

UNIT 11 - URINARY SYSTEM

LECTURE NOTES

11.01 FUNCTIONS OF THE URINARY SYSTEM

- A. Regulate the composition and volume of the blood by removing and restoring selected amounts of water and solutes.
- B. Excretes water, nitrogenous wastes from protein catabolism, inorganic salts, and assists in eliminating heat and carbon dioxide.
- C. Maintains blood pressure by controlling plasma volume of the blood.
- D. Helps in metabolic processes
 1. gluconeogenesis during times of starvation
 2. secretes erythropoietin to stimulate production of red blood cells
 3. participates in the synthesis of calcitriol (the active form of vitamin D)
- E. Helps to regulate the pH of blood.

11.02 IDENTIFY THE FOUR MAJOR ORGANS OF THE URINARY SYSTEM

A. Kidneys

Description and Functions

- a. The kidneys are paired organs. They are kidney bean shaped structures found against the posterior abdominal wall behind the peritoneum (retroperitoneal). They are protected by an adipose capsule.
- b. The kidneys are attached to the aorta by the renal artery and to the inferior vena cava by the renal vein.
- c. The kidneys contain the functional units, the nephrons, which actually filter the blood and form urine.

B. Ureters

Description and Function

- a. The ureters are long, slender tubes which extend from the renal pelvis of each kidney to the urinary bladder.
- b. Are composed of epithelial tissue and smooth muscle.
- c. Transport urine from the kidneys to the bladder.

C. Bladder

Description and Function

- a. A sac-like structure found in the pelvic cavity. Connected to the ureters and the urethra.
- b. Composed of epithelial tissue and smooth muscle.
- c. Functions to hold urine until micturition occurs.

D. Urethra

Description and Function

- a. A small tube (approximately 2 inches in females and 8 inches in males) transports urine from the bladder to the outside of the body.
- b. Composed of epithelial tissue and smooth muscle.

11.03 IDENTIFY THE GROSS ANATOMY OF THE KIDNEYS

A. Description

The kidneys are paired, reddish-colored organs that resemble a kidney bean. They are located just above the waist between the parietal peritoneum and the posterior wall of the abdomen and are said to be retroperitoneal. They measure about 10 -12 cm (4 to 5 inches) long, 5 to 7.5 cm (2 to 3 inches) wide, and 2.5 cm (1 inch) thick and are roughly the size of a fist. The concave border faces medially while the convex surface is positioned laterally. The hilus is the notch near the center of the concave medial border through which the ureter leaves the kidney, and blood and lymphatic vessels and nerves enter and leave the kidney. The renal sinus is the cavity within the kidney that originates at the hilus.

B. Internal Anatomy of the Kidney:

1. The Renal Cortex is the outer, reddish section of the kidney.
2. The Renal Medulla is the middle, brownish area of the kidney.
3. Renal (Medullary) Pyramids are 8 to 18 triangular structures located within the medulla.
4. The Renal Pelvis is a large cavity within the renal sinus that collects urine from the renal pyramids.

11.04 IDENTIFY THE MICROSCOPIC STRUCTURE OF THE NEPHRONS

The nephrons are the functional units of the kidneys. They filter the blood removing waste products and forming urine. The nephrons are located in both the cortical and medullary area of the kidney.

A. Structures of the Nephron

1. Renal Corpuscle: a tiny area of the kidney where the fluid is filtered as it passes through the kidney. The corpuscle is an expanded bulb-like structure.
 - a. Glomerular (Bowman's) Capsule is a double-walled, endothelial cup surrounding the glomerulus.
 - b. Glomerulus is a tuft or knot of capillaries where filtration occurs
 - i. Afferent Arteriole is the blood vessel that brings blood into the glomerulus. It is a large diameter arteriole.
 - ii. Efferent Arteriole is the blood vessel that exits the glomerulus. It is a small diameter arteriole. It takes blood away from the glomerulus to the peritubular capillary.
 - iii. Fenestrae are large pores in the endothelial walls of the capillaries of the glomerulus through which salts and other waste products diffuse out of the bloodstream.
 - iv. Podocytes are cells of the walls of the glomerular (Bowman's) capsule that have slits in them that work in conjunction with the fenestrae of the glomerulus to act as a filtration membrane to remove waste products and other substances from the blood.
2. Renal Tubule is an epithelial structure that provides areas for the filtered fluid to pass through to fine tune the composition of urine. This is where the processes of reabsorption and secretion occur.
 - a. Proximal Convoluted Tubule (PCT)
 - b. Loop of Henle (Nephron Loop)
 - i. descending limb
 - ii. nephron loop
 - iii. ascending limb
 - c. Distal Convoluted Tubule (DCT)
3. Peritubular Capillaries:
 - a. Blood vessels (capillaries) surrounding the renal tubules.
 - b. Involved with reabsorption of electrolytes and other necessary minerals from the filtrate as it passes through the renal tubule.
 - c. Also play a role in secretion as substances are removed from the blood and secreted back into the tubule for excretion as urine.
4. Juxtaglomerular Apparatus
 - a. Located where the distal convoluted tubule touches the afferent arterioles.
 - b. Plays an important role in regulating rate of urine formation and regulating blood pressure.

