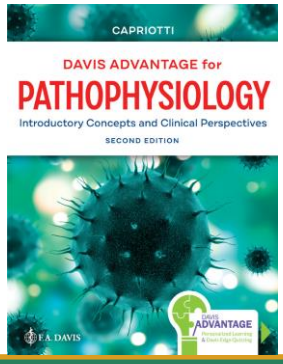
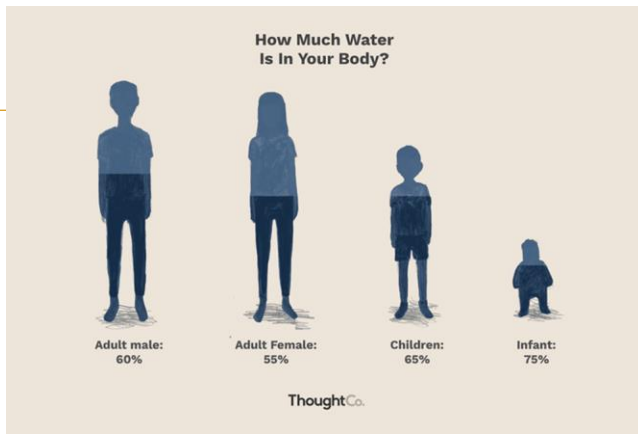
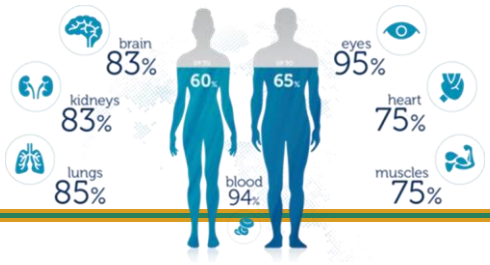


Chapter 7

Fluid and Electrolyte Imbalance

1

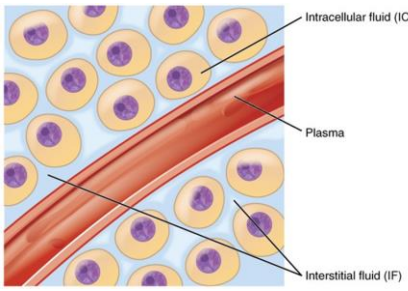


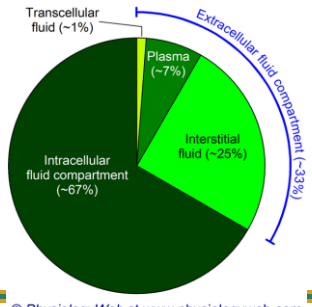


2

Basic Concepts of Fluid and Electrolyte Balance

- Human body is ~60% water
- Intracellular fluid (ICF)
  - Fluid in cells
  - ~40% of body weight
- Extracellular fluid (ECF)
  - Outside cells
  - Most found in interstitial and intravascular spaces
  - ~20% of body weight





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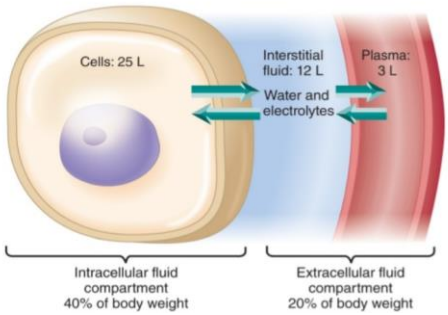
3

Basic Concepts of Fluid and Electrolyte Balance (continued)

- Interstitial fluid (ISF)
  - Filtrate of blood located between cells or between cells and capillaries
  - Normally lacks proteins



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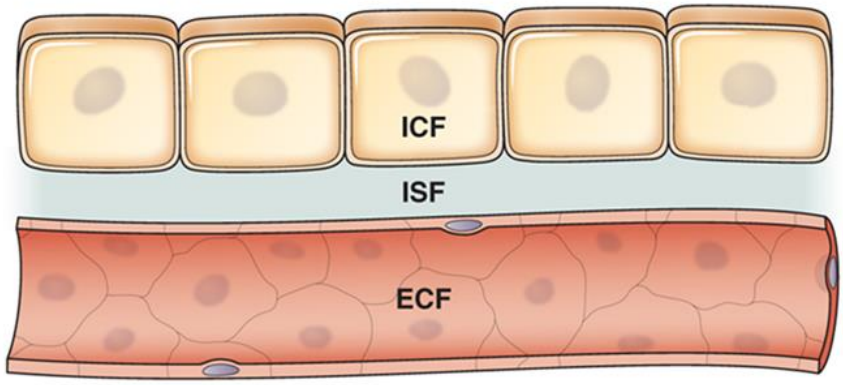
Fluid Compartments



