CHAPTER 12 –URINARY SYSTEM

OBJECTIVES

On completion of this chapter, you will be able to:

• Describe the organs of the urinary system.
• State the vital function of the urinary system.
• Describe the formation of urine.
• Describe urinalysis.
• Identify the normal constituents of urine.
• Identify abnormal constituents of urine.
• Analyze, build, spell, and pronounce medical words.
• Describe each of the conditions presented in the Pathology Spotlights.
• Comprehend the drugs highlighted in this chapter.
• Describe diagnostic and laboratory tests related to the urinary system.
• Identify and define selected abbreviations.
• Review the Pathology Checkpoint.
• Complete the Study and Review section and the Chart Note Analysis.

OUTLINE

I. Anatomy and Physiology Overview

The urinary system consists of two kidneys, two ureters, one bladder, and one urethra (Figs. 12–1 and 12–2, pp. 370, 371) (Table, p. 371). It is also known as the excretory system, genitourinary system (GU), or urogenital system (UG). The vital function of the urinary system is to provide:

• Excretion of certain wastes from the bloodstream.
• Conversion of these materials to urine.
• Transport of the urine from the kidneys via the ureters to the bladder.
• Elimination of urine at appropriate intervals via the urethra.

A. Kidneys – purplish-brown, bean-shaped organs located at the back of the abdominal cavity. There is one on each side of the spinal column, just above the wasteline, against the muscles in the back. Each kidney is surrounded by three capsules:

• True Capsule – a smooth fibrous connective membrane that is loosely adheres to the surface of the kidney.
• Perirenal Fat – the adipose capsule that embeds each kidney in fatty tissue.
• Renal Fascia – a sheath of fibrous tissue that helps to anchor the kidney to the surrounding structures and helps to maintain its normal position.

1. External Structure – each kidney has a concave and a convex border. The center of the concave border opens into a notch called the hilum in which the renal artery and vein, nerves, and lymphatic
vessels enter and leave. The ureter enters the kidney through the hilum into a saclike collecting portion called the renal pelvis.

2. **Internal Structure** – there are two distinct areas of the kidney as seen on cross section:
   a. **Cortex** – the outer layer that contains the arteries, veins, convoluted tubules, and glomerular capsules.
   b. **Medulla** – the inner layer that contains the renal pyramids, conelike masses with papillae projecting into calyces of the pelvis.

3. **Microscopic Anatomy**– there are about 1 million **nephrons**, which are the structural and functional units of the kidney. Each nephron contains:
   a. **Renal Corpuscle** – also known as malpighian consists of a:
      - Glomerulus
      - Bowman’s capsule
   b. **Tubule** – extends from the Bowman’s capsule and consists of:
      - Proximal convoluted portion
      - Loop of Henle
      - Distal convoluted portion that opens into a collecting tubule

4. **Nephron (Fig. 12–3, p. 373)** – The vital function of the nephron is to remove the waste products of metabolism from the blood plasma. The waste products are:
   - Urea
   - Uric acid
   - Creatinine
   - Excess sodium, chloride, and potassium ions
   - Ketone bodies

   The nephrons also aid in maintenance of normal fluid balance in the body by allowing for reabsorption of water and some electrolytes back into the blood.

B. **Ureters** – there is one ureter for each kidney. They are from 28 to 34 centimeters (cm) long and transport urine from the kidneys to the bladder. Each ureter consists of three layers:
   - **Mucous Membrane** – inner coat.
   - **Smooth Muscle** – middle coat.
   - **Fibrous Tissue** – outer coat.

C. **Urinary Bladder** – the muscular, membranous sac that serves as a reservoir for urine. It is located in the anterior pelvic cavity and consists of four layers. The parts of the bladder are:
   - **Neck** – lower portion that is continuous with the urethra.
   - **Apex** – upper portion that is connected with the umbilicus by the median umbilical ligament.
• **Trigone** – small triangular area near the base of the bladder. The wall of the bladder, which is thick when empty and thin when the bladder becomes distended, consists of four layers:
  • **Inner Layer of Epithelium**
  • **Muscular Coat of Smooth Muscle**
  • **Outer Layer of Longitudinal Muscle**
  • **Fibrous Layer**

D. **Urethra** – a musculomembranous tube extending from the bladder to the outside of the body. The external opening is the **urinary meatus**. The major differences between the male and female urethra is as follows:
1. **Male Urethra** – approximately 20 cm long, it carries both urine and semen. It is divided into three sections:
   • Prostatic
   • Membranous
   • Penile
2. **Female Urethra** – approximately 3 cm long situated between the clitoris and the opening of the vagina, it conveys only urine.

