

MODERN PRINCIPLES OF DIAGNOSIS AND MANAGEMENT OF URINARY TRACT INFECTIONS IN ADULTS

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Abstract: This article examines anatomical and functional abnormalities of the urinary tract that disrupt natural defense mechanisms and increase the risk of infections in both sexes. Particular attention is given to complications in patients with diabetes mellitus (pyelonephritis, papillary necrosis, septicemia, abscesses), as well as infections in kidney transplant recipients. Catheter-associated infections are highlighted as a leading cause of nosocomial bacteremia, and modern approaches to their prevention are described. The role of low-dose antibacterial prophylaxis is discussed in detail, including its application in pregnant women and patients with recurrent infections.

Keywords: urinary tract infections; urinary tract abnormalities; catheter-associated infections; pyelonephritis; papillary necrosis; kidney transplantation; diabetes; antibacterial prophylaxis.

Urinary tract infections (UTIs) represent one of the most common bacterial pathologies in both outpatient and inpatient clinical practice. Their clinical significance is determined by high morbidity, risk of recurrence, and the potential for severe complications - ranging from pyelonephritis to chronic kidney failure. The highest incidence of UTIs is observed among women of reproductive age, which is associated with the anatomical and physiological features of the genitourinary system. However, UTIs also pose a serious problem in men, particularly in the elderly with prostate diseases, as well as in patients with catheters or immunodeficiency conditions. Modern approaches to diagnosis and treatment are based on a combination of clinical data, bacteriological studies, and radiological methods, while prevention includes both antibacterial therapy and elimination of predisposing factors.

Although most UTIs in adults are uncomplicated and generally resolve quickly with empiric antibacterial therapy, they remain a significant medical and social issue. The prevalence is particularly high among women, with the annual rate of primary healthcare visits for cystitis and other forms of UTI estimated at approximately 62.5 cases per 1,000 women. In certain cases, UTIs can cause severe and irreversible kidney damage, particularly in the presence of congenital or acquired urinary tract abnormalities, during pregnancy, or in patients with diabetes mellitus. In young men without prior urogenital interventions, UTIs are extremely rare, except among sexually active homosexual men; however, after the age of 50, their incidence increases significantly due to prostate disease. Among elderly individuals in hospitals or nursing homes, the prevalence of asymptomatic bacteriuria reaches 20–50% in women and 5–20% in men. UTIs in childhood are of particular clinical importance, as they can lead to persistent and progressive renal tissue damage, which in some cases results in end-stage chronic kidney failure at a young age.

Diagnosis

The main clinical manifestations of cystitis are increased urinary frequency, dysuria, and suprapubic discomfort. These symptoms are often accompanied by significant sleep disturbances,

temporary disability, restrictions in social activity, and inability to travel. However, in differential diagnosis it is important to consider the possibility of urethral syndrome, sexually transmitted infections, and vaginitis.

Acute pyelonephritis, in contrast, is characterized by a pronounced systemic reaction. Patients typically present with chills, high fever, flank or lower back pain combined with costovertebral angle tenderness, as well as colicky abdominal pain, nausea, vomiting, and leukocytosis. Blood and urine cultures are positive in most cases; gram-negative septic shock may develop, particularly in complicated disease associated with obstructive uropathy or papillary necrosis.

Bacteriology

Traditionally, the diagnosis of urinary tract infection (UTI) is based on the isolation of microorganisms from a urine specimen. However, this seemingly simple criterion involves several methodological challenges: how urine should be collected, what bacterial count is considered clinically significant, how to interpret “sterile urine” in symptomatic patients, and whether bacteriological verification is always required.

Following Kass’s fundamental studies, the presence of $\geq 10^5$ colony-forming units (CFU) per 1 mL of midstream urine was proposed as a diagnostic threshold. This cutoff helps distinguish true infection from contamination. The risk of contamination increases with the isolation of mixed flora but decreases when the same pathogen is repeatedly identified or when the sample is obtained from a male patient. In certain cases, however, lower bacterial counts are considered clinically significant for example, in infections caused by fastidious organisms (*Staphylococcus saprophyticus*, *Chlamydia*, *Mycobacterium*) or in urine collected via catheterization. Any bacterial growth in samples obtained by suprapubic bladder aspiration is regarded as definitive evidence of infection.

Urine samples should be delivered to the laboratory without delay; if immediate transport is not possible, they must be stored at 4 °C to prevent artificial bacterial overgrowth. Automated culture systems can detect significant bacteriuria within 5–13 hours and, in some cases, determine pathogen susceptibility to antibiotics. However, their sensitivity decreases with low bacterial counts and is limited in hospital practice, where pathogens are often slow-growing. Direct microscopy is widely available but does not always provide reliable verification of bacteriuria.