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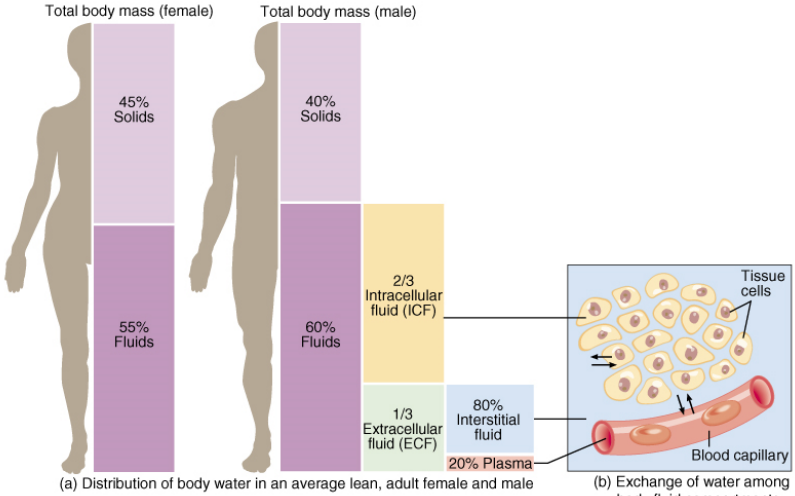
Distribution of Body Water (adults)



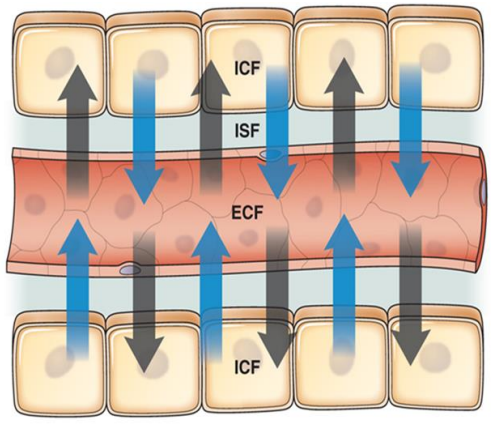
6

Overview of Key Terms

- Hydrostatic pressure
  - Force of fluid pressure in bloodstream
- Osmotic pressure
  - Pressure by solutes in solution
- Oncotic pressure
  - "Colloid pressure"
  - Pressure due to albumin in blood
- Osmolality
  - Concentration of solutes/kg solution
- Osmolarity
  - Number of osmoles of solute per liter of solution

7

Hydrostatic and Osmotic Pressures



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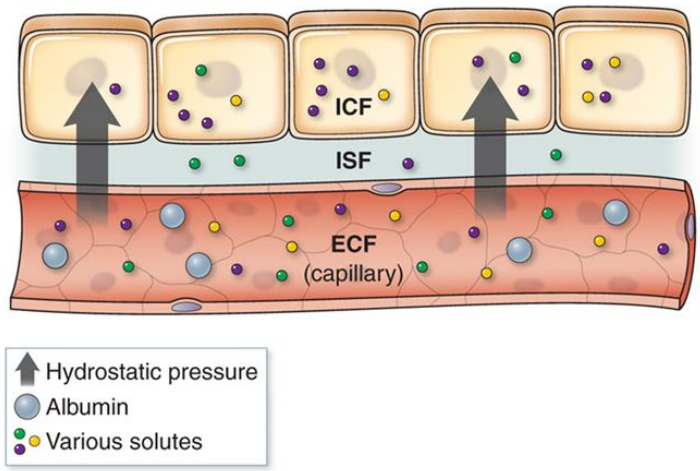
Oncotic Pressure



