The Urinary System

OUTLINE:
- Eliminating Waste
- Components of the Urinary System
- Kidneys and Homeostasis
- Dialysis and Transplant Surgery
- Urination
- Urinary Tract Infections

Eliminating Waste
- Excretion
  - Elimination of wastes and excess substances from the body
  - Metabolic wastes include carbon dioxide, water, heat, salts, and nitrogen-containing wastes (ammonia, urea, uric acid, creatinine)

Eliminating Waste
- Several organs eliminate wastes and excess essential ions
  - Lungs
    - Heat, water, and carbon dioxide
  - Skin
    - Heat, water, bicarbonate ions, salts, urea, uric acid
  - Organs of the GI tract
    - Solid wastes and some metabolic wastes
  - Kidneys
    - Form urine (mix of water and solutes): water, bicarbonate ions, inorganic salts, hydrogen ions, urea, uric acid, and creatinine

Components of the Urinary System
- The urinary system consists of two kidneys, two ureters, one urinary bladder, and one urethra
  - Functions
    - Regulates the volume, pH, pressure, and composition of the blood
  - Organs
    - Kidneys
      - Regulate the amount of water and dissolved substances that are removed from and returned to the blood
      - Substances not returned to the blood form urine

Components of the Urinary System
- Organs (cont’d)
  - Ureters
    - Transport urine from kidneys to bladder
  - Urinary bladder
    - Stores urine
  - Urethra
    - Transports urine from urinary bladder to outside the body

Kidneys and Homeostasis
- Kidneys are reddish brown in color and shaped like beans
- Each one is about the size of a fist
- Three regions
  1. Renal cortex
  2. Renal medulla
  3. Renal pelvis

**Kidneys and Homeostasis**
- Nephrons
  - Microscopic functional units of the kidneys
  - Responsible for formation of urine
  - Each nephron consists of
    - Renal corpuscle
    - Renal tubule

**Structure of the Kidneys**
- Renal corpuscle
  - Site of filtration
  - Consists of
    - Glomerulus: tuft of capillaries
    - Glomerular capsule: surrounds glomerulus

**Structure of the Kidneys**
- Renal tubule
  - Site of reabsorption and secretion
  - Consists of three sections
    - Proximal convoluted tubule
    - Loop of the nephron
    - Distal convoluted tubule

**Nephrons**
- Nephrons perform three functions
  - Glomerular filtration
  - Tubular reabsorption
  - Tubular secretion

**Nephrons**
- Glomerular filtration
  - Occurs as blood pressure forces water, ions, and other small molecules from the blood in the glomerulus to the space inside the glomerular capsule
  - The concentration of the filtrate within the glomerular capsule is close to that of blood

**Nephrons**
- Tubular reabsorption
  - Removes useful materials from the filtrate as it passes through proximal convoluted tubule
  - About 99% of filtrate is returned to the blood
  - Reabsorbed substances include water, essential ions, and glucose
• Tubular secretion
  • Occurs along the proximal and distal convoluted tubules and collecting ducts
  • Removes wastes and excess ions from blood

Acid–Base Balance
• Kidneys help regulate blood pH by
  • Returning bicarbonate ions to the blood during tubular reabsorption
  • Removing excess hydrogen ions from the blood during tubular secretion

Water Conservation
• Nephrons with long loops that extend into the renal medulla are responsible for conserving water
  • Maintenance of high solute concentrations in the interstitial fluid within renal medulla is key
    • Leads to water moving out of collecting ducts for conservation by the body
    • Leads to production of concentrated urine

Hormones and Kidney Function
• Our health depends on our keeping the salt and water levels in our body near certain optimum values
• Three hormones play important roles in adjusting kidney function
  1. Aldosterone
  2. Antidiuretic hormone (ADH)
  3. Atrial natriuretic peptide (ANP)

Hormones and Kidney Function
• Aldosterone
  • Released by the adrenal cortex
  • Increases reabsorption of sodium by the distal convoluted tubules and collecting ducts, resulting in more water following sodium as it moves from filtrate to blood
    • Increases blood volume and pressure
    • Production of concentrated urine
  • Released in response to blood pressure monitored by juxtaglomerular apparatus

Hormones and Kidney Function
• Antidiuretic hormone (ADH)
  • Produced by the hypothalamus and released by the posterior pituitary gland
  • Increases permeability to water of collecting ducts, resulting in more water moving from filtrate to blood
    • Increases blood volume and pressure
    • Production of concentrated urine

Hormones and Kidney Function
• Atrial natriuretic peptide (ANP)
- Released from the right atrium of the heart in response to increased blood volume and pressure
- Decreases reabsorption of sodium by the distal convoluted tubules and collecting ducts, resulting in more sodium and water remaining in the filtrate
  - Decreases blood volume and pressure
  - Production of dilute urine

**Red Blood Cells and Vitamin D**
- Kidneys have two homeostatic functions unrelated to the urinary system
  - Release erythropoietin
    - Hormone that stimulates the production of red blood cells in red bone marrow
  - Transform vitamin D into its active form
    - Promotes the absorption and use of calcium and phosphorus by the body

**Dialysis and Transplant Surgery**
- Renal failure
  - Decrease or complete cessation of glomerular filtration
  - Can be acute or chronic
  - Consequences
    - Acidosis
    - Anemia
    - Edema
    - Hypertension
    - Accumulation of nitrogen-containing wastes in the blood

**Dialysis and Transplant Surgery**
- Treatments for renal failure
  - Hemodialysis
    - Using artificial devices (e.g., artificial kidney machine) to cleanse the blood
  - Continuous ambulatory peritoneal dialysis
    - Using patient's own peritoneum as the dialyzing membrane
  - Kidney transplantation
    - The ultimate hope for many people whose kidneys fail is to receive a healthy kidney from another person

**Dialysis and Transplant Surgery**

**Urination**
- Process by which the urinary bladder is emptied
  - Includes both involuntary and voluntary components
    - Internal urethral sphincter
      - Smooth muscle; involuntary
    - External urethral sphincter
      - Skeletal muscle; voluntary

**Urination**
- Urinary incontinence
  - Lack of voluntary control over urination
- Norm for infants and toddlers
- Stress incontinence is more common in women

- Urinary retention
  - Failure to expel urine from the bladder to a normal degree

**Urinary Tract Infections (UTIs)**
- Caused by presence of microorganisms in organs of the urinary system
  - Bacteria can enter the urethra from the rectum or as STDs
- More common in women than men
- Symptoms include fever, blood in urine, painful and frequent urination
- Treated with antibiotics
  - Important to treat infection of lower urinary tract to prevent spread to the kidneys

**You Should Now Be Able To:**
- Understand how waste is eliminated
- Know the components of the urinary system
- Know the functions of the nephrons
- Understand kidneys and hormones
- Understand kidneys and homeostasis
- Explain dialysis and transplant surgery
- Know the process of urination
- Understand urination conditions and urinary tract infections