Pyuria serves as an indirect marker of clinically significant UTI, though leukocytes may also be present in “sterile urine,” suggesting the presence of fastidious pathogens (e.g., *Mycobacterium*) or recent antibiotic use. Pyuria detection relies on leukocyte esterase testing incorporated into dipsticks; when combined with a positive nitrite test, this method shows a sensitivity of approximately 87% and specificity of 67% for UTIs caused by enterobacteria. Microhematuria is observed in about 50% of UTI patients, whereas albumin detection on dipsticks is not considered a reliable diagnostic criterion for UTI.

Differences in Susceptibility to Urinary Tract Infections (UTIs)

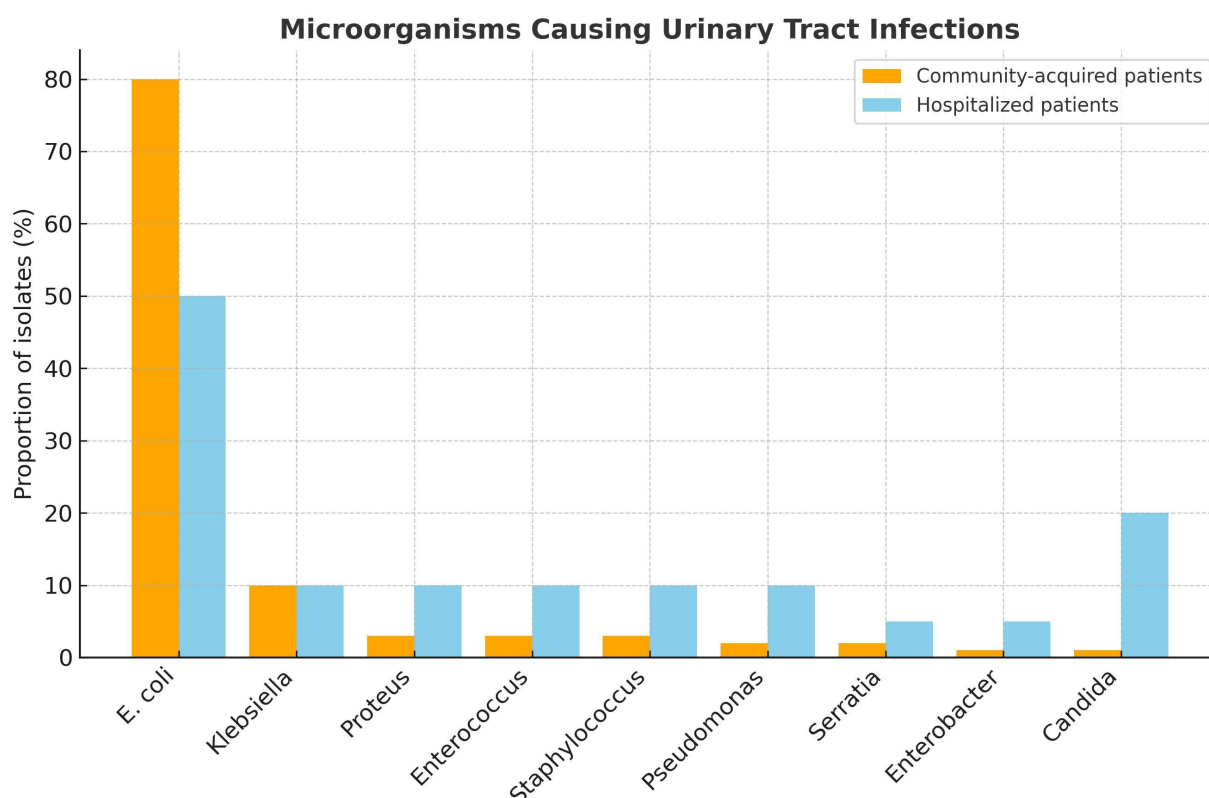
Variability in host susceptibility to UTIs is largely determined by the virulent properties of the causative pathogens. One of the key factors is the strong ability of certain microorganisms to adhere to the urothelium, which explains why some women are predisposed to recurrent infections and pyelonephritis, whereas others do not develop such complications.

Approximately 90% of community-acquired UTIs in women are caused by *Escherichia coli*. Less common pathogens include Gram-negative bacteria such as *Proteus mirabilis* and members

of the genus *Klebsiella*. Among sexually active women, up to 10% of infections are attributed to *Staphylococcus saprophyticus*; enterococci are occasionally isolated as well. These microorganisms generally remain sensitive to the most commonly used antibacterial agents.

