) is a synthetic antibiotic that interferes with the production of folic acid. Oral dosage is one double-strength pill or two regular-strength pills twice a day for 10 to 14 days (AHFS Drug Information, 2008).

The most common side effects of trimethoprim/sulfamethoxazole (Bactrim DS®, Septra®) are nausea, vomiting, loss of appetite, rash, and itching. Rare but fatal hypersensitivity reactions have occurred, including but not limited to Steven Johnson syndrome and toxic epidermal necrolysis. Both diseases can be fatal and usually are irreversible; initial symptoms include rash and bullae (fluid-filled vesicles) (AHFS Drug Information, 2008).

Use with caution in patients with renal impairment, the elderly, and patients with AIDS because they are at increased risk for severe side effects (AHFS Drug Information, 2008).

This drug causes sun sensitivity, and patients should be advised to use sunscreen and avoid tanning beds while on this medication. Patients should be taught to immediately report any rashes or flu-like symptoms to prevent severe side effects (AHFS Drug Information, 2008).

**Ciprofloxacin Hydrochloride**

Ciprofloxacin hydrochloride (Ciprofloxin XR®, Cipro®) is a fluoroquinolone that has broad-spectrum antibacterial action. It prevents bacterial DNA replication, repair, transcription, and recombination. The oral dosage of ciprofloxacin hydrochloride for an uncomplicated UTI is regular-strength 250 mg twice daily or 500 mg daily of extended release with meals for three days. For a complicated UTI, extend the dosage for 7 to 14 days (AHFS Drug Information, 2008).

The most common side effects are nausea, diarrhea, and vomiting. This tends to be mild and transient. Some patients may experience abnormal liver function test results and a rash. The initial studies on ciprofloxacin hydrochloride did not find an increase in C-diﬃﬃce; however, market studies since its release have shown an increase (AHFS Drug Information, 2008).

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Use with caution in patients who are taking anticoagulation therapy in the form of warfarin. The use of quinolones with warfarin may increase prothrombin time and put the patient at risk for bleeding (AHFS Drug Information, 2008).

**Levofloxacin**

Levofloxacin (Lequaquin®) is a fluoroquinolone anti-infective agent and works most effectively against gram-negative bacteria. The oral dosage for uncomplicated UTIs is 250 mg daily for three days. For a complicated UTI, the dose is extended for 10 days (AHFS Drug Information, 2008).

Side effects and precautions with levofloxacin are similar to ciprofloxacin hydrochloride and are listed above.

**Nursing Considerations**

Advise patients that antibacterials should only be used to treat bacterial infections. Prior to the initiation of antibiotics, a urine for culture should be obtained.

Stress the importance of finishing the full course of antibiotics as prescribed even if the patient is feeling better. Skipping doses or not completing the full course of antibiotic may decrease effectiveness and increase the likelihood that bacteria will develop resistance and be difficult to treat in the future.

Antibiotics should be taken at the same each day for single dose and 12 hours apart for twice-daily dosages. The patient should drink plenty of water when taking antibiotics to prevent high concentrations in urine.
Instruct the patient to notify his or her health care provider with any side effects of medications (see each medication).

If a patient misses a dose of medication, instruct him or her to take it immediately and continue with previous scheduled dose. Handouts for patient information can be obtained at local pharmacies or on patient educational Web sites (such as MD Consult). Please see SUNA’s Patient Fact Sheet Urinary Tract Infections for additional information.

### Cost

Table 1 presents cost estimates for antibiotics used to treat UTIs.

### Conclusions

Antibiotic use has become widespread throughout the United States, and microbial resistance is increasing. Many patients believe that antibiotics are the cure and request them even when clinical indications are not present. It is the duty of health care professionals to educate the public about the use and risks of antibiotics. The use of antibiotics is not without significant risks and side effects. The decision to treat must be made based on clinical indications, and the patient should always be given a urine culture prior to antibiotic administration. Antibiotics should and do have a place in the treatment of UTIs and should be used with careful consideration.

### References


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<tr>
<th>Drug</th>
<th>Cost</th>
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<td>Nitrofurantoin (generic)</td>
<td>50 mg $29.50/ 20 pills ($1.48/pill)</td>
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<td></td>
<td>100 mg $32.00/20 pills ($1.60/pill)</td>
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<td>Macrobid® (brand)</td>
<td>100 mg $50/ 20 pills ($2.50/pill)</td>
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<td>Trimethoprim/sulfamethoxazole DS (generic)</td>
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<td>Bactrim DS® (brand)</td>
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<td>Ciprofloxin hydrochloride (generic)</td>
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<td>500 mg $100.33/30 pills ($4.83/pill)</td>
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<td>Ciprofloxin XR® (Brand)</td>
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