B. Function of the Nephrons

The nephrons are responsible for removing wastes from the blood and regulating blood fluid and electrolyte composition.

1. Controls blood concentration and volume by removing selected amounts of water and solutes.

2. Regulates blood pH.
3. Removes toxic wastes from the blood.
4. The fluid and solutes removed from the blood by the nephrons are collectively called urine.
5. The entire volume of blood in the body is filtered by the kidneys approximately 60 times each day.
 - a. Filters about 180 liters (45 gallons) of fluid a day.
 - b. 99% of fluid that passes through the kidneys is returned to the blood.

11.05 NAME AND DESCRIBE THE THREE BASIC PHYSIOLOGICAL PROCESSES IN URINE FORMATION

There are three process involved in urine formation: filtration, reabsorption, and secretion. All the processes are associated with nephron function.

- A. Glomerular Filtration: the first step in urine production
 1. Forcing of fluids and dissolved substances from the blood through a membrane by pressure from the glomerulus to the glomerular (Bowman's) capsule.
 2. Occurs in the renal corpuscle of the kidney. Water and dissolved substances are forced out of the blood at the glomerulus into the glomerular capsule.
 3. Large molecules, such as plasma proteins and red blood cells, are not filtered out of the blood.

- B. Tubular Reabsorption: the movement of certain amounts of fluid and filtrate from the renal tubule back into the blood. This is carried out by both active and passive transport. The reabsorbed substances are moved out of the tubule and enter the blood of the peritubular capillary.
 1. Occurs in the renal tubules which are composed of:
 - a. proximal convoluted tubule
 - b. loop of Henle (nephron loop)
 - c. distal convoluted tubule
 2. As the filtrate passes through the renal tubules about 99% of the filtrate is reabsorbed by the body.
 - a. Only 1% of the filtrate actually leaves the body as urine (1.5 liters a day).
 - b. Materials commonly reabsorbed include: water, glucose, amino acids, urea, and ions such as Na^+ , K^+ , Ca^{+2} , Cl^- , HCO_3^- , and HPO_4^{-2} .
 - c. Allows the body to retain most of its nutrients.

- C. Tubular Secretion: the addition of materials to the filtrate from the blood.
 1. Essentially the opposite of reabsorption.
 2. Secreted substances include: K^+ , H^+ , ammonia, creatine, and the drugs penicillin and para-amino hippuric acid
 3. Certain materials can be removed from the body.
 4. Helps control the body's blood pH.

11.06. IDENTIFY THE ABNORMAL CONSTITUENTS OF URINE

Urinalysis: an analysis of the volume, physical, chemical, and microscopic properties of the urine. The normal characteristics have been provided to you to aid in your classroom discussion. The competency is actually covered in D of this section.

- A. Volume: the amount of urine produced
 - 1. The average, normal volume is approximately 1000 ml to 2000 ml (1 to 2 quarts) per day. Influenced by:
 - a. Blood Pressure: If the blood pressure were to fall the kidneys would try to increase blood pressure by renin-angiotensin pathway associated with the juxtaglomerular apparatus; the amount of urine would be reduced.
 - b. Blood Concentration: Kidneys maintain optimal blood concentration by controlling the concentration of solutes in both the blood and urine
 - c. Temperature: An increase in body temperature causes less blood to enter the kidneys and causes the kidneys to reabsorb more water to maintain optimal blood plasma volume. Since less blood enters to the kidneys the amount of urine produced would be reduced.
 - d. Diuretics: Typically cause an abnormal increase in urine production. Some common diuretics include:
 - i. coffee, tea, caffeine, alcoholic beverages
 - ii. can result in dehydration
 - e. Emotions: Emotional states can affect urine volume and output such as stress and anxiety may cause increased urine production and possibly more frequent expelling of urine.

- B. Physical characteristics of urine:
 - 1. Color: yellow or amber but can vary considerably with diet
 - 2. Turbidity: transparent when freshly voided but becomes turbid (cloudy) upon standing.
 - 3. Odor: odorless but becomes ammonia-like upon standing due to bacterial action.
 - 4. pH: avg. is about 6.0 but has a range from 4.6 to 8.0
 - a. varies considerably with the diet
 - b. vegetarians have a more basic or alkaline pH
 - 5. Specific Gravity: 1.001 to 1.035 – refers to the concentration of urine as compared to water.

