Urinary tract infection

Microbiology lecture 3

Dr. Hala Altarawneh

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Urinary tract infections (UTIs) are infections of the bladder, urethra, ureters, or kidneys that are most commonly caused by bacteria, especially E. coli. Infections of the bladder or urethra are called lower UTIs, whereas infections involving the kidneys or ureters are called upper UTIs.

Prevelance: UTIs are the most common outpatient infections. Between 50% and 60% of adult women will have at least one UTI in their life, and close to 10% of postmenopausal women indicate that they had a UTI in the previous year.

Etiology

Pathogens

Bacteria

Infection ascends from the urethra to the bladder. Can ascend further to the ureters and the renal pelvises. Bacteria that cause UTI, includes the follwing:

Escherichia coli: leading cause of UTI (approx. 80%).

Staphylococcus saprophyticus: 2nd leading cause of UTI in sexually active women.

Klebsiella pneumoniae: 3rd leading cause of UTI.

Proteus mirabilis

Nosocomial bacteria: Enterococci spp., and Pseudomonas aeruginosa.

Viruses

Immunocompromised patients and children are particularly susceptible to viral UTIs. Adenovirus, cytomegalovirus, and BK virus are commonly involved in hemorrhagic cystitis.

Predisposing factors

- Host-dependent factors:

Structural or functional abnormalities of the urinary tract

Prevent bladder emptying and/or result in urinary stasis. Examples include:

Benign prostatic hyperplasia

Congenital malformations causing vesicoureteral reflux

Urinary bladder diverticulum

Neurogenic bladder

Urinary tract calculi

Gender

Female individuals: anatomically predisposed because the urethra is shorter and anal and genital regions are in close proximity → bacteria spreading from the anal region → colonization of vagina → ascending UTIs.

Male individuals: higher risk in uncircumcised male infants

Pregnancy Hormonal changes during pregnancy → urinary stasis and vesicoureteral reflux → increased risk of UTIs

Postmenopause: ↓ estrogen → ↓ vaginal lactobacilli → ↑ vaginal pH → ↑ colonization by E. coli

Chronic constipation: common cause of UTIs in children

Prior conditions

Previous UTI, History of kidney surgery, Immunosuppression, Diabetes mellitus

- Other factors

Sexual intercourse

Postcoital cystitis (honeymoon cystitis): a lower urinary tract infection that occurs in women after recent sexual activity, which can cause irritation of the urethral meatus and facilitate bacterial entry into the urethra (e.g., from the genital and/or anal region).

Catheter-associated urinary tract infection (CAUTI)

Caused by indwelling urinary catheters

Most common cause of nosocomial urinary tract infection

Classification

Urinary tract infections are classified and treated based on location, severity, source of infection, and frequency. The presence of symptoms distinguishes UTI from asymptomatic bacteriuria, which only requires treatment in a select subset of patients.

Asymptomatic bacteriuria (ASB): defined by the presence of ≥ 100,000 CFU/mL in at least two voided urine samples in patients **with no symptoms of UTI** (e.g., dysuria, frequency, urgency, suprapubic pain). Asymptomatic bacteriuria typically resolves spontaneously in healthy, nonpregnant women without any side effects.

Classification of urinary tract infections		
		Details
By clinical presentation	Asymptomatic bacteriuria (ASB)	• Significant bacteriuria without clinical features of UTI
	Urinary tract infection (UTI)	• Bacteriuria and clinical features of UTI
By location	Lower UTI	• Infection of the bladder (cystitis), the most common location of UTIs • Often accompanied by urethritis (urethritis in isolation is suggestive of STI) • Can be associated with prostatitis in men
	Upper UTI	• Infection of the kidneys and ureter (pyelonephritis)
	Uncomplicated UTI	• Infection in nonpregnant, premenopausal women without further risk factors for infection, treatment failure, or serious outcomes
By severity	Complicated UTI (cUTI)	• Infection in patients with risk factors for infection, treatment failure, or serious outcomes, including: • Male sex • Pregnancy • Postmenopause • Children with features of atypical pediatric UTI • Significant anatomical or functional abnormalities • Immunosuppression • Renal failure • Metabolic disorders (e.g., diabetes) • Infection associated with recent instrumentation or medical devices, e.g.: Cystoscopy, indwelling catheters, drainage devices (e.g., ureteral stents, nephrostomy tubes). • Healthcare-associated UTIs
	Urosepsis	• UTI associated with a dysregulated immune response that can potentially lead to life-threatening organ dysfunction.
By frequency	Recurrent UTI	• ≥ 3 episodes of symptomatic, culture-proven UTI in one year or ≥ 2 episodes in 6 months

Clinical features

Clinical features of lower UTI

Irritative lower urinary tract symptoms (LUTS): increased urinary frequency, urinary urgency, dysuria.

