Urinary Tract Infections

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📖 Introduction

- UTIs = common bacterial infections caused mainly by ascension of normal enteric flora (e.g., *E. coli*) through the urethra → bladder.
- More common in women due to:
  - Shorter urethra
  - Proximity of urethra to anus and vagina
- Diagnosis = Clinical symptoms + Abnormal urinalysis + Positive urine culture
- Treatment = Antibiotics (but resistance is increasing)

🔬 Diagnostic Testing for UTIs

1. Urine Microscopy

- Findings:
  - Pyuria 🧪 (↑ WBCs in urine)
  - Hematuria 🩸 (RBCs in urine)

- Bacteria may be visible

- WBC casts → indicate pyelonephritis (not cystitis)

- Abundant squamous epithelial cells → suggest contamination ⃠

2. Urine Dipstick

- Uses chemical reagents on a strip.

- Findings suggestive of infection:

  - ✅ Positive leukocyte esterase (enzyme from WBCs)

  - ✅ Positive nitrite (Enterobacteriaceae convert nitrate → nitrite)

  - ✅ Positive hemoglobin

3. Urine Culture (Gold Standard) 🥇

- Urine in bladder = sterile (contamination may occur as urine passes through outer urethra → so numeric colony count used to confirm true infection.)

- Thresholds for infection:
    - Midstream void: $\geq 1 \times 10^5$ CFU/mL
    - Catheter sample: $\geq 1 \times 10^2$ CFU/mL
- Sample collection:
    - Midstream urine specimen
    - Bladder catheterization

📊 Table: Diagnostic Tests for UTIs

Test	Key Findings	Diagnostic Value
Microscopy	Pyuria, hematuria, bacteria, WBC casts	Quick, supportive
Dipstick	+LE, +Nitrite, +Hemoglobin	Screening tool
Culture	$\geq 10^5$ CFU/mL (voided), $\geq 10^2$ CFU/mL (catheter)	Gold standard ✅

Cystitis (Bladder Infection)

Definition

- Cystitis = Infection of the bladder

- Types:

    - *Uncomplicated*: Healthy, non-pregnant women
    - *Complicated*: All others (men, pregnancy, DM, recurrent UTIs, anatomic/neurologic problems, catheters)

Pathophysiology

- Route of infection: Ascension of bacteria via urethra → bladder

- Predisposing factors in women:

    - Short urethra
    - Urethra close to vagina & anus

- Mechanism:

    1. Vaginal colonization by *E. coli* (instead of normal *Lactobacillus*)

2. *E. coli* adhere to bladder mucosa via pili

3. Bacteria multiply → trigger inflammatory response → cystitis symptoms

📊 Risk Factors

Risk Group	Mechanism
Women	Short urethra, periurethral colonization
Abnormal bladder emptying	Cystoceles, neurogenic bladder (SCI, MS)
Foreign bodies	Indwelling Foley catheters
Infants (<3 months)	Higher risk in uncircumcised boys
Children & adults	Girls > boys after infancy

📌 Flowchart: Pathophysiology of Cystitis

Normal vaginal flora (Lactobacillus)

Colonization by *E. coli*

Ascension through urethra

Adhesion to bladder mucosa (via pili)

Bacterial proliferation

Inflammation → Cystitis

❖ Cystitis – Clinical Features, Pathogens, Diagnosis & Management

🔷 Clinical Manifestations

- Classic symptoms:
    - 🔥 Dysuria (painful urination)
    - 🚽 Frequency & urgency (low-volume urination)

- 😣 Suprapubic tenderness
- 💧 Gross hematuria

- Men: May have penile discharge

- Systemic features (fever, chills, flank pain) → suggest pyelonephritis (upper UTI) instead

📌 Exam tip: Cystitis = localized bladder symptoms without systemic illness

🔬 Pathogens

Category	Organisms	Key Notes
Gram-negative (most common)	*E. coli* 🥇 (most frequent), *Klebsiella*, *Proteus*	*Proteus* → associated with alkaline urine + stones
Gram-negative opportunistic	*Pseudomonas aeruginosa*	Usually healthcare-associated, abnormal GU tract, or multi-antibiotic use
Gram-positive	*Enterococcus*, *Staphylococcus saprophyticus*	*S. saprophyticus* = common in young women
Fungal	*Candida* spp.	Risk ↑ with Foley catheters +

		prolonged antibiotics
Viral (rare)	Adenovirus, BK virus, CMV	Cause hemorrhagic cystitis in immunocompromised (e.g., stem cell transplant)

🧪 Diagnosis of Cystitis

- Urinalysis findings:
  - Pyuria: WBCs on microscopy / +Leukocyte esterase
  - +Nitrite (Enterobacteriaceae)
  - Hematuria (RBCs in urine)
- Urine culture:
  - Voided midstream or catheter specimen
  - Confirms diagnosis with significant growth
- Must be correlated with clinical symptoms ✅

📌 Key Point: Asymptomatic bacteriuria ≠ cystitis (no treatment needed except in pregnancy, before urologic procedures).