E. **Urine** – waste product of fluid and dissolved substances (95% water and 5% solid substances) secreted by the kidneys, transported by the ureters to the urinary bladder where it is stored until it is voided through the urethra.
1. **Formation of Urine** (Fig. 12–4, p. 374) – urine is formed by the process of **filtration** and **reabsorption** in the nephron. Blood enters the nephron via the afferent arteriole, passes through the glomerulus, where water and dissolved substances are filtered and collected in the Bowman’s capsule, passes through the proximal tubule, into the loop of Henle, the distal tubule, and then the collecting tubule.
2. **Urinalysis (UA)** (Table 12–1, p. 375) – the laboratory procedure that involves the physical, chemical, and microscopic examination of urine. A freshly voided urine specimen will provide a more accurate test result. If a bacteriologic culture is necessary, the specimen will be collected by **catheterization**. Because the physical and chemical constituents of normal urine are constant, urinalysis is a valuable diagnostic tool.
II. Life Span Considerations
A. The Child – during the embryonic stage, the urinary and reproductive organs arise from one of the three layers of cells, the **mesoderm**. At approximately 3 months, the fetal kidneys begin to secrete urine with the amount increasing with fetal age. Glomerular filtration and absorption are relatively low under the age of 2; therefore there is a lack of ability to concentrate urine. The kidneys are also more susceptible to trauma because of the lack of fat padding. Urinary conditions common to infants and children include:

- **Fluid Volume Changes**
- **Fluid Volume Excess and/or Dehydration**
- **Urinary Tract Infections (UTIs)** – caused by microorganisms *Escherichia coli*, *Klebsiella*, and *Proteus*. Signs and symptoms are age related (Table 12–2, p. 376).

B. The Older Adult – during the fourth decade kidneys may lose mass as blood vessels degenerate resulting in a decrease in size and function. By the eighth decade, the kidneys have shrunk 30% and have lost a proportionate amount of function. Some of the changes in the aging kidneys, along with their effects, are as follows:

- **Loss of Glomerular Capillaries** – results in decrease in glomerular filtration and the kidneys lose their ability to conserve water and sodium.
- **Tubules** – diminish in their capacity for conserving base and ridding the body of excess hydrogen ions.
- **Fluid and Electrolyte Imbalance**
- **Urge Incontinence** – the inability to retain urine voluntary.
- **Stressful Situations** – the following may cause the kidneys to respond slower thus contributing to fluid and electrolyte imbalance:
  - Vomiting and diarrhea
  - Surgery
  - Diuretics
  - Decreased fluid intake
  - Fever
  - Renal damage from medications

III. Building Your Medical Vocabulary
A. **Medical Words and Definitions** – this section provides the foundation for learning medical terminology. Medical words can be made up of four types of word parts:

1. **Prefix (P)**
2. **Root (R)**
3. **Combining Forms (CF)**
4. **Suffixes (S)**

By connecting various word parts in an organized sequence, thousands of words can be built and learned. In the text, the word list is alphabetized so
one can see the variety of meanings created when common prefixes and suffixes are repeatedly applied to certain word roots and/or combining forms. Words shown in pink are additional words related to the content of this chapter that have not been divided into word parts. Definitions identified with an asterisk icon (*) indicate terms that are covered in the Pathology Spotlights section of the chapter.

IV. Drug Highlights

A. Diuretics – decrease reabsorption of sodium chloride by the kidneys, thereby increasing the amount of salt and water excreted in urine. This action reduces the amount of fluid retained by the body and prevents edema. Types:
   1. Thiazide – appears to act by inhibiting sodium chloride reabsorption in the early portion of the distal tubule.
   2. Loop – acts by inhibiting the reabsorption of sodium and chloride in the ascending loop of Henle.
   3. Potassium sparing – acts by inhibiting the exchange of sodium for potassium in the distal tubule; inhibits potassium excretion.
   4. Osmotic – is capable of being filtered by the glomerulus, but has a limited capability of being reabsorbed into the bloodstream.
   5. Carbonic Anhydrase Inhibitor – acts to increase the excretion of bicarbonate (HCO₃⁻) ion, which carries out sodium (Na), water (H₂O), and potassium (K).

B. Urinary Tract Antibacterials – sulfonamides are generally the drugs of choice for treating acute, uncomplicated urinary tract infections (UTIs), especially those caused by Escherichia coli and Proteus mirabilis bacterial strains. They exert a bacteriostatic effect against a wide range of gram-positive and gram-negative microorganisms.

C. Urinary Tract Antiseptics – may inhibit the growth of microorganisms by bactericidal, bacteriostatic, anti-infective, and/or antibacterial action.

D. Other Drugs – disorders of the lower urinary tract may be treated with other drugs that either stimulate or inhibit smooth muscle activity, thereby improving urinary bladder functions (the storage of urine and its subsequent excretion from the body).

V. Diagnostic and Lab Tests

A. Blood Urea Nitrogen (BUN) – blood test to determine the amount of urea excreted by the kidneys. Abnormal results indicate urinary tract disease.

B. Creatinine – blood test to determine the amount of creatinine present. Abnormal results indicate kidney disease.

C. Creatinine Clearance – urine test to determine the glomerular filtration rate (GFR). Abnormal results indicate kidney disease.

