Microbiology of Urogenital system

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Lecture 1

Overview

In this lecture, we will discuss the following regarding urinary tract infections (UTI):

- Urinary tract defenses.
- UTI clinical entities.
- UTI epidemiology and predisposing factors.
- UTI etiology and pathophysiology.

Urinary tract defenses

The urinary tract is typically a **sterile environment**, and bacterial colonization of the bladder epithelium does not go unchallenged. This happens in several ways:

- The bulk **flow of urine** through the bladder and micturition can work to **rinse away** nonattached or weakly adherent microbes from the bladder surface
- **Periurethral and Urethral microbiota**: lactobacilli, coagulase negative staph, corynebacterium and streptococci that form barriers against colonization. Changes in estrogen, low vaginal pH and cervical IgA affect colonization by normal flora.
- The low pH and osmolarity of urine can be inhibitory to bacterial growth, and the salts, urea, and organic acids present in urine can reduce bacterial survival
- Lactoferrin within urine can scavenge essential iron away from incoming microbes.

Urinary tract defenses

- A number of soluble and cell associated factors within the bladder, including Tamm-Horsfall protein, low molecular weight sugars, secretory IgA, and uromucoid, can act as anti-adherence factors, competitively inhibiting bacterial attachment to the bladder surface
- Bladder Epithelium expresses Toll-like receptors (TLRs) that recognize bacteria and initiate immune/inflammatory response (PMNs, neutrophils, macrophages, eosinophils, NK cells, mast cells and dendritic cells). Adaptive immune response then predominates (T and B lymphocytes). Induced exfoliation of cells also occurs to allow excretion of bacterial colonization.
- Kidney has Local immunoglobulin/ antibody synthesis in the kidney occurs in response toinfections (IgG, IgA)



Bacteria ascending into the bladder through the urethra is the most common cause of UTIs. There are several risk factors that may promote or encourage bacterial ascent:

Reduced Urine Flow

- outflow obstruction with incomplete bladder emptying (prostatic hyperplasia or foreign body)
- neurogenic bladder
- inadequate fluid uptake
- voiding dysfunction

Facilitate Ascent

- catheterization (chronic or intermittent)
- urinary incontinence
- fecal incontinence
- residual urine with ischemia of bladder wall

Definitions

The term urinary tract infection (UTI) encompasses a variety of clinical entities, including :

- Asymptomatic bacteriuria (ASB)
- Cystitis
- Prostatitis
- Pyelonephritis.



Definitions

When discussing UTI's it is important to distinguish among the following terms:

Contamination

– organisms are introduced during collection or processing of urine. No health care concerns

Asymptomatic bacteriuria (Colonization)

 organisms are present in the urine but are causing no illness or symptoms. Depending on the circumstances, significance is variable, and the patient often does not require treatment

Infection (UTI)

– the combination of a pathogen(s) within the urinary system and symptoms and/or inflammatory response to the pathogen(s) requiring treatment

Definitions

Uncomplicated UTI

 infection in a healthy, non-pregnant, pre-menopausal female patient with anatomically and functionally normal urinary tract

Complicated UTI

- infection associated with factors increasing colonization and decreasing efficacy of therapy

Recurrent UTI

– occurs after documented infection that had resolved. Defined as 2 or more infections in 6
 months, or > 3 infections in 12 months

Reinfection UTI

– a new event with reintroduction of bacteria into urinary tract or by different bacteria
 Persistent UTI

– UTI caused by same bacteria from focus of infection.

- As many as 50–80% of women in the general population acquire at least one UTI during their lifetime—uncomplicated cystitis in most cases.
- About **20–30%** of women who have had one episode of UTI will have **recurrent episodes**.
- Early recurrence (within 2 weeks) is usually regarded as relapse rather than reinfection and may indicate the need to evaluate the patient or a sequestered focus.
- Asymptomatic bacteriuria occurs in all age groups and does not necessarily result in clinical infection.
- Asymptomatic bacteriuria occurs in 1–3% of non- pregnant women and 2–9.5% of pregnant women.

- Urinary tract infections are the **most common type of healthcare-associated infection**, accounting for more than 30% of infections reported by acute care hospitals.
- Virtually all healthcare-associated UTIs are caused by instrumentation. (Catheterassociated urinary tract infection (CAUTI))
- The source of microorganisms causing CAUTI can be endogenous, typically via meatal, rectal, or vaginal colonization, or exogenous, such as via contaminated hands of healthcare personnel or equipment.