A different picture is observed with nosocomial infections. Only about half of such cases are due to *E. coli*, whereas a substantial proportion is caused by *Pseudomonas aeruginosa*, *Proteus*, *Klebsiella*, *Serratia*, *Enterobacter*, enterococci, staphylococci, yeasts, and other pathogens. These infections are often characterized by widespread multidrug resistance, which complicates treatment. Age-related differences are also important: in elderly men, Gram-positive microorganisms are isolated in 39% of cases, while in elderly women enterobacteria (*Escherichia*, *Klebsiella*, *Proteus*) predominate, accounting for up to 93% of isolates. Anaerobic bacteria are extremely rare and are typically associated with urinary tract obstruction, often caused by malignant tumors.

Candiduria develops in patients with diabetes mellitus, in those receiving prolonged antibiotic therapy, and after long-term bladder catheterization. In immunocompromised individuals, it may serve as an early indicator of disseminated candidiasis.



The diagram illustrates the distribution of the main causative agents of urinary tract infections (UTIs) in community-acquired and hospitalized patients. Among community-acquired cases, *Escherichia coli* predominates, accounting for up to 80% of infections, whereas its share decreases to approximately 50% among hospitalized patients. In sexually active women, about 10% of infections are caused by *Staphylococcus saprophyticus*. In hospitalized patients, *Proteus*

spp. and *Klebsiella* spp. are more frequently isolated, each accounting for around 10% of isolates. Enterococci, also comprising about 10% of isolates, are less commonly seen in outpatients. Finally, the “other” category includes various pathogens such as *Serratia*, *Enterobacter*, staphylococci, and yeasts; their contribution is particularly significant in the structure of nosocomial infections (around 20%).

Radiology

Radiological changes are rarely detected in premenopausal women without a history suggesting an underlying cause of infection. Plain abdominal radiography may reveal calculi or renal calcification associated with tuberculosis or renal tubular acidosis. Intravenous pyelography is indicated in cases of recurrent infections, persistent symptoms despite therapy, macroscopic hematuria or persistent microscopic hematuria, the first episode of infection in men, acute pyelonephritis in patients with systemic diseases increasing the risk of complications, detection of unusual pathogens, or persistent fever lasting more than 48 hours after initiation of antibiotic treatment.

Ultrasound is particularly effective for diagnosing and percutaneously draining hydronephrosis and renal abscesses, as well as in cases where intravenous pyelography is contraindicated due to impaired renal function. An additional advantage of ultrasound is its ability to detect pelvic pathology. For the diagnosis of vesicoureteral reflux, voiding cystourethrography or indirect radionuclide cystography with technetium-99m (MAG3) can be used, which reduces radiation exposure and avoids bladder catheterization. The optimal methods for detecting renal scarring are intravenous urography and renal scintigraphy with technetium-99m dimercaptosuccinic acid (DMSA).

Treatment

A thorough medical history is essential for determining the nature of the infection and selecting the appropriate treatment strategy, including the duration of therapy, the choice of antimicrobial agent, and the need for additional investigations. The physician must distinguish whether the case represents a first episode, a relapse (recurrence of infection with the same serotype), or a reinfection (a new microorganism from the fecal reservoir). It is also important to establish whether the infection is associated with urological instrumentation, the presence of prostatism, or a history of renal pathology (childhood urinary tract infection, pregnancy-induced hypertension). Although antibiotics are effective, they may cause adverse effects such as vulvovaginal candidiasis, hypersensitivity reactions, skin rashes, and gastrointestinal disturbances. Limiting the duration of therapy to the minimum necessary reduces the risk of adverse events, lowers treatment costs, and improves patient compliance. In women with bacterial cystitis, short courses or even a single high dose of an appropriate antibiotic are as effective as the traditional 7-14-day regimens.

Single-dose therapy demonstrates high efficacy in infections caused by *E. coli* and *Staphylococcus saprophyticus*; however, when the infection is due to *Proteus mirabilis* or *Streptococcus faecalis*, cure rates do not exceed 46%. The main limitation of single-dose therapy is its inability to eradicate pathogens from fecal and vaginal reservoirs, which contributes to recurrence. Therefore, for recurrent infections, short-course therapy lasting 3–5 days is considered optimal. Women with frequent recurrences (several episodes per year) may require longer treatment, extending up to six weeks.