Cloudy or foul smelling urine

Hematuria

Suprapubic tenderness

Clinical features of upper UTI (pyelonephritis)

Fever

Flank pain

Costovertebral angle tenderness

Fatigue/malaise

Nausea and vomiting

Additional features (special patient groups)

Male individuals: pain in the prostatic/perineal area

Children: Caregivers may report the following in young children: new-onset urinary incontinence (if toilet trained), irritability, crying when urinating, poor feeding, malodorous urine.

Older adults: delirium/acute confusion

Diagnostics

Approach

Symptomatic, uncomplicated lower UTIs can be diagnosed clinically. In all other patients, urinalysis is the most important initial diagnostic test.

Uncomplicated lower UTI in women:

> Typical symptoms: Treatment may be initiated without further diagnostics.
>
> Atypical or unclear symptoms: Perform urinalysis using a urine dipstick test and/or microscopy.
>
> > If urinalysis is **positive** (proof of pyuria and bacteriuria) → Initiate treatment.
> >
> > If urinalysis is **negative** but persisting suspicion → Obtain urine culture.

Complicated lower UTI in women:

> Obtain urinalysis and urine culture.

Consider the need for further diagnostics, depending on history and clinical presentation.

Lower UTI in men:

Obtain urinalysis and urine culture.

Consider referral to urology (e.g., in case of unclear diagnosis, hematuria, voiding difficulties, or recurrent UTI)

Consider concomitant prostatitis.

Laboratory studies

Urinalysis

Indications: best initial test for all patients

Procedure: visual, chemical (dipstick), and microscopic examination of urine

Specimen collection method: Clean-catch midstream sample to reduce contamination with vaginal or skin flora, or straight catheterization of the bladder: considered if the risk of contamination is high, suprapubic aspiration: no contamination if performed correctly but rarely used due to its invasive nature

Typical urinalysis findings of UTI:

Pyuria: presence of white blood cells (WBCs) in the urine.

Positive leukocyte esterase: an enzyme produced by WBC

Bacteriuria: presence of bacteria in the urine.

Positive urinary nitrites: indicate bacteria that convert nitrates to nitrites (most commonly gram-negative bacteria; e.g., E.coli)

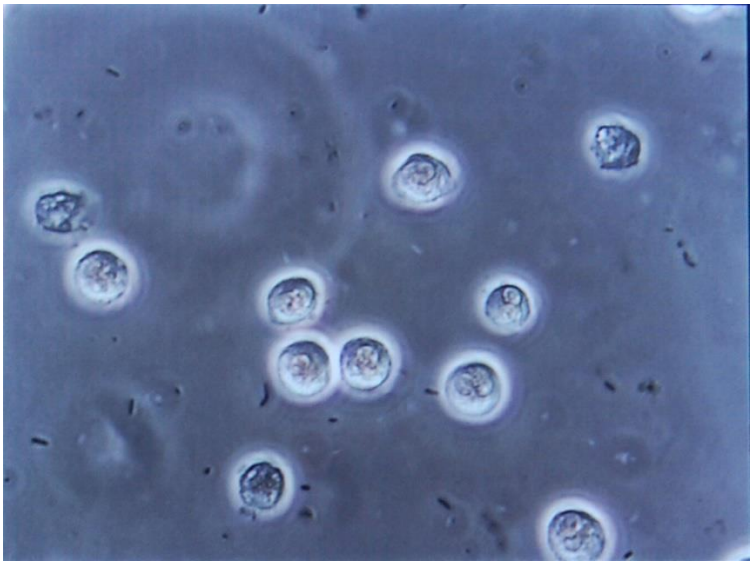
Direct visualization by gram stain (rarely performed)

Other findings:

Leukocyte casts rare finding, but considered to be a strong indicator for pyelonephritis.

Micro- or macroscopic haematuria may be present.

Alkaline urine (pH > 8) and struvite crystals in sediment: indicate urease-producing organisms (e.g., Proteus, Klebsiella, Staphylococcus saprophyticus)



Pyuria and bacteriuria on microscopy. Multiple white blood cells (large, light-colored structures) and bacteria (small black structures) are visible.

