

HOMEOSTASIS OF WATER AND SOLUTES (Chapter 43)

The kidney filters blood removing wastes/excess and reabsorbs beneficial substances such that the overall water and solute **gain = loss** maintaining homeostasis of water and solutes.

Water Gain and Loss

- Gain:
- 1) absorption from liquids and solid foods (thirst affects here)
 - 2) metabolism (produces water)
 - 3) reabsorption from fluid in kidney tubules (hormonally controlled)
- Loss:
- 1) excretion by urinary system (most important)
 - 2) evaporation from lungs and skin, sweating
 - 3) elimination by way of gut (diarrhea, vomiting)

Solute Gain and Loss

- Gain:
- 1) absorption from gut
 - 2) metabolism (produces solutes, molecular fragments)
 - 3) reabsorption from fluid in kidney tubules (hormonally controlled)
- Loss:
- 1) excretion by urinary system (most important)
 - 2) sweating
 - 3) elimination by way of gut (diarrhea, vomiting)

STRUCTURE-FUNCTION OF KIDNEY

Kidney Function

- filters water, mineral ions, organic wastes, and drugs/toxins from the blood
- only a small amount of water and solutes actually leave as urine (most is reabsorbed into blood)
- kidney regulates volume and solute concentration of blood and interstitial fluid
- excess fluid/solute is excreted as urine
- urine passes from kidney to urinary bladder (storage) via the ureter (one from each kidney), then out of body via urethra
- person is prompted to urinate when stretch-receptors in bladder sense expansion

Kidney Structure

- each kidney has an outer cortex wrapped around a central medulla
- a tough coat of connective tissue called the renal capsule encloses each kidney
- unfiltered blood enters the kidney via the renal artery; filtered blood exits via the renal vein
- internally, the kidney is divided into lobes
- each lobe contains blood vessels and nephrons

Nephrons

- functional unit of the kidney; where blood is filtered and urine is formed
- each kidney has more than 1 million tiny nephrons
- the top of the nephron is balloon-shaped and is called the glomerulus
- the glomerulus consists of the Bowman's capsule and glomerular capillaries
- blood enters glomerular capillaries via afferent arteriole, is filtered through tiny pores in the capillaries, small solutes and water (filtrate) is captured by Bowman's capsule
- filtrate flows from Bowman's capsule --> proximal tubule --> loop of Henle -- distal tubule --> collecting duct --> renal pelvis --> ureter --> urinary bladder --> urethra --> out of body
- surrounding the nephron are peritubular capillaries

URINE FORMATION

- 3 steps: Glomerular Filtration, Tubular Reabsorption, Tubular Secretion

Glomerular Filtration

- blood pressure forces water and small solutes (ie. minerals, glucose, ions, amino acids) through tiny pores in walls of glomerular capillaries into Bowman's capsule which captures the filtrate
- large substances (ie. blood cells, proteins) remain in blood (not filtrate)
- blood pressure influences rate of glomerular filtration and volume of filtrate
- filtrate in Bowman's capsule flows to proximal tubule

Tubular Reabsorption

- takes place at proximal tubule, loop of Henle, distal tubule, and collecting duct
- most water, glucose, amino acid, sodium reabsorption occurs in proximal tubule
- salt and water reabsorption also occurs in loop of Henle, distal tubule, and collecting duct
- loop of Henle is a long hair-pin tubule which dips deep into medulla of kidney; Na⁺ is actively pumped out of lumen of loop of Henle into interstitial space (making it hypertonic); water follows passively; both substances enter peritubular capillaries
- highly regulated by hormones

Tubular Secretion

- also occurs across walls of nephron (tubule) but in opposite direction to reabsorption
- excess H⁺, K⁺, Na⁺, drugs, etc. are moved out of peritubular capillaries surrounding tubule and into the tubule lumen
- critical for acid-base balance and ridding body of protein by-products such as ammonia, urea, uric acid, hemoglobin breakdown products, drugs/toxins
- occurs mostly in distal tubule
- highly regulated by hormones

- the fluid that exits the nephron after glomerular filtration, tubular reabsorption, and tubular secretion, and enters the collecting duct is now properly called "urine"

HORMONAL REGULATION

- hormonal adjustments are made mostly across the walls of distal tubule and collecting duct

ADH (Antidiuretic Hormone)

- acts mostly on collecting duct
- makes walls of collecting duct more permeable to water so water is absorbed (lumen to peritubular capillaries)
- secreted from posterior pituitary when blood becomes hypertonic (high solute, low water) or blood volume drops (hypovolemia)

Aldosterone

- acts mostly on distal tubule
- stimulates Na⁺/K⁺ pumps to move Na⁺ out of lumen (into blood) and K⁺ into lumen (from blood)
- also stimulates other Na⁺ and K⁺ channels (reabsorption of Na⁺, loss of K⁺)
- secreted from adrenal cortex when blood Na⁺ drops (hyponatremia)

Atrial Natriuretic Hormone

- acts mostly on collecting duct and distal tubule
- closes Na⁺ channels preventing Na⁺ reabsorption, inhibits aldosterone release, and reduces proximal tubule Na⁺ reabsorption
- secreted by atria when they sense increased blood volume (hypervolemia)
- by reducing Na⁺ reabsorption, more Na⁺ exits body and water follows lowering B.P. and blood volume