💊 Treatment of Cystitis

◈ Uncomplicated Cystitis

- First-line empiric therapy:
    - Trimethoprim-sulfamethoxazole (TMP-SMX)
    - Nitrofurantoin

◈ Complicated Cystitis

- Empiric therapy:
    - Fluoroquinolones (Ciprofloxacin, Levofloxacin)

◈ Symptomatic Relief

- Phenazopyridine → ↓ dysuria (analgesic, not antibiotic)

🛡 Prevention of Cystitis

- No absolute primary prevention method
- In recurrent cystitis:
    - 🌸 Promote growth of Lactobacillus (normal flora)
    - 👵 Intravaginal estrogen (post-menopausal women)

- 🚫 Avoid spermicides (increase risk of colonization)
- 💊 Postcoital antibiotics (for women with post-sex UTIs)

📌 Flowchart: Diagnosis & Management of Cystitis

Symptoms (dysuria, frequency, suprapubic pain)

Urinalysis (Pyuria, +LE, ±Nitrite, ±Hematuria)

Urine Culture (Confirm organism)

Uncomplicated → TMP-SMX / Nitrofurantoin
Complicated → Fluoroquinolone
Symptom relief → Phenazopyridine

Pyelonephritis

Definition

- Pyelonephritis = infection of the kidney(s)
    - "Pyelo" = renal pelvis
    - "Nephritis" = inflammation of kidney
- Types:
    - *Uncomplicated*: Healthy women
    - *Complicated*: All other cases (men, pregnancy, DM, recurrent UTIs, anatomic/neurologic problems, catheters, stones)

Pathophysiology

- Main route: Ascension of bacteria → Urethra → Bladder → Ureters → Kidney
- Other route: Hematogenous spread (e.g., infective endocarditis, TB, fungal infection)
- Risk factors:

- Kidney stones (esp. struvite stones with *Proteus*)
- Anatomic abnormalities (e.g., Vesicoureteral reflux in children)
- Neurologic bladder dysfunction

📌 Exam tip:

Recurrent Proteus infection → think of struvite stones!

🤒 Clinical Manifestations

- Systemic symptoms:
  - Fever 🌡️
  - Flank pain 🦴
  - Nausea & vomiting 🤢
- ± Lower UTI symptoms: Dysuria, frequency, hematuria, suprapubic tenderness

📌 Key Distinction:

Unlike cystitis, pyelonephritis has systemic features (fever, flank pain, N/V).

🦠 Pathogens

Route	Common Organisms	Notes
Ascending infection (most common)	*E. coli* 🥇, *Klebsiella*, *Proteus*	*Proteus* → linked with struvite stones
Healthcare-associated / abnormal GU tract	*Pseudomonas aeruginosa*	Seen in catheterized / multi-antibiotic patients
Hematogenous spread	*Staphylococcus Aureus*	Often from endocarditis
	Mycobacterium tuberculosis, fungi (Candida, Aspergillus)	Seen in disseminated infections / immunocompromised

📊 Comparison: Cystitis vs Pyelonephritis

Feature	Cystitis (Bladder)	Pyelonephritis (Kidney)
Fever	❌ Rare	✅ Common
Flank pain	❌ Absent	✅ Present

Nausea/vomiting	✗ Absent	☑ Present
Suprapubic tenderness	☑ Common	☑ Sometimes
WBC casts (urine)	✗	☑ Hallmark

📌 Flowchart: Routes of Pyelonephritis

Urethra → Bladder → Ascension to Kidney

↓

Typical pathogens (*E. coli, Klebsiella, Proteus*)

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Inflammation + systemic symptoms

OR

Hematogenous spread → Kidney

↓

Pathogens: *Staph. aureus, TB, fungi*

🧪 Diagnosis

- Urine findings (similar to cystitis):
    - Pyuria (+WBCs)
    - Hematuria
    - WBC casts 🧪 (hallmark → upper UTI)
- Blood tests:
    - ↑ WBC count (leukocytosis)
    - Blood cultures → occasionally positive
- Imaging (US/CT):
    - Detects inflammation, obstruction, or perinephric abscess
    - Not routinely recommended if patient responds quickly to antibiotics
- Sterile pyuria: Seen in renal tuberculosis (M. tuberculosis does not grow on routine culture media)

