Urine Formation by the Kidneys: I. Glomerular Filtration, Renal Blood Flow and Their Control.

Chapter 26

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Lecture-1 Introduction 31/3/2015
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**Textbook:** Textbook of Medical Physiology  
*By: Arthur C. Guyton and John E. Hall, 12th ed. 2011*

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**Optional Reading:**  
Renal System

Functions of kidney:
- Remove waste products from the blood
- Control the acid base balance (through HCO$_3^-$ & H$^+$)
- Secrete Hormones and enzyme like erythropoietin and rennin.
- Activates Vitamin D.
- Make G from non CHO sources (make sugar from proteins at time of starvation (gluconeogenesis)).
Example of Metabolic Waste Products Excreted by the kidneys

- Urea (from protein metabolism)
- Uric acid (from nucleic acid metabolism)
- Creatinine (from muscle metabolism)
- Bilirubin (from hemoglobin metabolism)
Examples of Foreign Chemicals Excreted by the kidneys

- Pesticides
- Food additives
- Toxins
- Drugs
Secretion, Metabolism, and Excretion of Hormones

Hormones produced in the kidney

- Renal erythropoietic factor
- 1,25 dihydroxycholecalciferol (Vitamin D)
- Renin

Hormones metabolized and excreted by the kidney

- Most peptide hormones (e.g. insulin, angiotensin II, etc)
- Hormones target the kidneys: Example: ADH, aldosterone etc.
Body fluid regulation.
Organs of the urinary system

- Diaphragm
- Esophagus
- Left adrenal (suprarenal) gland
- Left renal vein
- Left kidney
- Abdominal aorta
- Inferior vena cava
- Left ureter
- Rectum
- Left ovary
- Urinary bladder
- Urethra

Anterior view

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Internal anatomy of the kidneys

(a) Frontal section of right kidney

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Internal anatomy of the kidneys

- Nephron
- Path of urine drainage:
  - Collecting duct
  - Papillary duct in renal pyramid
  - Minor calyx
  - Major calyx
  - Renal pelvis
- Renal artery
- Renal vein
- Renal cortex
- Renal medulla
- Renal column
- Renal pyramid in renal medulla
- Renal sinus
- Renal papilla
- Fat in renal sinus
- Renal capsule

(a) Frontal section of right kidney

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Anatomy of kidneys:

- Cortex: contain glomeruli \(\rightarrow\) filtration
- Medulla: contain tubules \(\rightarrow\) secretion and reabsorption
- (each tubule is 5-6 cm long)
  * Cortical atrophy: glomerulonephritis
  * Medullary atrophy: tubular nephritis
- Cortical nephron have short loop of henle
- Juxta-medullary nephron have long loop of Henle and this is important in urine concentration (15-20%).
- In each kidney we have 1 million afferent arteriole & nephron.
Renal Blood Flow... Introduction

- The kidney weighs 113-170 gm each. Receives 1200 ml blood/min (> 4 ml blood per gram tissue weight)
- Renal artery arises as the fifth branch of the abdominal aorta. The renal artery arises from the aorta at the level of the second lumber vertebra. Because the aorta is to the left of the midline, the right renal artery is longer. The inferior vena cava lies to the right midline making the left renal vein two times longer than the right renal vein. For this reason it is better to take the donor left kidney (short artery, long vein) & place it in the right pelvis of the recipient. Multiple arteries & veins can supply the kidney.
Nephron Tubular Segments

- Proximal tubule
- Distal tubule
- Macula densa
- Cortex
- Connecting tubule
- Bowman's capsule
- Cortical collecting tubule
- Loop of Henle:
  - Thick segment of ascending limb
  - Thin segment of ascending limb
  - Descending limb
- Medulla
- Medullary collecting tubule
- Collecting duct
Cortical and juxtamedullary nephrons
Basic Mechanisms of Urine Formation
Functional Anatomy of the Kidney

- Structure & function of the kidney are closely matched. The kidney is a combination of:
  1. Ultrafiltration device (the glomerular apparatus).
  2. Epithelium, which modifies the ultrafiltrate by:
     - addition (secretion) or
     - removal (reabsorption).
Structures and functions of a nephron

1. Filtration from blood plasma into nephron
2. Tubular reabsorption from fluid into blood
3. Tubular secretion from blood into fluid

- Renal corpuscle
- Ultrafiltration device
- Glomerular capsule
- Renal tubule and collecting duct
- Epithelium to modify the ultrafiltrate
- Afferent arteriole
- Efferent arteriole
- Peritubular capillaries
- Urine (contains excreted substances)
- Blood (contains reabsorbed substances)
Excretion = Filtration - Reabsorption + Secretion

Filtration: somewhat variable, not selective (except for proteins), averages 20% of renal plasma flow

Reabsorption: highly variable and selective mos electrolytes (e.g. Na\(^+\), K\(^+\), Cl\(^-\)) and nutritional substances (e.g. glucose) are almost completely reabsorbed; most waste products (e.g. urea) poorly reabsorbed

Secretion: highly variable; important for rapidly excreting some waste products (e.g. H\(^+\)and K\(^+\)), foreign substances (including drugs), and toxins
Renal Handling of Different Substances