Bio 105: Urinary System and Excretion

Lecture 19
Chapter 16

Outline

- Function
- Organs of the Urinary System
  - Kidneys
    - Function
    - Structure
  - Urine Formation
    - Hormonal regulation
  - Kidney hormones
  - Other kidney functions
  - Urinary bladder and urination

Urinary System

- Digestive System
  - Eliminates waste from digestive tract
- Urinary System
  - Eliminates waste from the rest of the body

Function
- Excretion of metabolic wastes and to maintain homeostasis of blood

Review Question

- Which of the following systems does not function to excrete waste?
  - Digestive
  - Urinary
  - Integumentary
  - Circulatory

Urinary System - Urine

- Contents of Urine
  - Water
  - HCO₃⁻
  - Inorganic salts
  - H⁺
  - Urea
  - Uric acid
  - Creatinine

Urinary System

- Excretion
  - Majority of metabolic wastes removed from the body is mainly via the action of the kidneys
Urinary System - Organs

- Kidneys
  - Main organ
  - Produce urine
- Ureters
  - Carry urine from kidneys to the bladder

Kidney Functions

- Filter waste from blood
- Maintenance of water-salt balance of the blood
- Regulates blood pressure
- Maintenance of acid-base balance of the blood
- Secretion of hormones
  - Renin and Erythropoietin

Review Questions

- What cavity are the kidneys located in?
  - Cranial
  - Thoracic
  - Abdominopelvic
  - Pleural

The Kidneys

- Adrenal gland
- Renal artery
- Renal vein
- Ureter
- Outermost connective tissue layer
- Innermost connective tissue layer
- Adipose capsule

Ureter
- Transports urine from kidneys to bladder

Urinary bladder
- Stores urine

Urethra
- Transports urine from urinary bladder to outside the body
- Males – also reproductive tract organ

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.
Regions of the Kidney
- Renal Cortex
  - Outer granulated layer
- Renal Medulla
  - Cone-shaped tissue masses called renal pyramids
- Renal pelvis
  - Central cavity
  - Continuous with the ureter

Kidney - Nephrons
- Functional units of the kidneys
- Over 1 million nephrons per kidney
- Extend from renal cortex into the renal medulla

The Nephron

Parts of the Nephron
- Renal Corpuscle
  - Glomerulus
  - Glomerular capsule
- Renal Tubules
  - Proximal convoluted tubule
  - Loop of the nephron (Loop of Henle)
  - Distal convoluted tubule
- Collecting Duct
Nephron – Renal Corpuscle

- Where fluid is filtered from blood
- Consists of
  - Glomerulus
  - Network of capillaries
  - Glomerular capsule
    - Bowman’s capsule
    - Surrounds the glomerulus

Nephron – Glomerular Filtration

- Blood pressure forces water, ions and other small molecules in the blood through the pores in the glomerulus
- Enters the glomerular capsule
- Filtrate passes into the renal tubule

Nephron

- 3 Functions
  - Glomerular filtration
  - Tubular reabsorption
  - Tubular secretion
The Nephron

(b) Diagram of the glomerular filter showing how water and small solutes in the blood move first through the pores in the endothelium of the capillary, then through the basement membrane, and finally through slits in the inner lining of the glomerular capsule.

Nephron – Renal Tubule

- Proximal Convoluted Tubule (PCT)
  - Reabsorption of filtrate components
  - Tubular secretion
- Loop of the Nephron (Loop of Henle)
  - Descending limb and ascending limb
  - Creates vertical osmotic gradient
  - Regulates osmotic balance
- Distal Convoluted Tubule (DCT)
  - Reabsorption of water and salts
  - More secretion of wastes

Nephron – Collecting Ducts

- Carry urine to renal pelvis

Nephron – Functions, cont’d

- Tubular reabsorption
  - Transported from the lumen into the tissues then into capillaries
  - Occurs in the PCT and DCT
- Tubular secretion
  - Removed from the blood and added to the tubular fluid
  - Occurs in the DCT and PCT

TABLE 16.2 Review of Nephron Regions and their Roles

<table>
<thead>
<tr>
<th>Region of Nephron</th>
<th>Roles*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renal corpuscle (glomerular</td>
<td>Filters the blood, removing water, glucose,</td>
</tr>
<tr>
<td>capsule and glomerulus)</td>
<td>amino acids, ions, nitrogen-containing wastes,</td>
</tr>
<tr>
<td></td>
<td>and other small molecules</td>
</tr>
<tr>
<td>Proximal convoluted tubule</td>
<td>Reabsorbs water, glucose, amino acids, some</td>
</tr>
<tr>
<td></td>
<td>urea, Na⁺, Cl⁻, and HCO₃⁻</td>
</tr>
<tr>
<td></td>
<td>Secretes drugs, H⁺, NH₄⁺</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>
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</tr>
</tbody>
</table>

*Major reabsorbed or secreted substances are listed here.
Review Question

• What structure conducts urine from the kidneys to the bladder?
• What is the functional unit of the kidney?