💊 Treatment

- Empiric therapy (community-acquired):
    - Fluoroquinolone (ciprofloxacin, levofloxacin)
    - 3rd generation cephalosporin (ceftriaxone)
- High-risk patients (antibiotic exposure, healthcare setting, anatomic abnormalities):
    - Antipseudomonal coverage → Cefepime, Piperacillin, Meropenem
- Key principle: Start broad → Narrow therapy once culture & sensitivity available ✅
- Requirement: Antibiotics must achieve high renal parenchymal concentrations

🛡️ Prevention

- Bladder dysfunction → may require frequent catheterization to ensure drainage
- Pregnant women with asymptomatic bacteriuria → treat with antibiotics to prevent pyelonephritis

Asymptomatic Bacteriuria (ASB)

Definition

- Presence of bacteria in bladder without symptoms
- Criteria:
  - $\geq 1 \times 10^5$ CFU/mL of a single bacterial species
  - On two successive urine cultures
  - In a patient without UTI symptoms

Pathophysiology

- Bacteria ascend via urethra → bladder
- Not hematogenous
- Common in:
  - Diabetes patients
  - Anatomic/neurologic urinary tract abnormalities

- Indwelling Foley catheters
- Elderly

😬 Clinical Manifestations

- No symptoms of UTI (upper or lower tract)

🦠 Pathogens

- Same organisms as cystitis (esp. *E. coli*)
- Candiduria also possible in catheterized/immunocompromised patients

🧪 Diagnosis

- Positive urine cultures (as per definition)
- Pyuria present in ~50% cases

💊 Treatment

- Only indicated in high-risk groups:
  1. 🤰 Pregnant women

2. Patients undergoing urologic procedures that may cause mucosal bleeding → risk of bacteremia

3. Neutropenic patients

❌ Not treated in general population (e.g., elderly, diabetics, catheterized patients)

🛡️ Prevention

- Routine prevention strategies not used
- Focus = Identify & treat only high-risk groups

📊 Table: Asymptomatic Bacteriuria vs Cystitis vs Pyelonephritis

Feature	Asymptomatic Bacteriuria	Cystitis	Pyelonephritis
Symptoms	❌ None	✅ Dysuria, frequency, hematuria	✅ Fever, flank pain, N/V
WBC Casts	❌	❌	✅ Present

Culture	$\geq 10^5$ CFU/mL (2 specimens)	Positive	Positive
Treatment	Select groups only	TMP-SMX, Nitrofurantoin (uncomplicated)	Fluoroquinolones, Ceftriaxone; ± antipseudomonal

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Prostatitis

📜 Definition

- Inflammation of the prostate gland, most often due to bacterial infection.
- Can be acute or chronic in presentation.

🔬 Pathophysiology

- Most common route: Ascending infection → *urethra* → *prostatic ducts*.
- Other route: Hematogenous seeding.
- Severe infection → development of microabscesses in

prostate tissue.

Clinical Manifestations

Feature	Acute Prostatitis ⚡	Chronic Prostatitis ⏳
Onset	Sudden	Gradual
Symptoms	Fever, chills, dysuria, urinary frequency, pelvic/perineal pain	Dysuria, frequency, hesitancy, pelvic discomfort
Systemic signs	May progress to sepsis	Rare
DRE (Digital Rectal Exam)	Tender, swollen prostate	Mildly tender, boggy prostate

Common Pathogens

Patient Group	Likely Pathogens
👦 Young men	*Neisseria gonorrhoeae*, *Chlamydia trachomatis*
👴 Older men	Enteric gram-negative bacteria → *E. coli* (most common)

Hematogenous spread	*Staphylococcus aureus*

🧪 Diagnosis

- Acute prostatitis
    - Clinical suspicion + acutely tender prostate on DRE.
    - Urine & blood cultures for pathogen recovery.
    - ❌ Prostatic massage contraindicated (may worsen sepsis).
- Chronic prostatitis
    - Diagnosis via urine & prostatic secretion after gentle massage.
    - Helps identify causative organism.

💊 Treatment

- Antibiotics with good prostatic penetration:
    - Fluoroquinolones (ciprofloxacin, levofloxacin)
    - Trimethoprim-sulfamethoxazole (TMP-SMX)
- Always guided by antibiotic sensitivity testing.

🛡️ Prevention

- Prompt and effective treatment of acute prostatitis → prevents transition to chronic prostatitis.

