Urinary system

Urea, uric acid, creatine drugs, food additives dissolved in water
Functions of the urinary system

• Micturition-(removal of metabolic wastes)
• Regulate ionic concentration of plasma by controlling the amount lost in the urine
• pH balance-removal of ammonia for body fluids
• Regulates blood volume/pressure by controlling the amount of urine produced
• Stimulates erythrocyte production
Removal of wastes from the body

- The urinary system maintains homeostasis of the blood concentration, volume, pressure, pH and removes toxins.

- Functional unit of the kidney is the nephron
  - 1.25 million nephrons per kidney
The urinary system is located in the abdominal pelvic cavity.

Kidneys and ureters are in the retroperitoneal space.
Kidneys

- Located between T12 and L-3
- Right kidney lower than left (liver in the way)
- Located retroperitoneal
- Renal Capsule-collagen fibers on surface of kidney
- Perarenal fat-helps protect kidneys, adipose tissue
- Renal Fascia -Anchored to back abdominal wall
  - Runs from capsule through fat to wall
The right kidney is inferior to the left.
Connective tissue holds the kidneys in place against the posterior body wall.
Anatomy of the kidney

- Renal Cortex-Superficial region
- Renal Medulla-deeper region
  - Similar idea to adrenal cortex and medulla
FYI

• 4900ml of blood leaves the heart per minute

• About 1200ml of blood flows through the kidneys/per minute

• The liver and kidneys receive about half of the blood that leaves the aorta
Blood flow to & from the kidneys

Aorta

Inferior vena cava

Renal artery

Renal vein

Segmental arteries

Interlobar veins

Interlobar arteries

Arcuate veins

Arcuate arteries

Interlobular veins

Interlobular arteries

Venules

Afferent arterioles

Nephrons
Nephron

- The functional unit of the kidney
- 1.25 million nephrons per kidney
- Urine is formed in the nephrons

- The blood is filtered to remove wastes, toxins, & ions inside the nephrons
• Glomerulus is a cluster of capillaries inside the nephron
• Blood that exits the glomerulus enters the nephron to start filtration (removal of wastes)
Bowman’s capsule
filtration

• Filtering of plasma across three layers:
  • Capillary endothelium-fenestrated capillaries with pores
  • Basement membrane-blocks filtering of large proteins
  • Glomerular epithelium-podocytes cover most of the BM. Gaps –filtration slits
2. Fenestrated Capillary Bed
- have ‘pores’ called *fenestrations*.
- more ‘leaky’ than continuous.

- specific locations in body:
  - kidney, capillaries of endocrine organs, synovial joints.
Fig 26.6
Proximal convoluted tubule

Bowman’s capsule

Bowman’s capsule + glomerulus
Fig 26.7

- Interlobular veins
- Bowman’s capsule
- Peritubular capillaries
- Glomerulus
- Distal convoluted tubule (DCT)
- Collecting duct
- Loop of Henle
- Vasa recta

(e) Cortical nephron
(f) Juxtamedullary nephron
Renal corpuscle = bowman’s capsule + glomerulus
Cortical nephron
85% of nephrons
short loop of Henele

Majority of reabsorption occurs at the proximal convoluted tubule have microvilli

Juxtamedullary nephron 15% of nephrons
long loop of Henle
Juxtaglomerular apparatus

• Releases factors that effect blood:
  • Rennin-enzyme-leads to reduced urine volume
  • Erythropoietin-hormone-stimulates production of erythrocytes
Juxtaglomerular apparatus
Not a tracing to memorize!

