CHAPTER 26

Microbial Diseases of the Urinary and Reproductive Systems

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Structure and Function of the Urinary System

- **Urinary system**
  - Two kidneys
  - Two ureters
  - One urinary bladder
  - One urethra

- Infection prevented by:
  - Valves that prevent backflow to the kidneys
  - Acidity of urine
  - Mechanical flushing

Figure 26.1 Organs of the human urinary system, shown here in the female.
Structure and Function of the Reproductive Systems

- **Female reproductive system**
  - Two ovaries
  - Two uterine (fallopian) tubes
  - The uterus, including the cervix
  - The vagina
  - External genitals (vulva)

Figure 26.2 Female reproductive organs.

(a) Side view section of female pelvis showing reproductive organs

(b) Front view of female reproductive organs, with the uterine tube and ovary to the left in the drawing sectioned. The fimbriae move to create fluid movement that moves the egg into the uterine tube.
Structure and Function of the Reproductive Systems

- **Male reproductive system**
  - Two testes
  - System of ducts
    - Epididymis
    - Ductus (vas) deferens
    - Ejaculatory duct
    - Urethra
  - Accessory glands
  - Penis

Figure 26.3 Male reproductive and urinary organs.
Normal Microbiota of the Urinary and Reproductive Systems

- Urinary bladder and upper urinary tract are sterile
- Predominant microbes of the vagina:
  - Lactobacilli
    - Produce H$_2$O$_2$ and lactic acid
    - Growth promoted by estrogen
  - Streptococci, anaerobes, some gram-negatives
  - *Candida albicans* yeast
- Male urethra is usually sterile

Bacterial Diseases of the Urinary System

- **Urethritis**
  - An inflammation of the urethra
- **Cystitis**
  - An inflammation of the urinary bladder
- **Ureteritis**
  - Infection of the ureters
- **Pyelonephritis**
  - An inflammation of one or both kidneys
  - 7 million urinary tract infections annually
  - Most due to *Escherichia coli*
Cystitis

- Commonly caused by *E. coli*; also *Staphylococcus saprophyticus*
- Dysuria (difficult or painful urination); pyuria
- Eight times more common in women than men
  - Due to the short length of the urethra
- Diagnosis: >100 CFU/ml of potential pathogens and a positive leukocyte esterase (LE) test
- Treatment with trimethoprim-sulfamethoxazole

Pyelonephritis

- 75% of cases caused by *E. coli*
- Fever and back or flank pain
- Generally results in bacteremia
- Can form scar tissue in kidneys and become life-threatening
- Diagnosis: >10,000 CFU/ml and a positive LE test
- Treatment with cephalosporin
Leptospirosis

- Caused by *Leptospira interrogans*
  - Fine spiral; stains poorly; obligate aerobe
- Transmitted by skin/mucosal contact from urine-contaminated water from domestic or wild animals
- Headaches, muscular aches, fever
  - Kidney failure (Weil's disease)
  - Pulmonary hemorrhagic syndrome
- Diagnosed with a rapid serological test
- Treatment with doxycycline
Diseases in Focus: Bacterial Diseases of the Urinary System

• A 20-year-old woman feels a stinging sensation when urinating and feels an urgent need to urinate, even if very little urine is excreted. Lactose-fermenting, gram-negative rods are cultured from her urine.

• Can you identify infections that could cause these symptoms?
Bacterial Diseases of the Reproductive Systems

- **Sexually transmitted diseases (STDs)**
  - Also known as *sexually transmitted infections (STIs)*
  - Often no signs or symptoms
  - Over 30 types of infections
  - 15 million new cases in the United States annually
  - Treatment with antibiotics and prevented with condoms
Big Picture: STI Home Test Kits

- Collect samples at home and mail to a lab
  - Screens for chlamydia, gonorrhea, and trichomoniasis
    - Results in 1–2 weeks
    - Positive tests receive referrals to clinics
- Test for HIV
  - OraQuick: oral test
- Test for urinary tract infections
  - Uritest dipstick test
Big Picture: STI Home Test Kits

- Pros of at-home testing
  - More cases are diagnosed
  - Better access for patients
  - Quicker treatment

- Cons of home-testing
  - Cost
  - Privacy
  - Not all home test kits are equally accurate

**Negative Result**
If there is no line next to the “T”, the result is negative.

**Positive Result**
If there is a line next to the “T”, however faint, the result is positive.

A positive OraQuick HIV test contains a synthetic HIV gp-41 protein. If the sample contains antibodies against gp-41, the T strip changes color due to an enzyme reaction.
Gonorrhea

- Caused by *Neisseria gonorrhoeae*
  - Gram-negative diplococcus
- 300,000 cases in the United States annually
- Attaches to the epithelial mucosa by the fimbriae
  - Invades the spaces between the columnar epithelial cells
  - Causes inflammation
  - Forms pus
  - Pharyngeal gonorrhea and anal gonorrhea

Figure 26.5a The U.S. incidence and distribution of gonorrhea.