🔁 Flowchart: Pathophysiology Simplified

Urethral infection

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Spread to prostatic ducts

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Acute prostatitis (fever, dysuria, pain)
If untreated → Microabscesses

↓

→ May progress to chronic prostatitis

Organisms Causing UTI

1. Escherichia coli (E. coli)

- Prevalence: Most common (80–90% of cases).
- Characteristics: Gram-negative rod, lactose fermenter.
- Pathogenic factors (UPEC – 70–90%):
  - P-fimbriae / Type 1 fimbriae → adherence to uroepithelium.
  - Hemolysin → tissue damage.
  - K antigen (capsule) → immune evasion.

2. Staphylococcus saprophyticus

- Prevalence: 5–10% (2nd most common in young, sexually active women).
- Nickname: "Honeymoon cystitis."
- Characteristics: Gram-positive coccus, coagulase-negative, novobiocin resistant.
- Pathogenic factors:
  - Strong adhesion to uroepithelium.

    - Urease production → pathogenesis.

- Clinical: Similar to E. coli UTIs but usually milder.

3. Klebsiella pneumoniae

- Prevalence: 3–8% of UTIs.

- Characteristics: Gram-negative rod.

- Pathogenic factors:

    - Capsule → antiphagocytic.
    - Adhesins → attachment.

- Clinical: Complicated & catheter-associated UTIs (esp. hospital setting).

4. Proteus mirabilis

- Prevalence: 1–2% of UTIs.

- Characteristics: Gram-negative rod, highly motile, swarming growth on BA.

- Pathogenic factors:

- Urease production → ↑ urine pH.
- Biofilm formation → chronic infection.

- Clinical:

  - Ammonia odor urine.
  - Struvite crystals → staghorn calculi.

5. Enterococcus faecalis / faecium

- Prevalence: 5–15% (esp. hospital/catheter patients).

- Characteristics: Gram-positive coccus, catalase-negative.

- Pathogenic factors:

  - Biofilm → persistence.
  - Antibiotic resistance (incl. VRE).

- Clinical: Catheter-related UTIs.

6. Pseudomonas aeruginosa

- Prevalence: Common in hospital, catheterized patients.

- Characteristics: Gram-negative rod, non-lactose

fermenter, blue-green pigment, fruity odor.

- Pathogenic factors:
    - Biofilm formation.
    - Exotoxins → tissue damage.
- Clinical: Severe, complicated UTIs, high resistance.

7. Candida species

- Prevalence: Immunocompromised, catheterized patients.
- Characteristics: Yeast.
- Pathogenic factors: Adhesion + Biofilm.
- Clinical: Dysuria, burning, discharge.

8. Others

- Adenovirus: esp. children → hemorrhagic cystitis.

Laboratory Diagnosis

- Urine culture = gold standard.

- Collection: Midstream urine (MSU) after cleaning.

- Media:

    - Blood agar → Gram (+/–), hemolysis.
    - MacConkey agar → LF vs NLF.
    - CLED agar → preferred; prevents swarming (Proteus).
        - LF → yellow (E. coli).
        - NLF → blue/green (Pseudomonas).

- Significant bacteriuria: $>10^5$ CFU/mL

Antibiotic Susceptibility Testing

- Common options: Nitrofurantoin, TMP-SMX, Fosfomycin, Ciprofloxacin, Amoxicillin-clavulanate, Cephalexin

- Performed by disc diffusion (CLSI standards).

Clinical Cases

Case 1 (22-year-old woman):

- A 22-year-old woman presents with:
    - 2-day history of burning micturition, urinary frequency, urgency
    - No fever, no flank pain
    - Exam: afebrile, suprapubic tenderness
- Urinalysis: leukocyte esterase +, nitrites
- Urine culture: *E. coli*

✓ Likely: *Uncomplicated cystitis* (by E. coli).

✓ Route: Ascending infection.

✓ Tx: Nitrofurantoin / TMP-SMX / Fosfomycin (1st line).

Case 2 (70-year-old man, diabetic, catheterized):

- A 70-year-old man with diabetes, indwelling catheter for 10 days
- Presents with fever, chills, confusion
- Exam: febrile (38.9 °C), hypotension, CVA tenderness

- Labs: leukocytosis, urinalysis with pyuria and bacteriuria

✓ Likely organisms: E. coli, Klebsiella, Proteus, Pseudomonas, Enterococcus.

✓ Workup: Urine culture, blood culture, sensitivity testing.

✓ Management: Remove/replace catheter + broad-spectrum IV antibiotics (tailor to culture).