Urinary System and Excretion

Bio105
Lecture Packet 20
Chapter 16

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Outline – Urinary System

I. Function
II. Organs of the urinary system
   A. Kidneys
      1. Function
      2. Structure
   B. Urine formation
      1. Hormonal regulation
   C. Kidney hormones
   D. Other kidney functions
   E. Urinary bladder and urination

Urinary System

The digestive system eliminated waste from the digestive tract. But we also need a way to eliminate waste from the rest of the body.

Function of urinary system is: Excretion of metabolic wastes and to maintain homeostasis of blood.

Which of the following system does not function to excrete waste?

1. Digestive
2. Urinary
3. Integumentary
4. Circulatory

Urine

Urine contains:
- Water
- HCO₃⁻
- Inorganic salts
- H⁺
- Urea
- Uric acid
- Creatinine

Excretion

Excretion - the majority of the metabolic wastes removed from the body is mainly due to the action of the kidneys.

Organs of the Urinary System

1. Kidneys – main organ in the urinary system, produces urine.
2. Ureters - conduct urine from the kidneys to the bladder by peristaltic contractions produced from contractions of smooth muscles in ureter wall.
3. Urinary bladder - stores urine until it is expelled from the body.
4. Urethra - small tube that extends from the urinary bladder to an external opening. In males the urethra also functions as a reproductive tract organ.

Functions of the Kidneys

1. Filter waste from blood
2. Maintenance of water-salt balance of the blood. (fluid and electrolyte balance)
3. Regulates blood pressure
5. Secretion of hormones = renin and erythropoietin.
**Urinary System**

- **Kidney**
  - Produces urine
  - Conserves water
  - Regulates pH
  - Stimulates production of red blood cells
  - Transforms vitamin D into active form

- **Ureter**
  - Transports urine from kidneys to bladder

- **Urinary bladder**
  - Stores urine

- **Urethra**
  - Transports urine from urinary bladder to outside the body

**The kidneys are located in this cavity:**

1. Cranial
2. Thoracic
3. Abdominopelvic
4. Pleural

**The Regions of the Kidneys**

- Each kidney has three regions:
  1. Renal cortex
  2. Renal medulla
  3. Renal pelvis/sinus

**The Regions of the Kidney**

1. **Renal cortex** - an outer granulated layer.
2. **Renal medulla** - consists of cone-shaped tissue masses called renal pyramids.
3. **Renal pelvis** - a central cavity that is continuous with the ureter.

**Nephrons**

- The functional units of the kidneys.
- Over 1 million nephrons per kidney
- Nephrons extend from the Renal cortex, into the renal medulla
Parts of the Nephron

1. The renal corpuscle
   A. The glomerulus
   B. The glomerular capsule

2. The renal tubule
   A. Proximal convoluted tubule
   B. Loop of the nephron (Loop of Henle)
   C. Distal convoluted tubule

3. The collecting Duct

The Nephron

- The nephron performs three functions
  1. Glomerular filtration
  2. Tubular reabsorption
  3. Tubular secretion

The Nephron - Glomerular filtration

- Glomerular filtration occurs as blood pressure forces water, ions, and other small molecules in the blood through the pores in the glomerulus and into the glomerular capsule
  - The filtrate passes into the renal tubule

The renal corpuscle

- The renal corpuscle is where fluid is filtered from blood
- Consists of
  - The glomerulus - The network of capillaries
  - The glomerular capsule (Bowman’s capsule) - Surrounds the glomerulus

The renal tubule

1. Proximal convoluted tubule (PCT)
   a. reabsorption of filtrate components occurs
   b. tubular secretion also occurs here.
2. Loop of the Nephron (Loop of Henle) - consists of a descending limb and an ascending limb
   a. creates vertical osmotic gradient
   1. regulates osmotic balance
3. Distal convoluted tubule (DCT)
   a. reabsorption of water and salts
   b. more secretion of wastes
Collecting Ducts

- Collecting ducts - carry urine to the renal pelvis.

The Nephron

- Tubular reabsorption - many molecules are reabsorbed - transported from the lumen into the tissues then into capillaries. Occurs in the PCT and DCT (H₂O, nutrients, salts)

- Tubular secretion - substances are removed from the blood and added to the tubular fluid, occurs in the DCT and PCT (H⁺, K⁺, creatinine, and drugs like penicillin)

Urine Formation

- Tubular reabsorption - many molecules are reabsorbed - transported from the lumen into the tissues then into capillaries. Occurs in the PCT and DCT (H₂O, nutrients, salts)

- Tubular secretion - substances are removed from the blood and added to the tubular fluid, occurs in the DCT and PCT (H⁺, K⁺, creatinine, and drugs like penicillin)

What is the functional unit of the kidney?