Table 1 Incidence of Urinary Tract Infection According to Age and Sex

| Age Group | Incidence (%) | Approximate Sex Ratio (Male:Female) |
|------------------|---------------|-------------------------------------|
| Neonatal | 1.0 | 1.5:1.0 |
| Preschool age | 1.5-3.0 | 1:10 |
| School age | 1.2 | 1:30 |
| Reproductive age | 3-5 | 1:50 |
| Geriatric | 10-30 | 1:1.5 |

Clinically, UTIs are categorized as uncomplicated or complicated:

- Uncomplicated UTIs typically affect individuals who are otherwise healthy and have no structural or neurological urinary tract abnormalities
- Complicated UTIs are defined as UTIs associated with factors that compromise the urinary tract or host defence, including urinary obstruction, urinary retention caused by neurological disease, immunosuppression, renal failure, renal transplantation, pregnancy and the presence of foreign bodies such as calculi or indwelling catheters.

Etiology of UTIs



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Uropathogenic *E.coli* (UPEC)



- A gram negative rod, facultative anaerobe. The optimum growth temperature is 37°C. On Nutrient agar, colonies are large, thick, greyish white, moist, smooth.
- E. coli and other facultative anaerobes constitute about 0.1% of **gut microbiota**.

Enterococcus faecalis

- The enterococci are gram-positive cocci, typically arranged in **pairs and short chains** .
- *E. faecalis* is found in the large intestine in high concentrations (e.g., 10⁵ to 10⁷ organisms per gram of feces) and in the genitourinary tract.
- enterococci are one of the most common causes of infections acquired in the hospital (nosocomial infection). The urinary tract is the most common site of enterococcal infections, and infections are frequently associated with urinary catheterization or instrumentation.



Klebsiella pneumoniae

- *Klebsiella* species are routinely found in the human nose, mouth, and gastrointestinal tract as normal flora.
- The ability of *K. pneumoniae* to colonize the hospital environment, including carpeting, sinks, flowers, and various surfaces, as well as the skin of patients and hospital staff, has been identified as a major factor in the spread of hospital-acquired infections



Proteus mirabilis

Proteus mirabilis is a Gramnegative, facultatively anaerobic, rod-shaped bacterium. It shows swarming motility and urease activity.

A direct result of **urease** activity and ammonia generation is an **increase in local pH**. In the urinary tract alkaline pH leads to precipitation of calcium and magnesium ions and the formation of **urinary stones** composed of magnesium ammonium phosphate (**struvite**) and calcium phosphate (**apatite**)



Some important acronyms in antimicrobial resistance

- Antimicrobial resistance (AMR)
- Multidrug resistant (MDR)
- Extensively drug-resistant (XDR)
- **ESKAPE** is an acronym comprising the scientific names of six **highly** virulent and antibiotic-resistant bacterial pathogens including Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter spp. The acronym is sometimes extended to ESKAPEE to include Escherichia coli.



Virulance factors in UPEC (many factors are shared with other bacteria causing UTI)

- adhesive **fimbriae**, which enable bacteria to adhere avidly to specific receptors on the urothelium.
- flagella that enable bacteria to swim along the urinary tract including 'upstream' from the bladder to the kidneys.
- toxins, such as haemolysin and cytotoxic necrotizing factor, which disrupt the epithelial barrier and enable access to the underling tissue
- **siderophores**, which enable bacteria to chelate iron that is important for growth
- expression of cell surface capsules, which enable them to resist the bactericidal actions of complement and phagocytic cells





Vaginal ecology Anatomy/urinary retention Medical devices

FIGURE 33-1

Pathogenesis of urinary tract infection. The relationship among specific host, pathogen, and environmental factors determines the clinical outcome.

Pathophysiology of UTIs





Pathophysiology of UTIs



Pathophysiology of UTIs



1.What is the most common pathogen responsible for UTIs in women? a) Escherichia coli b) Klebsiella pneumoniae c) Staphylococcus aureus d) Streptococcus pyogenes Answer: a) Escherichia coli

2.Which age group is most commonly affected by UTIs? a) Infants and toddlers b) Adolescents c) Young adults d) Older adults

Answer: d) Older adults

3.Which gender is more prone to develop UTIs? a) Males b) Females c) Both genders are equally affected d) It depends on the age group

Answer: b) Females

4. Which anatomical factor increases the risk of developing UTIs in women? a) Shorter urethra b) Longer urethra c) Narrower urethra d) Wider urethra

Answer: a) Shorter urethra

5. Which condition is a risk factor for recurrent UTIs? a) Hypertension b) Diabetes

mellitus c) Hypothyroidism d) Asthma

Answer: b) Diabetes mellitus

6.What is the most common mode of transmission for UTIs? a) Airborne transmission b) Direct contact transmission c) Vector-borne transmission d) Foodborne transmission Answer: b) Direct contact transmission

7.What is the most common site of infection in UTIs? a) Kidneys b) Bladder c) Ureters d) Urethra

Answer: d) Urethra

Further reading:

- Oxford handbook of infectious diseases and microbiology-Part4: Clinical syndroms
 Chapter 17 Urinary tract infections
- Harrison's Infectious Diseases 3rd Edition
 SECTION III Infections in organ systems
 Chapter 33