Urinary System and Excretion

Bio105
Lecture 20
Chapter 16

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Outline

I. Function
II. Organs of the urinary system
   A. Kidneys
      1. Function
      2. Structure
III. Disorders of the urinary system

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.

Urine

- Urine contains:
  - Water
  - $\text{HCO}_3^-$
  - Inorganic salts
  - $\text{H}^+$
  - 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.
Organs of the Urinary System

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
3. Regulates blood pressure
5. Secretion of hormones = renin and erythropoietin.

Vascularization

- Aorta
- Renal artery
- Arterioles
- Capillaries
- Venules
- Renal Vein
- Vena Cava

The Kidneys

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

Blood vessels and protective layers around kidneys

Heart
Adrenal gland
Renal artery
Renal vein
Diaphragm
Inferior vena cava
Aorta
The Regions of the Kidneys

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

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

The Nephron

- A nephron and its blood supply
- Diagram showing the nephron and its components
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
   C. Distal convoluted tubule

3. The collecting Duct

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 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 Nephron

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

The renal corpuscle consists of the glomerular capsule and a ball of capillaries called the glomerulus.

Afferent (incoming) arteriole

Efferent (outgoing) arteriole

Path of filtrate

Path of blood

Movement of water and small solutes

Filtrate

Glomerulus

Glomerular capsule

Space within the glomerular capsule

Capillary wall

Proximal convoluted tubule

The renal tubule

1. Proximal convoluted tubule (PCT) - where reabsorption of filtrate components occurs, tubular secretion can also occur here.

2. Loop of the Nephron (Loop of Henle) - consists of a descending limb and an ascending limb that regulates osmotic balance.

3. Distal convoluted tubule (DCT) – Further absorption of water and salts; leads to the renal pelvis

Collecting Ducts

- Collecting ducts - carry urine to the renal pelvis.

Urine Formation

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

- Tubular secretion - substances are removed from the blood and added to the tubular fluid, mainly in the DCT. (H⁺, creatinine, and drugs like penicillin)
Diuretics increase urinary output, making more dilute urine

Examples:
- Caffeine
- Lasix
- Alcohol

Hormonal Regulation of Urine

1. Antidiuretic hormone (ADH)
   - Makes more concentrated urine
   - Increases blood volume and pressure

2. Aldosterone
   - Makes more concentrated urine
   - Increases blood volume and pressure

3. Atrial Natriuretic Peptide (ANP)
   - Makes more dilute urine
   - Decrease blood volume and pressure
### Hormonal Regulation of Urine - ADH

- **Antidiuretic hormone (ADH)**
  - Makes the collecting duct more permeable to water therefore, increases the water reabsorption in the collecting duct, making more concentrated urine.
  - Produced by the hypothalamus, stored in the posterior pituitary gland.
  - Site of action: collecting ducts.

### Diabetes insipidus

- Diabetes insipidus is caused by producing too little ADH
- Symptoms: excrete large amounts of dilute urine

### Kidney Function and ADH

- Decrease in concentration of water in blood detected by the hypothalamus.
- Antidiuretic hormone (ADH) prompts an increase in the permeability to water of distal convoluted tubules and collecting ducts of nephrons.

### Hormonal Regulation of Urine - Aldosterone

- **Aldosterone**
  - Hormone produced and released by the adrenal cortex
  - Increases sodium reabsorption in the distal convoluted tubule and the collecting duct, water follows
  - Making more concentrated urine.

### Juxtaglomerular apparatus and Aldosterone

- Aldosterone is released in response to blood pressure monitored by the juxtaglomerular apparatus
- The cells in the juxtaglomerular apparatus release the hormone renin.
- Renin is converted to an active form that stimulates the adrenal cortex to release aldosterone.
Hormonal Regulation of Urine - ANP

- **Atrial Natriuretic Peptide (ANP)**
  - Hormone produced by the heart in response to increased blood volume and pressure
  - Decreases sodium reabsorption in the distal convoluted tubule and the collecting duct, water stays in the filtrate
  - Also inhibits production of aldosterone and renin
  - Making more dilute urine. Lowers blood pressure and blood volume

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

- 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

- **HCO3-** is secreted into the tubules and hydrogen ions are reabsorbed into the kidney tubule
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.

Urinary Function Disorders

- Acute renal failure
- Urinary tract infections (UTIs)

Urinary Function Disorders

- Acute renal failure – abrupt and nearly complete failure of kidney to function
  - Caused by severe inflammation, drugs, or poisons.
  - Treatment – dialysis and organ transplant
## Urinary Function Disorders

- Urinary tract infections (UTIs) – Bacterial infection of the urinary tract:
  - Urethritis - infection confined to the urethra.
  - Cystitis - infection of the urethra and bladder.
  - Pyelonephritis - infection reaches the kidneys.
- Treatment: antibiotics

## Important Points

- Read Chapter 17 for next lecture
- 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 cause of diabetes insipidus
- 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 salt/water balance effect blood pressure?
- Be able to discuss the disorders of the urinary system, including the causes, effects and treatments?

## Definitions

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