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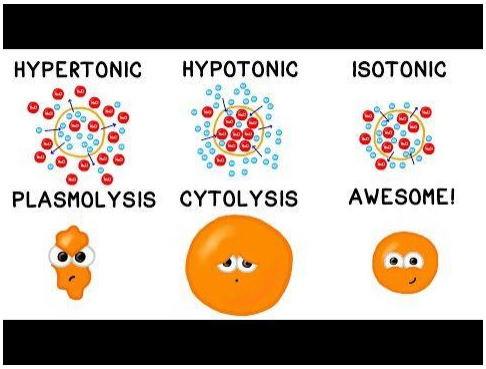
Tonicity

- Amount of solutes in solution compared with the bloodstream
- Isotonic
  - Same tonicity as blood
  - Does not cause fluid shifts or changes in cell size
  - Standard isotonic solution: 0.9% NaCl



- Ringer's lactate
  - Similar physiological constituents as those found in blood

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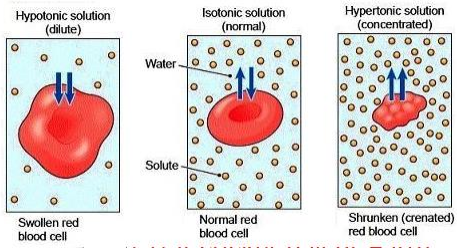
Tonicity (continued)



- Hypotonic
  - Fewer particles (more water) than blood
  - IV infusion causes shift from ECF into ICF
  - 0.45% NaCl as treatment for dehydration
- Hypertonic
  - More particles (less water) than blood
  - IV infusion pulls water from ICF into ECF; 3% NaCl
  - Mannitol infusion used in cerebral edema

11

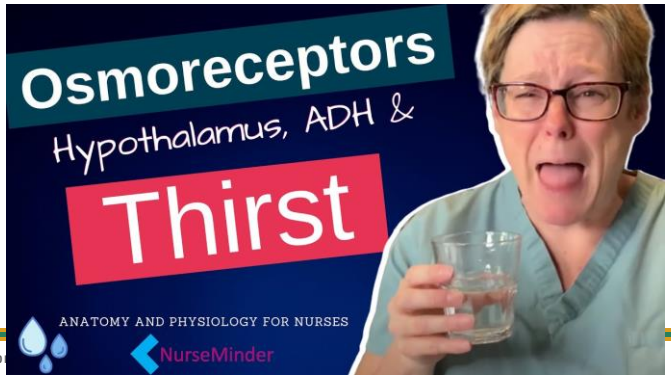
Starling Law of Capillaries

- Explains the movement of fluid that occurs at capillary beds
- Outcome of 2 major opposing forces:
  - Hydrostatic pressure
  - Osmotic pressure
- Alterations in forces can lead to edema
  - Increased blood volume = increased hydrostatic pressure
  - Lower albumin = reduced osmotic pressure
- *Case*: Swollen feet →Epson salt bath (hypertonic solution)

12

Osmoreceptors, ADH, and Thirst

- Normal plasma osmolality ~290 mOsm
- Osmoreceptors
  - Located in hypothalamus and stimulated by increased plasma concentration
  - Initiate thirst mechanism and antidiuretic hormone (ADH) release



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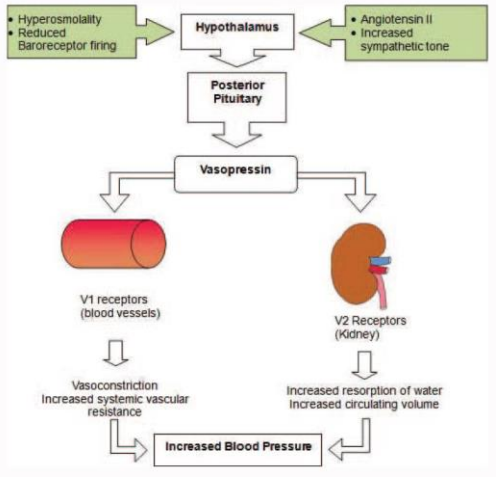
Osmoreceptors, ADH, and Thirst

- ADH (also known as vasopressin)
  - Synthesized by hypothalamus and released from posterior pituitary
  - Stimulates kidney nephron to reabsorb more water