Short-Course Antimicrobial Therapy

Short courses of antibiotic treatment are highly effective in urinary tract infections (UTIs) caused by the two most common pathogens in women *Escherichia coli* and *Staphylococcus saprophyticus*. However, they should never be used in men, in cases of pyelonephritis, infections lasting longer than one week, anatomical or functional abnormalities of the urinary tract, immunocompromised patients, catheter-associated infections, pregnant women, or reinfections where the likelihood of pathogen resistance is high.

Patients at high risk of deep infection (men, individuals with pyelonephritis, patients with symptoms lasting more than seven days, those with anatomical or functional urinary tract disorders, immunocompromised individuals, or those with permanent catheters) should receive longer and more intensive therapy. Failure of single-dose treatment often indicates a subgroup of women with renal involvement who require thorough evaluation and closer monitoring.

Choice of Antimicrobial Agents

Amoxicillin has lost popularity in UTI therapy due to widespread resistance among intestinal flora, which contributes to recurrence. However, when combined with a β -lactamase inhibitor (amoxicillin/clavulanate), it remains effective. Trimethoprim is active against most typical pathogens and is especially suitable for low-dose suppression therapy, as it achieves high vaginal concentrations, though recurrences due to resistant enterobacteria are becoming more frequent. Co-trimoxazole is associated with more side effects and offers no advantages compared with monotherapy. Oral cephalosporins produce less resistance among intestinal flora than penicillins and are excreted in high active concentrations in urine.

New fluoroquinolones (norfloxacin, ciprofloxacin) have a broad spectrum of activity and are effective against both Gram-negative and Gram-positive bacteria, including *Pseudomonas*. They are contraindicated in pregnancy and should be prescribed with caution in patients with epilepsy. Fluoroquinolones increase plasma concentrations of theophyllines, while simultaneous administration of antacids, calcium, or iron reduces their intestinal absorption by half. Nitrofurantoin concentrates in urine, does not promote resistance of intestinal flora, and is therefore suitable for prophylaxis in patients with preserved renal function, but it is contraindicated in renal insufficiency.

Инфекции нижних мочевых путей

Преходящая неосложнённая бактериурия часто возникает у женщин, особенно после полового акта, и обычно проходит самостоятельно в течение 24–72 часов (кроме беременности). При симптоматическом цистите назначение антибактериальной терапии наряду с рекомендациями по обильному питью и правильному режиму мочеиспускания позволяет быстрее устранить инфекцию и уменьшить выраженность симптомов. В амбулаторной практике острые дизурические жалобы у женщин можно лечить коротким курсом антибиотика при тяжёлом течении, откладывая посев мочи и дополнительные обследования для тех, у кого наблюдаются повторные эпизоды.

Острый пиелонефрит

Острый пиелонефрит требует немедленного и интенсивного лечения, часто с использованием парентеральных антибиотиков в условиях стационара. Женщины, не беременные, не страдающие диабетом и способные принимать жидкости внутрь, могут лечиться амбулаторно. При известной чувствительности возбудителя назначаются максимально эффективные и наименее токсичные препараты. До получения результатов посевов назначают эмпирические схемы: цефалоспорины II–III поколения,

ципрофлоксацин, ко-тримоксазол, триметоприм или широкоспектральные пенициллины
(Here is the academic English translation of your passage:

Lower Urinary Tract Infections

Transient uncomplicated bacteriuria often occurs in women, particularly after sexual intercourse, and usually resolves spontaneously within 24–72 hours (except during pregnancy). In cases of symptomatic cystitis, antibiotic therapy combined with recommendations for increased fluid intake and proper voiding habits accelerates infection resolution and reduces symptom severity. In outpatient practice, acute dysuric complaints in women may be treated with a short course of antibiotics in severe cases, while urine culture and additional investigations can be deferred for those with recurrent episodes.

Acute Pyelonephritis

Acute pyelonephritis requires immediate and intensive treatment, often with parenteral antibiotics administered in a hospital setting. Non-pregnant women without diabetes who are able to tolerate oral fluids may be treated on an outpatient basis. When the pathogen's susceptibility is known, the most effective and least toxic agents should be prescribed. Empirical regimens prior to culture results include second- or third-generation cephalosporins, ciprofloxacin, co-trimoxazole, trimethoprim, or broad-spectrum penicillins (e.g., ticarcillin with clavulanic acid). Aminoglycosides are effective and inexpensive but require plasma level monitoring to avoid toxicity. Sensitivity data are usually available within 48 hours, during which aminoglycoside toxicity remains minimal in the absence of renal insufficiency. After stabilization and defervescence (within 48 hours), patients may be switched to oral antibiotics, with treatment continued for approximately two additional weeks. It is crucial to exclude underlying predisposing conditions such as diabetes, urinary tract abnormalities, or neurogenic bladder.

