Urinary Tract Infections

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Urinary Tract Infections

- Definitions (Terms)

- Microbiology and epidemiology

- Pathogenesis
  - Bacterial factors
  - Host factors

- Clinical symptoms and diagnosis

- Clinical scenarios
Terms

- **Bacteriuria**: presence of bacteria in the urine

- **Significant bacteriuria**: number of bacteria in voided urine that exceeds that expected from contamination of the anterior urethra ($10^5$ bacteria/ml)

- **Urinary tract infection**: significant bacteriuria with the presence of symptoms
Terms (2)

- **Asymptomatic bacteriuria**: Significant bacteriuria without clinical symptoms

- **Lower UTI**: cystitis, urethritis, prostatitis

- **Upper UTI**: pyelonephritis, intra-renal abscess, perinephric abscess (usually late complications of perinephric abscess)
Terms (3)

- **Uncomplicated UTI**: Infection in a structurally and neurologically normal urinary tract

- **Complicated UTI**: Infection in a urinary tract with functional or structural abnormalities (e.g. Indwelling catheter or renal calculi)
Terms (4)

- **Pyuria**: the presence of pus (WBC’s) in urine (>10PC/hpf), which may or may not be caused by UTI. The preferred method for quantification is enumeration in unspun urine.

- The leukocyte esterase nitrite test (Urine dipstick) has a sensitivity of between 70% and 90% for symptomatic UTI.

- **Urethral syndrome**: characterized by frequency, dysuria, and suprapubic discomfort **BUT** negative bacterial culture (virus, chlamydia, anaerobes, ureaplasma).
Overview of UTI

- 7 million office visits yearly
- 1 million hospitalizations
- About 2/3rds of patients are women
  - 40% to 50% of women have UTI at some point during their lives
- Important complications of pregnancy, diabetes mellitus, polycystic disease, renal transplantation, conditions that impede urine flow (structural and neurologic)
Overview of UTI by age and sex
Asymptomatic bacteriuria

- In patients with asymptomatic bacteriuria without infection, a colony count of $> 10^5$ cfu/ml defines infection.

- Screening has little apparent value in adults except during pregnancy and prior to urologic surgery.

- Up to 40% of elderly men and women have asymptomatic bacteriuria.

- Treat: Neonates, children & pregnant.
Frequency of significant bacteriuria

- After one bladder catheterization: 2%
- Medical outpatients: 5%
- Pregnancy at term: 10%
- Hypertensive patients: 14%
- Diabetes mellitus: 20%
- Women with cystocele: 23%
Frequency of significant bacteriuria

• Congenital urologic disease: 57%

• Hydronephrosis; nephrolithiasis: 85%

• Indwelling catheter, open drainage > 48 hours: 98%

(reference: Jackson et al, Arch Intern Med 1962; 110: 663)
Routes of urinary tract infection

- **Ascending Route: (~90%)**
  - The common route of nearly all forms of urinary tract infection (bacteria initially colonize periurethral tissues)
  - Common in females than in males because of shorter urethra
  - Single bladder catheterization can result in UTI in 1% of the ambulatory population
Routes of Urinary Tract infection (2)

• Hematogenous Route:
  • Frequently seen with *Staphylococcus aureus* bacteremia or endocarditis
  • Also seen to occur in experimental models with *Candida*
  • Infections with gram negative bacilli rarely occurs by this route

• Lymphatic Route:
  • ? Significance of this route
  • Increase bladder pressure can cause lymphatic flow to be directed toward the kidney
Role of bacterial virulence in UTI

- Bacterial adherence to uroepithelial cells involves specific binding of bacterial surface receptors (*adhesins*) to complementary components on the epithelial cells (*receptors*).

- The ability of *E. coli* to adhere to uroepithelial cells is associated with the presence of pili or fimbriae.

- However, virulence of *E. coli* strains does not seem to depend upon a single virulence factor. There may well be an additive effect among multiple virulence factors (including adhesins, hemolysin, capsular polysaccharide).
Host Defenses

Antimicrobial properties of urine:

- Extremes of osmolality
- High urea concentration
- High organic acid concentration
- Low pH

Anaerobic and fastidious organisms that make up most the urethral flora do not multiply in the urine
Host Defenses

Anti-adherence mechanisms:

- Bacterial interference (naturally endogenous bacteria in the urethra, vagina, and periurethral region)

- Urinary oligosaccharides (have the potential to detach epithelial-bound *E. coli*)

- *Tamm-Horsfall protein*: coating of *E. coli* by this protein might prevent attachment
Figure 66-3 Light-microscopic specimen of urine showing uromucoid (Tamm-Horsfall protein) with large numbers of adherent uropathogenic bacteria.
Host Defenses

Miscellaneous:

- Mucopolysaccharide lining of the bladder
- Urinary immunoglobulins
- Spontaneous exfoliation of uroepithelial cells with bacterial detachment
- Mechanical flushing of micturition
Urinary tract bacteriology

- At room temperature, the doubling time of common aerobic bacteria is about 20 minutes


- *Any* bacterial growth is significant if the specimen is collected from a normally-sterile site (e.g., direct bladder puncture)
Urinary tract bacteriology (2)

- In pyelonephritis, the “$>10^5$ cfu/ml” rule breaks down; fewer colonies can be significant. Up to 20% of young women with acute uncomplicated pyelonephritis have between $10^3$ and $10^4$ cfu/ml.