(a) Incidence of gonorrhea in the United States, 1941–2013
Gonorrhea

- **Symptoms**
  - Men: painful urination and discharge of pus; epididymitis
  - Women: fewer symptoms; pelvic inflammatory disease
- If left untreated, may disseminate and become systemic
  - Endocarditis
  - Meningitis
  - Arthritis
- **Ophthalmia neonatorum**: infant blindness due to a gonorrheal infection of the eyes
Gonorrhea

• No adaptive immunity
  • Antigenic variability
  • Opa proteins bind to T cell receptors, preventing activation and immunological memory
• Diagnosis with Gram stain, ELISA, or monoclonal antibodies
• Treatment first with cephalosporins
  • Fluoroquinolones not recommended due to resistance
Figure 26.7 A smear of pus from a patient with gonorrhea.

Leukocyte nuclei

Neisseria gonorrhoeae

Clinical Focus 26.1

<table>
<thead>
<tr>
<th>Year</th>
<th>Penicillin</th>
<th>Tetracycline</th>
<th>Fluoroquinolones</th>
<th>Azithromycin</th>
<th>Ceftriaxone</th>
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<tr>
<td>1988</td>
<td>20%</td>
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<td>2005</td>
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<td>2008</td>
<td>5%</td>
<td>10%</td>
<td>30%</td>
<td>25%</td>
<td>40%</td>
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<tr>
<td>2012</td>
<td>5%</td>
<td>5%</td>
<td>20%</td>
<td>20%</td>
<td>25%</td>
</tr>
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</table>
Nongonococcal Urethritis (NGU)

- **Nonspecific urethritis (NSU)**
  - Any inflammation of the urethra not caused by *N. gonorrhoeae*
- Caused by:
  - *Chlamydia trachomatis*
  - *Mycoplasma hominis*
  - *Ureaplasma urealyticum*
- Painful urination and watery discharge; often asymptomatic; pelvic inflammatory disease (PID) in women
- Diagnosis: culture or PCR
- Treatment with doxycycline and azithromycin

Pelvic Inflammatory Disease (PID)

- Extensive bacterial infection of the female pelvic organs
- Polymicrobial infection, usually:
  - *N. gonorrhoeae*
  - *C. trachomatis*
- Chronic abdominal pain
- **Salpingitis**: infection of the uterine tubes
  - Most serious form of PID
  - Scarring can cause infertility or ectopic pregnancy
- Treatment with doxycycline and cefoxitin
Syphilis

- Caused by *Treponema pallidum*
  - Gram-negative spirochete
  - Grows slowly in cell culture
  - Invades the mucosa or through skin breaks and enters the bloodstream
  - Induces an inflammatory response
  - Some strains cause *yaws*
    - Skin disease is not sexually transmitted
  - Stable incidence in the United States
Figure 26.9 Treponema pallidum, the cause of syphilis.

Figure 26.10  The U.S. incidence and distribution of primary and secondary syphilis.

Note: The primary and secondary syphilis rate in the United States and territories (Guam, Puerto Rico, and Virgin Islands) was 5.1 cases per 100,000 population.

(b) Geographical distribution of cases in 2012
Syphilis

• **Primary stage**
  • **Chancre** at the site of infection about 3 weeks after exposure
    • Painless and highly infectious
    • Disappears after 2 weeks
  
• **Secondary stage**
  • Skin and mucosal rashes, especially on the palms and soles
    • Due to an inflammatory response
  
• **Latent period**
  • No symptoms

Syphilis

• **Tertiary stage**
  • Appear years after latency
    • Due to cell-mediated immune reactions
  • Gummatous syphilis: **gummas** on many organs
  • Cardiovascular syphilis: weakens the aorta
  • Neurosyphilis: affects the CNS; dementia
  
• **Congenital**: neurological damage to the fetus
Syphilis

- Microscopic tests
  - Direct fluorescent-antibody test (DFA-TP) with monoclonal antibodies
- Nontreponemal serological tests
  - Slide agglutination VDRL test
  - Rapid plasma reagin (RPR) test
- Treponemal-type serological tests
  - Enzyme immunoassay (EIA)
  - Fluorescent treponemal antibody absorption test (FTA-ABS)
- Treatment with benzathine penicillin
Lymphogranuloma Venereum (LGV)

- Caused by *C. trachomatis*
- Infects the lymphoid tissue
  - Regional lymph nodes become enlarged and tender
  - Discharge of pus and scarring
- Diagnosis with blood test for antibodies to the organism
- Treatment with doxycycline

Chancroid (Soft Chancre)

- Caused by *Haemophilus ducreyi*
  - Gram-negative rod
- Associated with drug use
- Painful ulcers of the genitals and swollen lymph nodes in the groin
  - Factors in the sexual transmission of HIV
- Treatment with azithromycin or ceftriaxone
Bacterial Vaginosis