1. Renal medulla
2. Nephron
3. Renal cortex

This structure conducts urine from the kidneys to the bladder

1. Urethra
2. Ureters

TABLE 16.3 Review of Nephron Regions and their Roles

<table>
<thead>
<tr>
<th>Region of Nephron</th>
<th>Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renal cortex</td>
<td>Filters the blood, removing water, glucose, amino acids, ions, nitrogen-containing wastes, and other small molecules.</td>
</tr>
<tr>
<td>Glomerular capsule (glomerular)</td>
<td>Removes water, glucose, amino acids, some urea, Na⁺, Cl⁻, and HCO₃⁻.</td>
</tr>
<tr>
<td>Renal convoluted tubule</td>
<td>Secrets H⁺, NH₄⁺, K⁺, H₂O.</td>
</tr>
<tr>
<td>Loop of the nephron</td>
<td>Reabsorbs water, Na⁺, Cl⁻, and K⁺.</td>
</tr>
<tr>
<td>Distal convoluted tubule</td>
<td>Reabsorbs water, Na⁺, Cl⁻, and HCO₃⁻.</td>
</tr>
</tbody>
</table>

NOTE: Molecules reabsorbed or secreted do not enter the filtrate.
Regulation of Urine formation

- **Diuretics** increase urinary output, making more dilute urine
  - **Examples:**
    - Caffeine
    - Lasix
    - Alcohol

Hormonal Regulation of Urine formation

1. **Antidiuretic hormone (ADH)** (posterior pituitary)
   - Makes more concentrated urine
   - Increases blood volume and pressure
2. **Aldosterone** (adrenal cortex)
   - Makes more concentrated urine
   - Increases blood volume and pressure
3. **Atrial Natriuretic Peptide (ANP)** (Heart atria)
   - Makes more dilute urine
   - Decreases blood volume and pressure

Table 16.3 Review of Hormones

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Produced by</th>
<th>Effect on Osmolarity</th>
<th>Effect on Blood Volume</th>
<th>Effect on Blood Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antidiuretic hormone (ADH)</td>
<td>Posterior pituitary</td>
<td>Makes more concentrated urine</td>
<td>Increases</td>
<td>Increases</td>
</tr>
<tr>
<td>Aldosterone</td>
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<td>Heart atria</td>
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</table>

Hormones Produced by the kidneys

1. **Renin** – Increases blood pressure by triggering the release of aldosterone by the adrenal cortex
2. **Erythropoietin** – speeds up the maturation process of RBCs, target = stem cells in bone marrow

The Kidney’s role in Vit D pathway

- Vitamin D is produced in the skin in response to sunlight, and provided by certain foods in diet
- The kidneys and liver transform Vitamin D into the active form, calcitrol.
- Calcitrol promotes the absorption of calcium into the small intestine and reabsorption of calcium in the kidneys.

Kidney’s role in Acid-Base Balance

- H⁺ is secreted into the tubules and bicarbonate is reabsorbed out of the tubules

When H⁺ is secreted into the tubules, this lowers the pH of the blood.

1. True
2. False

Kidney’s role in Salt-Water Balance

- The kidneys reabsorb salt and water, maintaining osmotic balance in the blood, this also affects blood pressure

Bladder

- The urine goes from the kidneys into the ureters then to the bladder where it is stored until it can be released through the urethra.
Urination

- Urination is controlled by both voluntary and involuntary actions
- When the bladder fills to about 250ml of urine then the motor nerve impulses cause the bladder to contract and the sphincters to relax so that urination is possible.

What hormone is secreted by the kidneys to increase blood pressure:

1. ADH
2. Renin
3. Aldersterone
4. Erythropoietin

Important Points

- What are the functions of the urinary system?
- What compounds are contained in urine, what compounds are not contained normally in urine?
- What are the organs of the urinary system and their functions, including all the functions of the kidney?
- What are the blood vessels that lead to and from the heart and the kidney and the vessels within the kidney?

Important Points

- What are the three regions of the kidney?
- What is the function of a nephron, what are the parts of the nephron and the functions of these parts?
- What is glomerular filtration, reabsorption and secretion in the nephron, what is contained in the filtrate leaving the renal corpuscle, what compounds are reabsorbed and what are secreted and where in the nephron are the compounds reabsorbed or secreted?

Important Points

- How is urinary output regulated, what are examples of diuretics? What hormones decrease or increase urinary output? What effect on blood pressure do these hormones have? Where are these hormones produced, stored and released from. What is their effect on the nephron?
- What is the function of renin, where it is produced, what is the target and what is the effect of renin on urine production and blood pressure?

Important Points

- What is the function of erythropoietin, what is the target, where is it produced?
- What is the role of the kidney in Vit D production and calcium absorption? What is the active form of Vit D?
- How does the kidney regulate blood pH and maintain osmotic balance? How does the regulation of saltwater balance effect blood pressure?

Definitions

- Excretion, renal pyramids, renal corpuscle, tubular reabsorption, tubular secretion, filtration, filtrate, diuretic, calcitrol