D. Urine Culture – urine test to determine the presence of microorganisms. Abnormal results indicate urinary tract infection.
E. **Cystoscopy (Cysto)** – visual examination of the bladder and urethra via a lighted cystoscope. Abnormal results indicate the presence of renal calculi, a tumor, prostatic hyperplasia, and/or bleeding.

F. **Intravenous Pyelography (Pyelogram) (IVP)** – test to visualize the kidneys, ureters, and bladder. A radiopaque substance is intravenously injected, and x-rays are taken. Abnormal results can indicate renal calculi, kidney or bladder tumors, and kidney disease.

G. **KUB (Kidney, Ureter, Bladder)** – flat-plate x-ray taken of the abdomen to indicate the size and position of the kidneys, ureters, and bladder.

H. **Renal Biopsy** – removal of tissue from the kidney. Abnormal results may indicate kidney cancer, kidney transplant rejection, and glomerulonephritis.

I. **Retrograde Pyelography (RP)** – x-ray recording of the kidneys, ureters, and bladder following the injection of a contrast medium through a urinary catheter into the ureters and the calyces of the pelves of the kidneys. Useful in locating urinary stones and obstructions.

J. **Ultrasonography, Kidneys** – use of high-frequency sound waves to visualize the kidneys. Abnormal results may indicate kidney tumors, cysts, abscess, and kidney disease.

VI. **Abbreviations (p. 389)**

VII **Pathology Spotlights**

A. **Cystitis** – an inflammation of the bladder, usually occurring secondary to ascending urinary tract infections. Cystitis may be acute or chronic; it occurs when the urethra and bladder are infected by bacteria and become irritated and inflamed. Females are more prone to cystitis because of the short distance between the openings of the urethra and anus. In men, cystitis is usually secondary to some other type of infection. The most common symptoms include, frequent painful urination, burning sensation during urination, chills, and fever. With chronic cystitis pyuria may be the only symptom.

   - **Interstitial cystitis (IC)** is a painful inflammation of the bladder wall. The cause is unknown and IC does not respond to antibiotics.

B. **Kidney Stones (Nephroliths)** – are deposits of mineral salts, called *calculi*, in the kidney. Kidney stones occur when urine has a high level of minerals, with most being caused by calcium. Stones irritate the kidney and block urine flow if they descend into the ureters. Extreme pain is the first symptom, followed by nausea, vomiting, and possibly blood in the urine. Stones that don’t normally pass out of the body may require treatment by:

   - **Extracorporeal Shockwave Lithotripsy** (Fig. 12–16, p. 391)
   - **Percutaneous Ultrasonic Lithotripsy (PUL)** (Fig 12–12, p. 383)

C. **Pyelonephritis** (Fig. 12–17, p. 391) – an infection of the kidney and renal pelvis and may occur in acute or chronic forms. It is usually caused by
bacteria entering the kidneys from the bladder. *Escherichia coli*, a bacillus that is normally found in the large intestines, causes about 90% of kidney infections. Symptoms include back, side, and groin pain; urgent, frequent urination; pain or burning during urination; fever; nausea and vomiting; and pus and blood in the urine. Untreated or recurrent kidney infections can lead to chronic pyelonephritis, scarring of the kidneys, and permanent kidney damage. Other causes of bacteria entering the urinary tract include:
- **Indwelling Catheters**
- **Use of a Cystoscope** (an instrument used to examine the urethra and bladder).

**D. Renal Failure** – there are two types of renal failure: **acute** and **chronic**. In both types, the goal is to identify and treat any reversible causes of renal failure and to focus on preventing excess accumulation of fluids and waste, while allowing the kidneys to heal.

1. **Acute Renal Failure (ARF)** – occurs when the filtering function of the kidneys changes so that the kidneys are not able to maintain healthy body function. People with preexisting kidney disease are at a higher risk for ARF. Symptoms include no signs initially, decreased renal output causing a fluid buildup in the body and possibly arrhythmias, ascites, and edema. Other conditions leading to acute renal failure are as follows:
   - **Blockage** – blocked urine flow out of the kidneys into the bladder.
   - **Drugs** – exposure to certain drugs and/or toxic substances.
   - **Blood Loss** – significant loss of blood or a sudden drop in blood flow to the kidneys.

2. **Chronic Renal Failure (CRF)** (Fig. 12–18, p. 393) – occurs when there is a gradual and progressive loss of kidney function. It occurs over a number of years as the internal structures of the kidney are slowly damaged. Diabetes and hypertension are the two most common causes of chronic renal failure. It is often not diagnosed until the uremic stage is reached. **Uremia** refers to the syndrome or group of symptoms associated with end-stage renal disease (ESRD).

VIII. Pathology Checkpoint

IX. Study and Review (pp. 395–400)

X. Practical Application: SOAP: Chart Note Analysis