- Caused by *Gardnerella vaginalis*
  - Pleomorphic gram-negative rod
- **Vaginitis**: inflammation of the vagina due to infection
- **Vaginosis**: no sign of inflammation
- pH above 4.5, fishy odor, copious frothy discharge
- Clue cells
  - Sloughed-off vaginal epithelial cells covered with a biofilm of *G. vaginalis*
- Treatment with metronidazole

Figure 26.12 Clue cells.
Genital Herpes

- Caused by herpes simplex virus type 2 (HSV–2)
  - In the United States, 1 in 4 over age 30 are infected
- Painful vesicles on the genitals; painful urination
  - Heals within 2 weeks
- Recurrences from viruses latent in nerve cells
  - Due to menstruation, emotional stress, or illness
- Diagnosis via culture or PCR
- No cure; suppression and management with acyclovir, famciclovir, and valacyclovir
Neonatal Herpes

- Herpesvirus crosses the placental barrier and infects the fetus
  - Damages the CNS, developmental delays, blindness, hearing loss
- Survival rate of 40%
- Newborns infected from HSV exposure during delivery
- Diagnosed by PCR tests and fluorescent antibody tests
- Treatment with intravenous acyclovir
Genital Warts

- Also known as condyloma acuminata
- Caused by human papillomaviruses
- 25% of 14- to 59-year-old women in the United States are infected
- Visible warts caused by serotypes 6 and 11
- Serotypes 16 and 18 cause cervical cancer
  - Kills 4000 women in the United States annually
- Treatment via removal of warts; podofilox and imiquimod
- Prevention with the Gardasil and Cervarix vaccines

Figure 26.15  Genital warts on a vulva.
Candidiasis

- Caused by *C. albicans*
  - Grows on the mucosa of the mouth, the intestinal tract, and the genitourinary tract
  - Due to opportunistic overgrowth caused by:
    - Antibiotic use
    - Diabetes
    - Hormones
- **Oral candidiasis:** thrush
- **Vulvovaginal candidiasis:** vaginitis
- Yeasty, thick, yellow discharge
- Treatment with clotrimazole or fluconazole

Trichomoniasis

- Caused by *Trichomonas vaginalis*
  - Normal inhabitant of the vagina and urethra
  - Grows when normal acidity of the vagina is disturbed
  - Irritation and a profuse foul, greenish yellow frothy discharge
  - Diagnosis with microscopic identification or a DNA probe
  - Treatment with metronidazole
The TORCH Panel of Tests

- Panel of tests that screens for antibodies to infections in pregnant women
- Toxoplasmosis
- Other (such as syphilis, hepatitis B, enterovirus, Epstein-Barr virus, varicella-zoster virus)
- Rubella
- Cytomegalovirus
- Herpes simplex virus
Diseases in Focus: Microbial Diseases of the Reproductive System

- A 26-year-old woman has abdominal pain, painful urination, and fever. Cultures grown in a high-CO₂ environment reveal gram-negative diplococci.
- Can you identify infections that could cause these symptoms?
### Diseases in Focus 26.3 (2 of 3)

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Symptoms</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonorhea</td>
<td>Neisseria gonorrhoeae</td>
<td>Painful urination and discharge of pus. Women: few symptoms but possible complications, such as PID.</td>
<td>Ceftriaxone</td>
</tr>
<tr>
<td>Meningococcal Urethritis (Meningitis)</td>
<td>Neisseria meningitidis</td>
<td>Painful urination and discharge of pus. Women: few symptoms but possible complications, such as PID.</td>
<td>Ceftriaxone</td>
</tr>
<tr>
<td>Pelvic Inflammatory Disease (PID)</td>
<td>N. gonorrhoeae, C. trachomatis</td>
<td>Chronic abdominal pain, possible infertility</td>
<td>Doxycycline, antibiotics</td>
</tr>
<tr>
<td>Syphilis</td>
<td>Treponema pallidum</td>
<td>Initial sore at site of infection, later skin rashes and mild fever; late stages may be severe, damage to cardiovascular and nervous systems.</td>
<td>Benzathine penicillin</td>
</tr>
<tr>
<td>Lymphogranuloma Venereum (LVG)</td>
<td>C. trachomatis</td>
<td>Swelling in lymph nodes in groin</td>
<td>Doxycycline</td>
</tr>
<tr>
<td>Chancroid (Soft Chancroid)</td>
<td>Haemophilus ducreyi</td>
<td>Painful ulcers of genitals; swollen lymph nodes in groin</td>
<td>Erythromycin, colistin</td>
</tr>
</tbody>
</table>

### Diseases in Focus 26.3 (3 of 3)

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<th>Treatment</th>
</tr>
</thead>
<tbody>
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<td>Genital Herpes</td>
<td>Herpes simplex virus type 2/HSV type 1</td>
<td>Painful vesicles in genital area</td>
<td>Acyclovir</td>
</tr>
<tr>
<td>Genital Warts</td>
<td>Human papillomaviruses</td>
<td>Warts in genital area</td>
<td>Podofilox, imiquimod, preventive vaccine</td>
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<td>AIDS</td>
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<td>Fungal Disease</td>
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