Chapter 20: Urinary/Excretory System

Theory Lecture Outline

Objectives
1. Explain the function of the excretory organs
2. Describe the structure and function of the organs in the urinary system
3. Explain how the kidneys regulate water balance
4. List and describe some common disorders of the urinary system
5. Define the key words that relate to this chapter

Introduction
The overall function of the urinary system is to maintain the volume and composition of body fluids within normal limits. The urinary system accomplishes this by ridding the body of waste products that accumulate as a result of cellular metabolism. Because of this, the urinary system is sometimes referred to as the excretory system. Although the urinary system has a major role in excretion, other organs contribute to the excretory function. The lungs through the respiratory system excrete some waste products, such as CO₂ and water. The skin is another excretory organ that rids the body of wastes through the sweat glands. The liver and intestines excrete bile pigments that result from the destruction of hemoglobin. The major task of excretion, however, still belongs to the urinary system. If the urinary system fails, the other organs cannot take over and compensate adequately. In addition to ridding the body of waste products, the urinary system maintains an appropriate fluid volume. It does this by regulating the amount of water that is excreted in the urine. Other functions of the urinary system include regulating the concentrations of various electrolytes in the body fluids and maintaining normal pH of the blood. In addition to maintaining fluid balance in the body, the urinary system controls red blood cell production by secreting the hormone erythropoietin. The urinary system also plays a role in maintaining normal blood pressure by secreting the enzyme rennin.

Urinary System
The urinary system performs the main part of the excretory function in the body
- Excretion of nitrogenous wastes, salts, and water
- Components of the urinary system
  a. Two kidneys are the most important excretory organs
     o Form the urine
  b. Two ureters (transport urine away from the kidneys to the bladder)
  c. One bladder (stores urine until excretion from body)
  d. One urethra (carries urine form bladder to outside the body)

Elimination of Waste Products Summary Table 20-1 pg. 427
- Lungs (exhalation)
  o Carbon dioxide and water vapor
- Kidneys (urination)
  o Nitrogenous wastes and salts dissolved in water to form urine
- Skin (perspiration)
  o Dissolved salts
- Intestines (defecation)
  o Solid wastes and water

Functions – Urinary System
- Excretion
  o The process of removing nitrogenous waste material, certain salts and excess water from the blood
- Aid in maintaining acid-base balance
- Secretion of waste products in the form of urine
- Elimination of urine from the bladder where it is stored

Kidneys

Are the organs that filter the blood, remove the wastes and excrete the waste in the urine

- Located retroperitoneal
  - a. Behind the peritoneum and in front of the back muscles on either side of the vertebral column
  - b. Right kidney is usually slightly lower than the left because the liver displaces it downward
- Adipose capsule
  - o Thick layer of adipose tissue that surrounds each kidney
- Hilum
  - o Indentation that is the passageway for the lymph vessels, nerves, renal artery and vein, and the ureter
- Renal pelvis
  - o Funnel-shaped structure at the upper end of each ureter
- Two layers
  - a. Medulla – inner striated layer
  - b. Cortex – Outer granular layer

Nephron

The kidneys have the potential to work harder than they actually do; under ordinary circumstances, only a portion of the nephron is used

- Basic structural and function unit of the kidney
- Each kidney has over 1 million
- Structures of the nephron
  - a. Afferent arteriole
    - o Carries blood to the Bowman’s capsule and glomerulus
  - b. Bowman’s capsule
    - o Double-layered epithelial capsule that surrounds the glomerulus
  - c. Glomerulus
    - o Cluster of some 50 separate capillaries
  - d. Proximal convoluted tubule
    - o Highly coiled tube that carries fluid away from the glomerulus
  - e. Loop of Henle
    - o Tubule that descends into the medulla
  - f. Distal convoluted tubule
    - o Tubule ascends back into the cortex
  - g. Collecting tubule
    - o Larger, straight vessel the tubule opens into
  - h. Efferent arteriole
    - o Carries blood away from the glomerulus

Path of Urine Formation

- Blood enters the afferent arteriole → passes through the Glomerulus → becomes Filtrate (blood minus the red blood cells and plasma proteins) into the Bowman’s Capsule → continues through the Proximal Convoluted Tubule → descends through the Loop of Henle → to the Distal Convoluted Tubule → to the Collecting Tubule
  - a. At the collecting tubule approx 99% of the filtrate has been reabsorbed
  - b. About 1 ml of urine is formed per minute
- The 1 ml of urine goes to the Renal Pelvis → to the Ureter → Bladder → Urethra → Urinary Meatus
Urine Formation in the Nephron
The kidney nephrons form urine by three processes: filtration by the glomerulus, reabsorption within the renal tubules and secretion by the tubular cells