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Renin-Angiotensin-Aldosterone System (**RAAS**)

Hypotension, hypovolemia, low cardiac output

1. Renin released from kidneys
   - Converts angiotensinogen (from liver) to angiotensin I
2. Angiotensin I converted to angiotensin II
   - In lungs by angiotensin-converting enzyme (ACE)
3. Angiotensin II (vasoconstrictor)
   - Activates adrenal cortex to release aldosterone
4. Aldosterone
   - Increases sodium and water reabsorption and potassium secretion by kidneys

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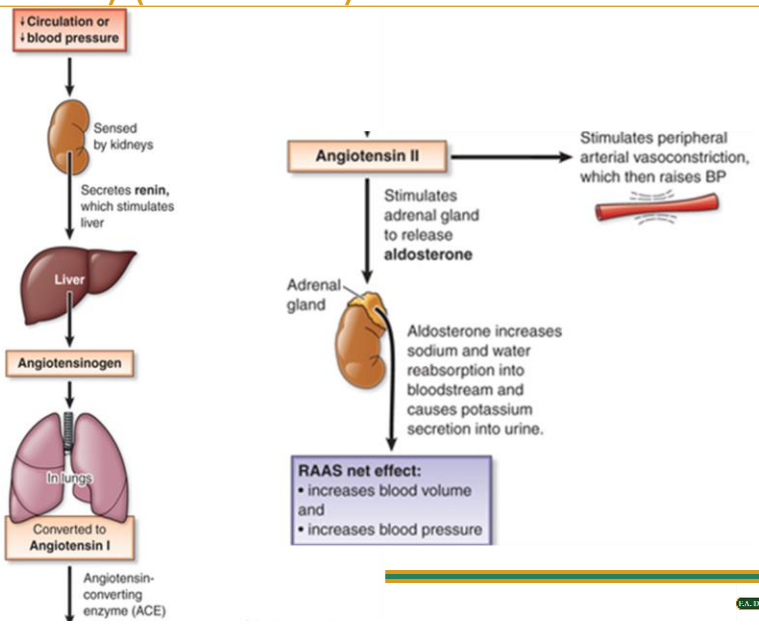
Renin-Angiotensin-Aldosterone System (RAAS) (continued)



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Natriuretic Peptides

- Natriuresis
  - Excretion of large amounts of sodium and water
- Three peptides promote natriuresis
  - Atrial natriuretic peptide (ANP)
    - Atrial cells when atria stretched
  - Brain natriuretic peptide (BNP)
    - Heart ventricles and to lesser extent, the brain
  - C-type natriuretic peptide (CNP)
    - Endothelial cells of arteries and ventricular cells

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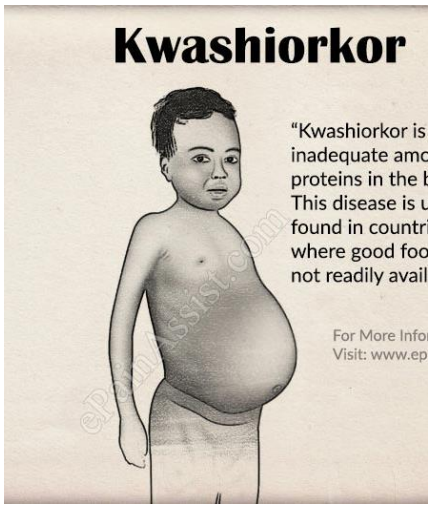
Edema

- *Excess of fluid in the ISF and ICF compartments*
- Primary causes
  - Elevated hydrostatic pressure
    - Increased ECF volume as occurs in heart failure
  - Decreased osmotic forces in blood
    - Hypoalbuminemia
      - Liver failure, protein malnutrition



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Edema (continued)

- Alterations in capillary permeability
  - Histamine
  - Inflammation
- Sodium retention
  - Due to illness or consumption of salty foods
  - Pulls fluid from ICF into ECF

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Dependent and Pitting Edema

Dependent Edema

- Lower extremities
- Venous blood collects
- Fluid accumulates in feet and ankles
- TEDS: Thromboembolic stockings