Urine Formation Regulation

• Diuretics
  • Increase urinary output
  • Make more dilute urine
  • Examples
    • Caffeine
    • Lasix (Furosemide)
    • Alcohol

Urine Formation - Regulation

• Hormonal Regulation
  • Antidiuretic Hormone (ADH)
    • Makes more concentrated urine
    • Increases blood volume and pressure
  • Aldosterone
    • Makes more concentrated urine
    • Increases blood volume and pressure
  • Atrial Natriuretic Peptide (ANP)
    • Makes more dilute urine
    • Decreases blood volume and pressure
### Table 16.3 Review of Hormones

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Effect on Water and Solute Reabsorption in Tubules</th>
<th>Effect on Blood Volume and Pressure</th>
<th>Urine Produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angiotensin II (Ang II)</td>
<td>Increases permeability in medulla of collecting ducts, resulting in increase in water moving from filtrate to blood</td>
<td>Increases</td>
<td>Concentrated</td>
</tr>
<tr>
<td>Aldosterone</td>
<td>Increases reabsorption of Na+ by distal convoluted tubules and collecting ducts, resulting in formation of more concentrated urine (concentrated urine)</td>
<td>Increases</td>
<td>Concentrated</td>
</tr>
<tr>
<td>Atrial natriuretic peptide (ANP)</td>
<td>Decreases reabsorption of Na+ by distal convoluted tubules and collecting ducts, resulting in more dilute and water-removing urine</td>
<td>Decreases</td>
<td>Dilute</td>
</tr>
</tbody>
</table>

### Kidney – Hormone Production
- **Renin**
  - Increases blood pressure
  - Triggers release of aldosterone by the adrenal cortex
- **Erythropoietin**
  - Speeds up maturation process of RBCs
  - Target = Stem cells in bone marrow

### Kidney – Vitamin D
- Produced in the skin in response to sunlight
- Provided by certain foods in diet
- Transformed into the active form – Calcitriol
  - Occurs in kidneys and liver
- Calcitriol
  - Promotes absorption of calcium into the small intestine
  - 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

### Review Question
- When \( H^+ \) is secreted into the tubules, this lowers the pH of the blood?
  - True
  - False

### Kidneys – Salt/Water Balance
- Reabsorb salt and water
- Maintain osmotic balance in the blood
- Effects blood pressure
**Bladder**

- **Urine Pathway**
  - Made in kidneys →
  - Into ureters →
  - Into bladder, stored until it can be released →
  - Exits body via urethra

**Urination**

- Controlled by both voluntary and involuntary actions
- Bladder fills to ~ 250 ml
  - Motor nerve impulses cause the bladder to contract
  - Sphincters relax so that urination is possible

**Review Question**

- What hormone is secreted by the kidneys to increase blood pressure?
  - ADH
  - Renin
  - Aldosterone
  - Erythropoeitin

**Important Concepts**

- What are the functions of the urinary system?
- What compounds are contained in urine? What compounds are not contained in urine?
- What are the organs of the urinary system? What are their functions? Include all functions of the kidney
- What are the blood vessels that lead to and form the heart and the kidney and the vessels within the kidney?
Important Concepts

• 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?

Important Concepts

• What is the function of renin?
• Where is it produced?
• What is the target and what is the effect of renin on urine production and blood pressure?

Important Concepts

• What is the function of erythropoietin? What is the target and where is it produced?
• What is the role of the kidney in Vitamin D production and calcium absorption? What is the active form of vitamin D?
• How does the kidney regulate blood pH and maintain osmotic balance? How does the regulation of salt/water balance effect blood pressure?

Definitions

• Excretion
• Renal pyramids
• Renal corpuscle
• Tubular reabsorption
• Tubular secretion
• Filtration
• Filtrate
• Diuretic
• Calcitrol

The End