- **Filtration**
  a. First step in urine formation
  b. Blood from the renal artery travels through the afferent arteriole into the glomerulus, the blood vessels grow narrower and narrower resulting in an increase in blood pressure
  c. High blood pressure forces a plasma-like fluid to filter from the blood in the glomerulus into the Bowman’s capsule as filtrate (consists of water, glucose, amino acids, some salts and urea)
  d. Nephric filtrate continues along the tubules, 99% of this fluid is reabsorbed back into the bloodstream; therefore, only 1-1.5L (1,000-1,500ml) of urine are excreted per day

- **Reabsorption**
  a. Starts in the proximal convoluted tubules, continues through the Henle’s loop, the distal convoluted tubules and the collecting tubules
  b. **Threshold**
     1. Term used to describe the limit of reabsorption
     2. Glucose, amino acids, vitamins, and some sodium ions are actively transported back into the blood except when levels exceed normal limits

- **Secretion**
  a. Opposite of reabsorption
  b. Substances are actively secreted into the tubules
  c. Substances secreted into the urine include ammonia creatinine, hydrogen ions, potassium ions and some drugs
  d. Electrolytes are selectively secreted to maintain the body’s acid-base balance

- **Urinary output and urinalysis values**
  a. Urinary output is between 1,000 and 2,000 ml/24 hours with an average of 1,500 ml per day
  b. Urinalysis is an examination and analysis of urine
     1. Table 20-2 pg. 433
     2. Most common noninvasive diagnostic

**Ureters**
- Two ureters
  o One for each kidney
  - Carries urine to the bladder for storage
  - About 10-12 inches long and ¼ inch wide
  - Mucous membranes line ureters
  - Smooth muscle fibers lie beneath the mucous membrane lining
    o Peristalsis pushes urine down the ureter to the bladder

**Urinary Bladder**
- Hollow muscular organ made of elastic fibers and involuntary muscle
- Stores up to about 1 pint (500ml) of urine
- Involuntary contractions of bladder can be controlled to some extent by nervous system
  o Contraction of the bladder muscles forces the urine through the urethra
- Urine leaves bladder through urethra then through opening called urinary meatus
Control of Urinary Secretion

**The control of the secretions of urine is under both chemical or hormonal and nervous control**

- **Chemical control**
  - ADH (antidiuretic hormone) controlled by the hypothalamus makes the distal convoluted tubule and collecting duct more permeable to water
    1. An increase in the osmotic blood pressure due to salt retention causes an increase in ADH secretion
    2. Inhibits normal urine formation and water may be held in the tissues
  - Aldosterone secreted by the adrenal cortex promotes the excretion of potassium and hydrogen ions and the reabsorption of sodium ions
  - Renin is an enzyme produced in the kidney that stimulates the release of aldosterone
  - Diuretics increase urinary output by inhibiting the reabsorption of water
    1. Alcohol inhibits ADH
    2. Caffeine increases the loss of sodium ion, thus increasing the loss of water

- **Nervous control**
  - Accomplished directly through the action of nerve impulses on the blood vessels leading to the kidney and on those within the kidney leading to the glomeruli

**Effects of Aging**

- Kidneys shrink
- Changes result in decreased renal blood flow
- Kidney compromised in removing waste products
- Decreased glomerular filtration rate
  - Drug dosages have to be adjusted
- Glucose resorption also decreases
  - Hyperglycemia
- Loss of muscle tone in the urinary bladder
- Urinary incontinence

**Disorders – Urinary System**

Disorders will be discussed further during the urinalysis module; however, you should still read through the disorders in the chapter and become familiar with the terminology

- Acute kidney failure
- Chronic renal failure
- Glomerulonephritis
- Acute glomerulonephritis
- Chronic glomerulonephritis
- Hydronephrosis
- Pyelonephritis
- Kidney stones or renal calculi
- Cystitis
- Incontinence
- Neurogenic bladder

**Dialysis**

- **Treatment** Used for kidney failure
  - Involves the passage of blood through a device which has a semi-permeable membrane to rid the blood of harmful wastes, extra salt and water
    - **Hemodialysis**
      1. Process for purifying blood by passing it through thin membranes and exposing it to a solution which continually circulates around the membrane
      2. The client is connected to the dialysis unit by means of needles and tubing that take blood form the client to the machine and return it to the client
      3. Usually done two to three times a week and each treatment lasts from 2 to 4 hours
    - **Peritoneal dialysis**
      1. Uses the client’s own peritoneal lining instead of a dialyzer to filter the blood
2. Fluid, wastes, electrolytes and chemicals pass from tiny blood vessels in the peritoneal membrane into the dialysate solution
3. After several hours, the dialysate is drained from the abdomen, taking the wastes from the blood with it – repeat cleaning procedure

Kidney Transplants
Kidney transplants are done in cases of prolonged chronic debilitating diseases and renal failure involving both kidneys
• Two types
  a. Living donor transplant
  b. Unrelated donor who has died
• Major concern
  o Rejection of kidney by the recipient
• Medications taken daily to prevent rejection
• Allows for better quality of life than dialysis