Pitting Edema

- Occurs when pressure applied to small area
- Indentation persists after release of pressure
- Severity: +1, +2, +3

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Pitting Edema

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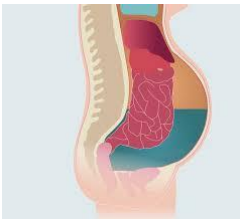
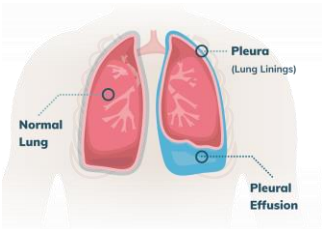
Sequestered Fluids

- Fluid accumulates in body cavities normally free of fluids
  - AKA: third-space accumulation or *third-spacing*
  - Pericardial sac, peritoneal cavity, and pleural space
- Fluid called “effusion”
  - Transudate: Serous filtrate of blood
  - Exudate: Contains blood, lymph, proteins, pathogens, inflammatory cells





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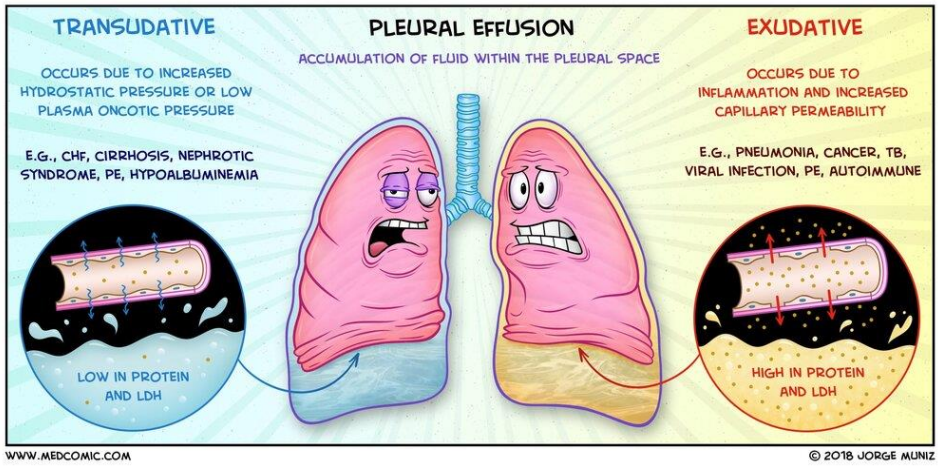
Sequestered Fluids



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Fluid Volume Overload

- Bloodstream has excessive amount of water
- One of most common causes is *heart failure* (through activation of RAAS due to low perfusion of kidney)
- Edema develops due to high hydrostatic forces

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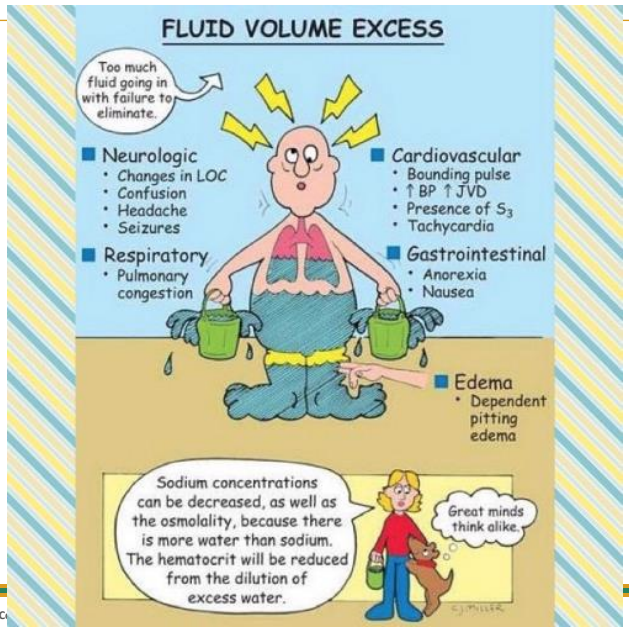
Fluid Volume Overload



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Dehydration

- State of diminished water volume in body (hypovolemia)
- Fluid moves from ICF causing cells to shrink (cellular dehydration)
- Response to dehydration
  - Osmoreceptors stimulate thirst, ADH release
  - Vasoconstriction and increased HR
  - RAAS activated
- Decreased circulating blood volume leads to tachycardia and hypotension