- C. Chemical composition of urine: water accounts for about 95% of the total volume of urine with the remaining 5% consisting of solutes derived from cellular metabolism and outside sources such as drugs
 - 1. Organic components of urine:
 - a. Urea: a crystalline solid found in blood, lymph, and urine formed by deamination of amino acids
 - b. Uric Acid: a crystalline acid occurring as an end product of nucleic acid metabolism

- c. Creatine: the decomposition product of the metabolism of phosphocreatine - an end product of muscle metabolism and/or energy metabolism
 - d. Ketone Bodies: substances containing carboxyl groups as a result of incomplete metabolism of fatty acids - a sign of metabolic acidosis
2. Inorganic components of urine:
- | | |
|-----------------------|-----------------------|
| a. NaCl | d. SO_4^{2-} |
| b. PO_4^{3-} | e. NH_4^+ |
| c. Mg^{2+} | f. Ca^{2+} |
- D. Abnormal Constituents of Urine:
1. Glucose (glucosuria or glycosuria): can be linked to diabetes, high stress levels, or liver disease
 2. Ketone Bodies (ketosis or acetonuria): could indicate diabetes, starvation, or too little carbohydrates in the diet
 3. Erythrocytes (hematuria): blood in the urine which may be linked to acute inflammation of the urinary organs as a result of kidney stones, tumors, trauma, or kidney disease
 4. Leukocytes (pyuria): leukocytes or other components of pus in the urine that usually indicates infection of the urinary system
 5. Bilirubin (bilirubinuria): small amounts are normal, excessive amounts could indicate urinary dysfunction or hepatitis.
 6. Microbes: bacteria in the urine.

11.07. DESCRIBE THE METHODS OF FLUID INTAKE AND OUTPUT BY THE BODY

A. Fluid Intake

1. Oral intake includes the ingestion of food and water through the mouth. This is the most common way to intake fluid.
2. Intravenous is the introduction of fluid into the veins. This is usually done in the hospital when patients are NPO, not able to eat or drink.
3. Metabolic fluid, water, is formed as a waste product of cellular respiration.

B. Output

1. Micturition: urination
2. Voiding: the elimination of urine from the urinary tract.
3. Sweat: production and evaporation of fluids from the body in an attempt to regulate body temperature.
4. Feces: some water is eliminated by the body through defecation of fecal material. The amount varies and is dependant upon volume and consistency of feces.
5. Exhaled Vapor: some fluid is lost from the body through ventilation of exhaled water vapor - amount is dependant upon ventilation rate, humidity of atmospheric air, and environmental temperature.

11.08. DISEASES AND DISORDERS OF THE URINARY SYSTEM

A. **Cystitis**

Cystitis is the inflammation of the urinary bladder caused by bacteria. It is more common in women than in men. Signs and symptoms of cystitis include urgency, frequency, burning upon urination, dysuria, and possible urethral discharge. It is treated with antibiotics.

B. **Diabetes Insipidus**

Diabetes insipidus is the excessive urination of water due to a lack of the antidiuretic hormones (ADH). The kidneys are not able to absorb water which results in the excessive formation of urine. Causes may include neoplasms, infections, or head trauma. The signs and symptoms include four to 16 liters of urine daily, excessive thirst, and excessive fluid intake. Treatment may include hormone replacement therapy.

C. **Glomerulonephritis**

Glomerulonephritis, inflammation of the glomeruli, is caused by a bacterial infection. The signs and symptoms include edema, oliguria, proteinuria, azotemia, hematuria, and fatigue. Treatment includes antibiotic therapy, diuretics, bedrest, and fluid restrictions. It typically resolves within two weeks.

D. **Incontinence**

Incontinence is the inability to control urination. It may be caused by aging, pregnancies, or surgery in the lower pelvic area (such as prostate surgery). It may be treated with medications, bladder muscle retraining, and sometimes, surgery.

E. **Kidney Stones**

Kidney stones (renal calculi, nephrolithiasis) are crystallized mineral chunks that develop in the renal pelvis or calyces. Stones may develop as minerals crystallize on the renal papillae and break off into the urine. Intense pain, known as a renal colic, develops as rhythmic muscle contraction of the ureter attempts to dislodge it. Other symptoms include fever, chills, and hematuria. Hydronephrosis can develop as a complication of this disorder. Predisposing factors for kidney stones include dehydration, infection, obstruction, and genetics. Treatment includes medication to relieve the pain, forcing fluids, and sometimes surgical intervention such as lithotripsy.

F. Renal Failure

Renal failure is the sudden interruption of kidney function due to obstruction, reduced circulation, or kidney disease. It may be acute, which comes on suddenly, or chronic, which occurs over a long period of time. The acute form has a good prognosis. Signs and symptoms of renal failure include oliguria, azotemia and electrolyte imbalances. Treatment includes a modified diet, IV fluids, and possibly, temporary dialysis until the kidney function returns.

G. Urinary Tract Infections

Urinary tract infections include cystitis and urethritis. They are generally caused by bacteria and are treated with antibiotics.