Ch17-18 Urinary System

Main Function:

- Filter the blood

Other Functions:

- maintain purity and consistency of internal fluids
- eliminates nitrogenous wastes, toxins, and drugs from the body
- regulates blood volume and chemical makeup to maintain proper balance between water and salts and between acids and bases
- produces the enzyme renin to help regulate blood pressure
- releases hormone erythropoietin to stimulate red blood cell production
- converts vitamin D into active form
- manufactures urine

Every day, kidneys filter gallons of fluid from our bloodstream

Organs

- kidney, paired ureters, urinary bladder, and urethra
  - Provide reservoirs or transportation channels

Location

- Along dorsal wall (T12 to L3 vertebrae level) in the retroperitoneal space
- Right kidney is slightly lower because of liver
- Layer of fat helps hold each kidney in place

Structure of Kidney

- Hilus – medial indentation where ureters, renal blood vessels, and nerves enter and exit
- Outer region – renal cortex (light colored)
- Inner region – renal medulla (dark colored)
- Triangular part of renal medulla – medullary pyramids
- Cavity leading from the hilus to the pyramids – renal pelvis

- **Nephron**: structural and functional unit of kidneys and responsible for the formation of urine

Structure of Nephron

- Glomerulus – knot of capillaries that has arterioles coming in and leaving the capillaries
- Bowman's capsule – cup-shaped tube that surrounds glomerulus
- Proximal tubule – located closest to Bowman's capsule and does reabsorption and secretion

- Loop of Henle – only does reabsorption of NaCl and water out of the renal tubules and is located in the medulla

- Distal tubule – located farthest from Bowman's capsule and does reabsorption and secretion

- Collecting duct – leads to ureters and last site of water reabsorption

Steps of Urine Formation

- Filtration – all materials small enough to fit through the membrane moves into the renal tubes (ALL IN)
- Reabsorption – good nutrients are moved back to the blood through passive and active transport (GOOD BACK OUT)
- Secretion – any remaining bad materials in the blood move into the renal tubes (BAD IN)
- Excretion – urine leaves the body

Characteristics of Urine

- Clear to pale yellow
- Yellow = pigment urochrome that is produced when blood destroys hemoglobin
- Sterile
- Has an odor; drugs, vegetables, or diseases can alter the odor

- pH slightly acidic; can change with diet or body metabolism

- Water plus solutes
  - Normal solutes: Na, K, urea, uric acid, creatinine, ammonia, bicarbonate ions, and other ions
  - Abnormal solutes: RBC, WBC (pus), glucose, blood proteins, hemoglobin, and bile

Blood Composition

- Depends on:
  - diet
  - metabolism
  - urine output

- **Our kidneys can keep our blood composition fairly constant by allowing different amounts of filtration and reabsorption despite a wide variation in our diets and cell activity.**

3 Roles in Regulating Blood Composition

- Excretion of nitrogenous wastes
- Maintaining water and electrolyte balance
- Ensuring proper blood pH

Nitrogenous wastes

- Nitrogenous wastes – by-products of reactions that the body needs to get rid of
  - Urea = less toxic form of ammonia and is formed in liver when proteins are broken down
  - Uric acid = less common and even less toxic and released when nucleic acids are metabolized
  - Creatinine = released when creatine metabolism takes place in muscles

Water and Electrolyte Balance

- Water intake needs to be greater than water loss
  - Water is found in many locations in body: intracellular fluid, extracellular fluid, and fluid in plasma, cerebrospinal, and eyes
  - It is important to maintain a balance of water in all areas of the body for cells to work properly
  - Water % decreases as you age (45% water in old age; 75% water as a baby)

- Electrolytes = charged ions that conduct electrical signals
  - Examples: Na^+, K^+, Ca^{2+}, Cl^-

- Solute changes cause osmosis to occur
  - This can change blood volume and pressure as well as functioning of nerves and muscles
  - **Rule: Water follows Salt**
    - The more concentrated one side of a membrane, the more water will move to that area (high to low)

Blood pH

- Cell metabolism continually adds H^+ to blood as a byproduct
  - Disrupts acid-base balance

- CO_2 forms carbonic acid (regulated by **lungs** with breathing to decrease pH of blood) and other acids such as lactic acid (all other molecules are regulated by **kidneys**)

- Blood buffers help “tie up” acids and bases in blood to regulate pH levels
  - Release or bind H^+ to increase or decrease pH

- Increase or decrease in respiratory rate depends on need for CO_2 in blood

Hormone Regulation

- Blood pressure balance:
  - Juxtaglomerular complex, **smooth muscle cells in wall of capillaries near the glomerulus**, detects a drop in blood pressure
  - Renin (enzyme) is then secreted from the smooth muscle cells and moves to the liver
  - Renin reacts with a protein from the liver to then trigger the release of **aldosterone** (glucocorticoid and mineralcorticoid) from the adrenal gland

- Aldosterone will act on the kidney and **help to move Na+ and K+ from the renal tubes back into the blood**
- This causes **more water to move into the blood**
- Meanwhile, blood vessels get a signal to **constrict**
- Blood pressure is returned to normal

Simply Put

- Some cells in your blood vessels in the kidneys detect a drop in blood pressure
- The cells release a chemical, which activates another chemical from the liver, which causes the adrenal gland to release its hormone
- The hormone constricts your blood vessels and has the kidneys keep more Na+ and K+ in your blood, which also puts water back in your blood
- Now, blood pressure can go back up

Hormone Regulation

- Water balance
  - **Antidiuretic hormone** is released from the pituitary gland if blood water levels are low
  - ADH attaches to the **collecting duct** and more **water is moved back into the blood** by adding more water channel proteins
  - This keeps water in the body instead of being released with the urine

Disorders

- Diabetes mellitus – disruption of the acid-base balance in which ketones (acids) are not broken down in the body and leave through the urine

- Water intoxication – babies who drink too much water under the age of 3 months start to have swelling and eventually seizures

- Kidney disease – reduces glomerular filtration
- Incontinence – inability to voluntarily control the external sphincter
- Urinary retention – when bladder is unable to expel its urine
- Dehydration – water output exceeds water intake

Development

- In young embryos, there are 3 different times that kidneys form and then are degenerated
  - Third formation, they become the functioning kidneys

- By 3rd month, kidneys are excreting urine through the placenta

- Voluntary control of sphincters follows nervous development
  - By 18 months, bladder can be held for 2 hours – start of potty training
  - Complete nighttime control by 4 years old

- Micturition (Voiding) = act of emptying the bladder by the control of 2 sphincters

- Old age = decrease function of nephrons and less efficient filtrate reabsorption

Video

- Organs
- Nephron
- Kidney stone removal: Laparoscopic Pyelolithotomy

- Urine Formation