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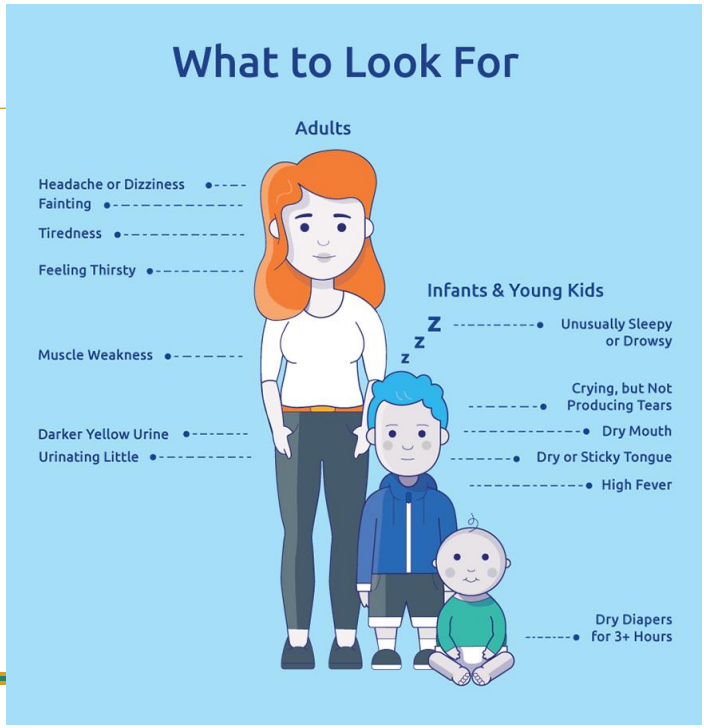
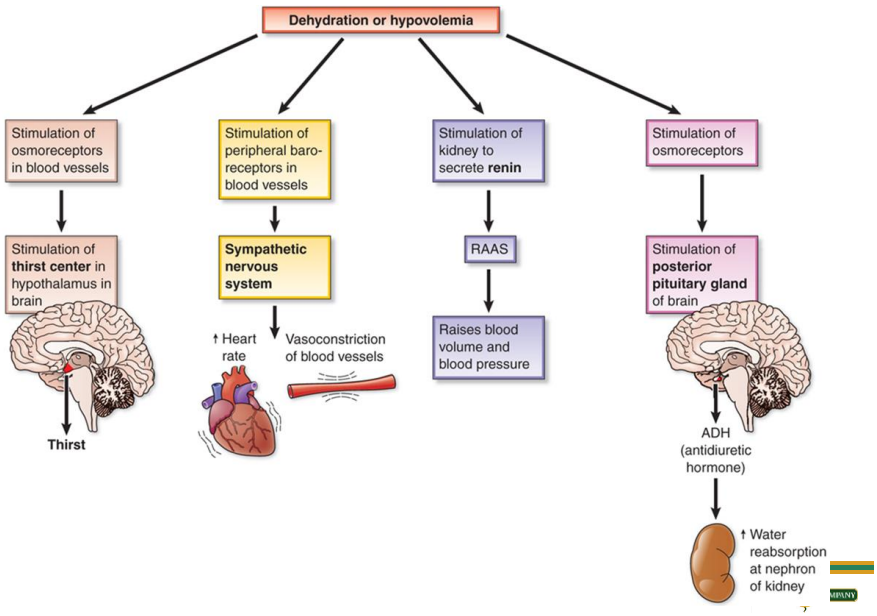
Dehydration (continued_1)

- Causes
  - Reduced fluid intake
  - Reduced ADH or kidneys not responsive to ADH
  - Burns, fever, perspiration
  - Osmotic diuresis, as occurs with elevated blood glucose levels
  - Hypernatremia

Dehydration



Dehydration (continued_2)



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Assessment of Fluid Status

- Daily weight
- 24-hour I & O (input and output)
  - Record in mL: 1 ounce of fluid equals 30 mL
- Vital signs such as heart rate and blood pressure
- Orthostatic hypotension may develop in dehydration
- Assess status of mucous membranes, skin turgor, urine output, edema