Urine culture

Indications:

Suspicion for complicated UTI or healthcare-associated UTI,

Suspicion for pyelonephritis or urosepsis

Suspicion for uncomplicated cystitis with either of the following:

History of recurrent UTIs, unclear urinalysis, atypical symptoms, concern for multiresistant pathogens, e.g., due to recent antibiotic use, age ≥ 65 years

Follow-up cultures for test of cure in the following cases: Nonresolving symptoms despite antibiotic treatment, anatomic or functional abnormalities of the urinary tract, continued pathological findings on urinalysis

Interpretation

Cultures are considered positive if either of the following is present:

Significant bacteriuria: defined as ≥ 10^5 CFU/mL in a clean-catch specimen

Any organisms in a specimen obtained by suprapubic aspiration

Typical colony findings:

E. coli: intensely pink on MacConkey agar

Klebsiella pneumoniae: viscous colonies

Proteus mirabilis: swarming motility pattern

Pseudomonas aeruginosa: blue-green pigment

Imaging

Imaging is generally not indicated or helpful for the diagnosis of lower UTI, but it may be performed in select patients to rule out complicating factors (e.g., urinary tract obstruction) or if complicated pyelonephritis or urosepsis are suspected.

Indications may include:

Suspected urinary tract obstruction

Severe illness (e.g., septic shock)

Early recurrence of UTI (within two weeks of appropriate treatment)

Persistent bacteriuria despite treatment

Recurrent complicated UTI

Men with febrile UTI

Modalities:

1- CT scan:

CT abdomen and pelvis with or without IV contrast is considered most sensitive for initial imaging

Findings supportive of pyelonephritis → Renal parenchyma may appear normal (early) or edematous

Findings supportive of urinary tract obstruction → Hydroureter, hydronephrosis

Nephrolithiasis, urolithiasis

Other findings that may be present include congenital abnormalities of the renal tract

And abscess

2- Ultrasound of the kidneys and bladder

Perform if there are contraindications to contrast or radiation.

Useful for detecting hydronephrosis and measuring postvoid residual volume if an obstruction is suspected

3- Additional modalities include MRI abdomen and pelvis, voiding cystourethrography, and retrograde cystography.

Treatment

General principles:

- Antibiotic treatment is recommended for all patients with symptomatic UTI.
- The optimal therapy depends on disease severity, local resistance patterns, and patient characteristics (e.g., allergies).
- Initial treatment is with an empiric regimen, which is maintained for uncomplicated cystitis. In unclear or complicated cases, the regimen may subsequently have to be adjusted based on urine culture data.
- Consider the need for supportive treatment.
    - a urinary analgesic.
    - Oral analgesia, e.g., with NSAIDs, can provide additional relief.

Uncomplicated lower UTI

Management can typically be done in the outpatient setting with oral therapy.

Empiric antibiotic treatment of uncomplicated lower UTIs

First-line treatment: Nitrofurantoin for 5 days

Persistent symptoms despite antibiotic therapy suggest complicated UTI and/or indicate the need to change the empiric therapy.

Complicated lower UTI

Empiric antibiotic therapy should have broad-spectrum activity against the expected uropathogens. Antibiotic therapy must be adapted to culture results and is commonly given for 7–14 days.

In addition to antibiotic therapy, complicating factors (e.g., obstruction) should be treated, if possible.

For UTI in men, referral to urology may be warranted especially in the following cases: Treatment failure or recurrent UTIs, Hematuria, Voiding difficulties, and Suspected acute bacterial prostatitis

Options for **the initial empiric treatment** of complicated lower UTIs include:

Fluoroquinolones PO or IV: e.g., ciprofloxacin or levofloxacin

Uncomplicated pyelonephritis

Outpatient treatment is generally appropriate.

Empiric antibiotic therapy for uncomplicated pyelonephritis

Most patients can be treated with an oral fluoroquinolone for 5–7 days.

Complicated pyelonephritis

Patients with complicated acute pyelonephritis should be admitted to the hospital and started on parenteral empiric antibiotic therapy as soon as possible.

Not severely ill and no risk factors for multidrug-resistant bacterial infection: A fluoroquinolone like Ciprofloxacin

Severely ill (i.e., septic) and/or with risk factor(s) for multidrug-resistant gram-negative bacterial infection: carbapenem like Meropenem, or Aztreonam

Complications

General

Perinephric abscess

Urosepsis

Emphysematous pyelonephritis

Atrophic kidneys

End-stage renal disease (ESRD): if both kidneys are affected, the patient has a single kidney, or the other kidney has been damaged by a different pathology

In male individuals

Urethral stricture

Epididymitis

Prostatitis

Orchitis

In pregnant women

Increased risk of preterm labour and birth