- In catheterized patients in whom specimens are obtained directly from the catheter, between $10^2$ and $10^4$ cfu/ml may be significant.
Urinary tract bacteriology (3)

- Patients with uncomplicated infection almost usually have a single organism;

- In complicated infections more than one organism may be seen (IDC)

- *Unspun* midstream urine: One bacterium/high-powered field (hpf) correlates with $> 10^5$/ml (thus, high positive predictive value)
Urinary tract bacteriology (4)

- Gram’s stain of *spun* urine: absence of visible bacteria makes $> 10^5$ cfu/ml highly unlikely (that is, high negative predictive value)

- 20% of patients with urinary tract infection do not have pyuria
Etiology of community-acquired UTI

- Aerobic gram-negative rods most often
- *E. coli* accounts for about 90%

- *Staphylococcus saprophyticus* has been increasingly appreciated in recent years (with seasonality, tending to occur in the summer)
  - Especially young females
- Rare: anaerobes; pyogenic cocci; viruses

BEWARE OF TUBERCULOSIS
RECURRENT UTI? CANDIDA
Etiology of nosocomial UTI

- *E. coli* is the most common pathogen

- However, also common are other Enterobacteriaceae (*Proteus, Klebsiella, Enterobacter, Serratia, Providencia* species) and Pseudomonadaceae (notably, *Pseudomonas aeruginosa*)

- Enterococci: often in obstructive uropathy

- Yeasts: *Candida albicans*, others
Asymptomatic bacteriuria

- Pregnancy
- Elderly
- Sexually active
- Tract abnormalities
Risk factors for UTI

**Female**
- Previous urinary tract infection
- Urologic instrumentation or surgery
- Urethral catheterization
- Urinary tract obstruction, including calculi
- Neurogenic bladder
- Renal transplantation
- Sexual intercourse
- Spermicidal contraceptive jellies
- Pregnancy
- Lower socioeconomic group
- Diabetes
- Functional or mental impairment
- Estrogen deficiency (loss of vaginal lactobacilli)
- Bladder prolapse

**Male**
- Lack of circumcision (children and young adults)
- Urologic instrumentation or surgery
- Urethral catheterization
- Urinary tract obstruction including calculi
- Neurogenic bladder
- Renal transplantation
- Functional or mental impairment
- Prostatic enlargement
- Condom catheter drainage
Symptoms of UTI

- **Children**
  - FTT, vomiting, unwell, abdo pain, fever
  - Behaviour problems

- **Elderly**
  - Confused
  - Behaviour problem
  - FUO

- **Adults-classic**
  - Dysuria, frequenturia, Loin pain, fever, chills
Case #1

• 5 year old girl

• presents with high fever, dysuria and abdominal pain.

• She was treated for a urinary tract infection two months ago.

• Urinalysis with evidence of pyuria
Figure 66-5 **Vesicoureteral reflux in a young girl with recurrent urinary tract infections.** A, Right kidney demonstrates grade II reflux. B, Left kidney shows dilatation of the ureter, grade III reflux, and calyceal clubbing. *(Courtesy of T. Slovis, M.D.)*
Urinary Tract Infections in children

• Infants:
  • overall rate is about 1-2% (higher in males than in females in the first 3 months)

• Preschool children:
  • UTI is 10 to 20 times more common in girls.
  • If seen in males usually associated with congenital abnormalities

• School-aged children:
  • about 1.2% of schoolgirls have bacteriuria on any given day
Urinary Tract Infection in children

- Vesicoureteral reflux
  - Most common urologic anomaly in children
  - Retrograde passage of urine from the bladder into the upper urinary tract

- Microbiology
  - *E. coli* is the most common pathogen (80%)
  - Klebsiella, Proteus, Enterobacter, *Staphylococcus saprophyticus*
  - Viruses like adenovirus, enterovirus less common and usually associated with lower UTI

BEWARE: Worm Infection
UTI in adults

- Women:
  - bacteriuria increases with age and sexual activity

- Men:
  - bacteriuria is rare before age 50 (and as a corollary, calls for more aggressive evaluation than in women).
  - Subsequently, bacteriuria increases with onset of prostatism
upper versus lower UTI

- Frequency, dysuria, and urgency (lower UTI symptoms) can occur with upper UTI as well.