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Intake and Output Sheet

INTAKE AND OUTPUT SHEET

Hospital # _____ **Patient's name** _____

Date _____ Room # _____

	INTAKE			OUTPUT			
				Urine		Gastric	
	By Mouth	Tube	Parenteral	Voided	Catheter	Emesis	Suction
Time 7–3	6 oz tea		IV 500 mL D5W in NaCl 0.9%	500 mL			
Time 3–11	6 oz tea		IV 500 mL D5W in NaCl 0.9%	500 mL			
Time 11–7	8 oz water			200 mL			
24-hour total	600 mL		1,000 mL				
24-hour grand total • **Intake**			1,600 mL	24-hour grand total • **Output**			1,200 mL

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Electrolyte Imbalance Overview

- For proper cell functioning, serum electrolytes must be kept in narrow range
- Sodium (Na+)
  - Major ion in ECF
  - Primary determinant of ECF osmolarity and volume
  - Fluid status can affect Na+ ion concentration
- Potassium (K+)
  - Major ion in ICF

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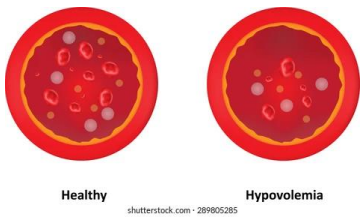
Electrolyte Imbalance

- Alteration in sodium, potassium, and calcium affect neurotransmission and muscular contraction
  - Action potentials along neurons are disrupted
  - Cardiac rhythm abnormalities may develop
  - Skeletal muscle function is compromised

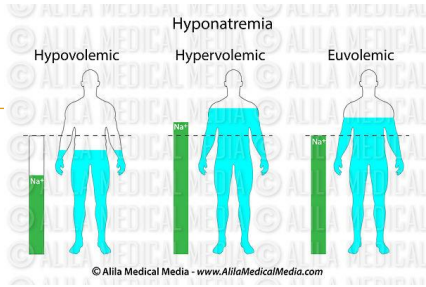
Hyponatremia

- Serum sodium less than 135 mEq/L
- Hypovolemic hyponatremia (loss of sodium and fluid)

- CAUSES (Etiology):
  - ✓ Renal: Adrenal insufficiency, osmotic diuresis, diuretic use
  - ✓ Nonrenal (primarily GI losses): Excessive sweating, diarrhea, vomiting
- SIGNS AND SYMPTOMS (Clinical manifestation):
  - ✓ Thirst, hypotension, and tachycardia are present
  - ✓ Neurological deficits may develop
- TREATMENT:
  - ✓ Slow replacement of sodium with adequate fluid



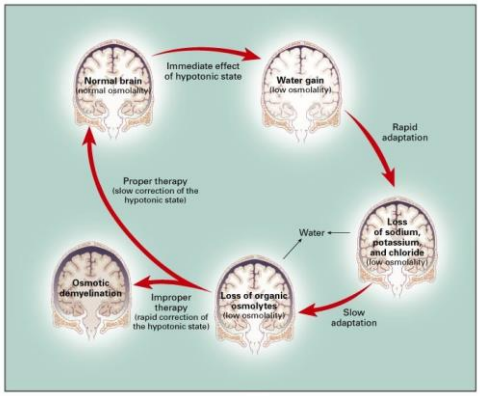
Hyponatremia



- Hypervolemic hyponatremia
  - Excess water, sodium is diluted
    - *Example*: syndrome of inappropriate ADH (SIADH)
  - S/S:
    - Headache, lethargy, confusion, muscle cramps
    - If serum osmolality falls, water moves from ECF into ICF, causing cell swelling (may affect brain cells, leading to seizure and coma)
  - Treatment involves correcting etiology of excess fluid

Hypernatremia

- Sodium level greater than 145 mEq/L
  - Can occur with excess or decrease in body water
  - Loss of water most commonly plays a role
- Cells become dehydrated and shrink
- CNS manifestations
  - Neuron shrinkage
  - Electrolyte imbalances across membrane
- Changes in membrane potentials and cell responsiveness to signals