Infections in Pregnancy

Screening for bacteriuria is mandatory during pregnancy. More than one-quarter of women with bacteriuria will subsequently develop symptomatic infection or acute pyelonephritis if untreated. Persistent bacteriuria is associated with an increased risk of preterm labor and higher perinatal mortality. Despite the attractiveness of single-dose therapy (due to reduced fetal exposure), its efficacy during pregnancy has not been proven. Currently, a 7–14-day course with low-toxicity agents is recommended: sulfonamides, ampicillin, amoxicillin, or cephalexin. However, sulfonamides are contraindicated in late pregnancy due to the risk of kernicterus in newborns. Post-treatment urine culture is mandatory to confirm eradication of the pathogen.

Elderly Patients

Bacteriuria is common in frail elderly individuals, largely due to incontinence, incomplete bladder emptying, and catheterization. In this group, the classic signs of UTI may be attenuated or absent; confusion or shock may often be the predominant manifestations. In most cases, asymptomatic bacteriuria is benign; however, in the presence of symptomatic cystitis, a short course of broad-spectrum antibiotics is indicated. Elderly patients are more susceptible to the toxic and adverse effects of antibiotics; therefore, careful dose adjustment and drug level monitoring are required. In women with frequent recurrences, low-dose estrogen therapy may be beneficial, as it promotes the replacement of Gram-negative vaginal flora with lactobacilli. Elderly men often present with prostatitis, which requires at least four weeks of treatment with co-trimoxazole, ciprofloxacin, or erythromycin to ensure adequate tissue penetration.

Urinary Tract Abnormalities

Anatomical or functional abnormalities of the urinary tract that impair normal hydrokinetic defense mechanisms predispose individuals of both sexes to UTIs (Fig. 5). Infections in the presence of obstruction, calculi, or impaired bladder emptying can lead to severe deterioration of renal function. The prevalence of bacteriuria is higher in patients with diabetes, who are also at increased risk of complications such as pyelonephritis, papillary necrosis (Fig. 6), septicemia, and renal abscesses. Elevated urinary glucose concentrations, leukocyte dysfunction, obesity, vulvovaginitis, and bladder neuropathy may also serve as risk factors for UTIs.

In kidney transplant recipients, both anatomical and immunological factors predispose to UTIs, which occur in 30–50% of patients. Vesicoureteral reflux of infected urine into the transplanted kidney often causes pyelonephritis with bacteremia and may trigger acute rejection. Whenever possible, urine cultures should be obtained preoperatively and regularly during the postoperative period, and bacteriuria should be treated. The duration of bladder catheterization in these patients should be kept to a minimum.

Urinary Catheters

Long-term catheterization is responsible for 40–75% of nosocomial UTIs and is a leading source of Gram-negative bacteremia. Careful catheter management and specialized nursing teams can reduce infection rates, although local disinfection procedures have proven largely ineffective. For catheterization lasting up to 14 days, prophylactic antibiotics reduce the risk of bacteriuria fivefold. However, during prolonged catheter use, the frequent emergence of resistant microorganisms has led to the recommendation that only symptomatic infections be treated. Management of candidal colonization of the bladder includes catheter removal, discontinuation of antibiotics, and bladder irrigation with amphotericin. Intermittent self-catheterization with clean technique has advantages in patients with atonic or neurogenic bladders, including paraplegics in specialized units, as it reduces the risk of cross-infection.

Prevention

Continuous low-dose antibiotic prophylaxis can reduce the recurrence rate of UTIs by 95% in sexually active women. The efficacy of low nightly doses of co-trimoxazole, trimethoprim, nitrofurantoin, and norfloxacin is well documented, with a low incidence of adverse effects even during long-term use. Such prophylaxis is typically prescribed for 6 or 12 months but can be continued for 2–5 years without increasing the risk of complications.

Infections that occur during suppressive therapy are usually caused by resistant pathogens; therefore, alternative agents should be selected according to susceptibility. An alternative to long-term prophylaxis is postcoital therapy combined with voiding after intercourse in women who report a clear relationship between recurrence and sexual activity. Early self-initiated treatment with a broad-spectrum antibiotic at the onset of symptoms is also effective in women with recurrent infections.

Low-dose prophylaxis is also recommended after acute pyelonephritis during pregnancy, as recurrences occur in 10–25% of cases. Furthermore, antibiotic prophylaxis should be administered prior to any urological intervention to prevent bacteremia and Gram-negative sepsis. Antibiotics are also indicated before extracorporeal shock wave lithotripsy to prevent infection from viable microorganisms remaining within stone fragments.

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