- Fever and flank pain indicate acute upper UTI.

- Scarring of the kidney by imaging procedures suggests chronic UTI.

- The distinction is sometimes difficult
Acute uncomplicated cystitis in young women

- Acute bacterial cystitis is usually characterized by sudden onset, multiple urinary symptoms, pyuria, and sometimes hematuria

- Acute dysuria in young women usually indicates:
  - acute bacterial cystitis; the urethral syndrome; or vaginitis
Acute uncomplicated cystitis in young women

- Although most patients have lower urinary symptoms only, 30% to 50% may have subclinical renal involvement

- Causes: *E. coli* (80%), *S. saprophyticus* (10% to 15%), and occasionally *Klebsiella, Proteus mirabilis*, and other microorganisms
Acute uncomplicated cystitis in young women

- A short course of antibiotics (e.g., three days) usually suffices

- Abbreviated work-ups (e.g., leukocyte-esterase nitrite test) without culture or routine follow-up is now acceptable for typical encounters.
Acute uncomplicated pyelonephritis in young women

- Largely a clinical diagnosis

- Pyuria is usually present; about 20% have positive blood cultures; causative organisms the same as with cystitis

- Predisposing factors: structural abnormalities; strains of *E. coli* with unique markers; genetically-determined carbohydrate receptors on uroepithelial cells
White blood cell casts

- Highly significant!
- Presence suggests pyelonephritis
Recurrent UTI

This may be either relapse or reinfection:

- Relapse: is a recurrence with the same infecting microorganism that was present before therapy was started (due to persistence of organism in the urinary tract)

- Reinfection: recurrence with a microorganism that is different from the original infecting bacterium. It is a new infection. Sometimes can be the same microorganism.
Recurrent UTIs in women

- Between 20% and 25% of young women with acute uncomplicated cystitis have two or more infections per year, usually due to reinfection with a different *E. coli* strain.

- Predisposing factors: genetically-determined receptors on uroepithelial cells; diaphragm-spermicide use.
Catheter-associated UTI

- Over 1 million catheter-associated UTIs occur in the United States each year

- Risk factors: female sex; duration of catheterization; disconnecting the junction between the catheter and the collecting tube

- Rule: Change IDC after 2 weeks.
Care of the Urinary Catheter

ENTRY POINTS FOR BACTERIA

1. URETHRAL MEATUS AND AROUND CATHETER.
2. JUNCTION BETWEEN CATHETER AND COLLECTION TUBE.
3. CONNECTION TO DRAINAGE BAG AND REFLUX FROM BAG TO TUBING.
4. MOUTH OF THE SPIGOT
UTI and asymptomatic bacteriuria in pregnancy

- Bacteriuria occurs 2-7% all pregnancies
- Usually occurs in the first trimester
- Smooth muscle relaxation and urethral dialatation seen in pregnancy
- Greater propensity to progress to pyelonephritis (up to 40%)
UTI and asymptomatic bacteriuria in pregnancy

- Microorganisms same as in nonpregnant women
- If left untreated, associated with preterm birth, low birth weight & perinatal mortality
- UTI occurs in approximately 1% of pregnant women
BACTERIURIUA IN PREGNANCY
The incidence of clinical acute pyelonephritis

3.9%
Treated Bacteriuria

26.7%
Untreated Bacteriuria
Sterile Pyuria

- Poor collection
- Treated UIT
- Analgesic nephropathy
- TB of Urinary Tract
- Calculi (staghorn)
- Bladder Tumours
Case #2

- 32 year old male
- Recurrent episodes of UTI with Proteus
- Complains of flank pain and hematuria
Figure 66-4 Staghorn calculus visible in the dilated pelvis of a hydronephrotic kidney. (Courtesy of M. Bergeron, M.D.)
Urease-producing microorganisms

- Urease splits urea into ammonia, which has a direct toxic effect on the kidney; inactivates C4, and alkalinizes the urine with production of struvite crystals (MgNH₄P0₄·6H₂O) crystals

- *Proteus mirabilis* most often; also *Providencia*, *Morganella*, *S. saprophyticus*, *Klebsiella*, Corynebacterium D2; mycoplasma
Prostatitis

- Relapsing acute UTI in men caused by the same bacterial species often suggests chronic prostatitis with periodic spill-over into the bladder

- Symptoms: pelvic “heaviness,” rectal or perineal pain, urinary hesitancy, dribbling, and burning

- A risk of catheterization
Computed tomogram demonstrating a large prostatic abscess (arrow) adjacent and lateral to the urethra. The rectum contains contrast material.
References:

- Harrison’s Principle of Medicine 17th Edition
- www.uptodate.com