- Aorta
- Renal artery
- Segmental artery
- Lobar artery
- Interlobar artery
- Arcuate artery
- Interlobular artery
- Afferent arteriole
- Glomerulus
- Efferent arteriole
- Peritubular capillary network
- Interlobular vein
- Arcuate vein
- Interlobar vein
- Lobar vein
- Renal vein
- Inferior vena cava

Wastes dissolved in water form the urine in at the minor calyces

“Cleansed” blood

Remember there are about 2.5 million nephrons doing this simultaneously

Nutrients, hormones etc. return to the cardiovascular system
Blood doping-FYI

• Taking erythropoietin to increase erythrocyte levels
  – Increase oxygen levels in the blood
• There is a another very clever way to do this.
Kidney physiology-FYI

• Filtration - glomerulus to bowmans capsule
• Secretion - capillaries to nephron
• Reabsorbtion - nephron to blood
• Excretion - nephron to minor calyx
FYI

• Kidney failure-kidney no longer function to remove toxins from the blood
  – Uremia-toxicity of the blood
• Dialysis- a machine that does the function of the kidneys
• The peritoneal membrane can be used for dialysis
• Having only one kidney is good enough but two kidneys are better than one!
ADH-antidiuretic hormone

- ADH produced in the hypothalamus
- Released by the neurohypophysis (posterior)
- Effects cells of the collecting ducts
- ADH signal these cells to reabsorb (transfer from nephron to blood) water
- Alcohol inhibits the release of ADH from the neurohypophysis causing increased urine volume
Ureters-

- 12 inches long
- descend from Renal Pelvis to bladder
- opens to bladder in a posterior-lateral side
- enter bladder through slit-like orifice (membrane covered)
  - open when relaxed
  - closed when bladder muscles contract
- **Transitional epithelium** in musoca- found in areas of stretching
- strong muscular tunic actively moves urine to bladder → peristaltic contractions
Urinary Bladder-

- Hollow muscular, temporary storage organ
- Trigone- funnel-shaped region formed between 3 openings
  - Infection more common in females
- Detrusor muscles- 3 smooth muscles layers of bladder
  - 1 circular musc. Between 2 longitudinal musc.
- Micturition controlled through spinal reflex. But can overrides with somatic motor!
Urethra-

- Controlled by sphincter muscles
- Involuntary \( \rightarrow \) Internal urethral sphincter (smooth muscle)
- Voluntary \( \rightarrow \) External urethral sphincter (skeletal muscle)
- Female 1-1 ½ inches - urinary organ
- Male 7-8 inches (three regions) - reproductive and urinary organ
Kidney stones form in the calyces, renal pelvis, & ureters.
Urine bladder

Pubic symphysis

External urethral sphincter

Penile urethra

External urethral meatus

Prostate gland

Urogenital diaphragm

Urethra [see part (c)]

(a) Male pelvis, sagittal section
<table>
<thead>
<tr>
<th>Substance</th>
<th>Amount filtered per day</th>
<th>Amount excreted per day</th>
<th>Percent reabsorbed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>180L</td>
<td>1.8L</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Without ADH</td>
<td>6X</td>
</tr>
<tr>
<td>Sodium-ion</td>
<td>630g</td>
<td>3.2g</td>
<td>99.5</td>
</tr>
<tr>
<td>Glucose-nutrient</td>
<td>180g</td>
<td>0g</td>
<td>100</td>
</tr>
<tr>
<td>Urea-cellular waste product</td>
<td>54g</td>
<td>30g</td>
<td>44 can be used to synthesize amino acids</td>
</tr>
</tbody>
</table>
• Break
• Histology
Fig 26.1

- Left kidney
- Right kidney
- Ureter
- Urinary bladder
- Urethra
- Diaphragm
- Renal artery
- Renal vein
- Adrenal gland
- 11th and 12th ribs
- L4 Lumbar vertebra
- Inferior vena cava
- Iliac crest
- Aorta

(b) Posterior view
Fig 26.3

(a) Frontal section of left kidney, anterior view
Segmental arteries lead to each lobe
Fig 26.4

- Renal cortex
- Interlobular vessels
- Renal columns
- Interlobar vessels
- Arcuate vessels
- Nephron
- Renal pyramid

(b) Cortical circulation
• Kidney slide