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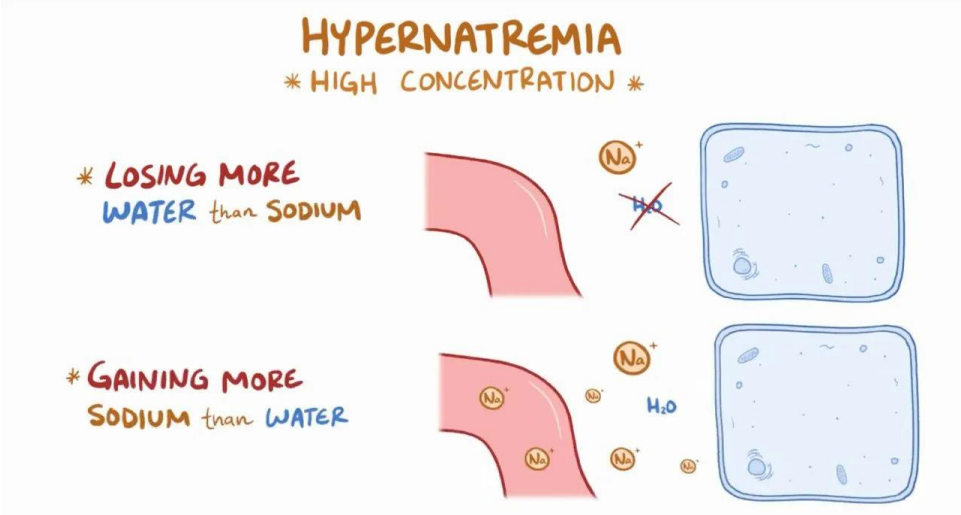
Hypernatremia



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Hypernatremia (continued)

- CAUSES
  - ✓Fluid overload
    - ✓ Edema, weight gain, hypertension
  - ✓No fluid overload
    - ✓ Dehydrated, thirst, tachycardia, oliguria
- Treatment involves fixing underlying cause

Potassium

- Major intracellular ion
- Serum levels are affected by pH, fluid shifts between ICF and ECF
- Involved in muscle contraction, cardiac rhythms, synthesis of ATP, neuronal signaling

Hypokalemia

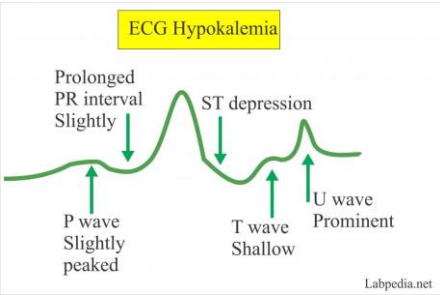
- Blood K+ concentration less than 3.5 mEq/L
- Diuretic therapy most common cause
- Most K+ loss from body through renal system
  - Renal losses increase with stress, metabolic alkalosis
  - Burns, vomiting, diarrhea
  - Other causes: large amounts of IV dextrose, administration of adrenergic agents

Hypokalemia (continued)

- Signs and symptoms
  - Anorexia, cardiac arrhythmias, leg cramps
  - ECG: prolonged PR interval, flattened T wave, and prominent U wave
- Adrenergic agents or use of IV dextrose (which stimulate insulin release) may lower K+ levels
- Digitalis toxicity may develop with hypokalemia
- Treatment
  - Replace potassium at acceptable rate
  - Rapid K+ infusion can cause cardiac arrest

Hyperkalemia

- Serum K+ greater than 5.2 mEq/L
- Decreased renal perfusion can lead to K+ retention
- Patient presentation depends on level of K+ elevation and if chronic or acute elevation
  - Early symptoms: numbness, muscle cramps, diarrhea
  - ECG: wide QRS, tall and peaked T waves, bradycardia
  - Can lead to cardiac arrest



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Hyperkalemia (continued)

- If levels severe (>7.0 mEq/L) rapid treatment to move K+ from ECF to ICF needed
  - Infusion of 50% dextrose, insulin, sodium bicarbonate
- Diuretic may also be given

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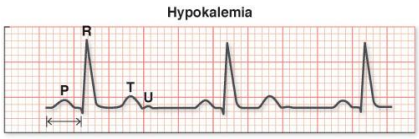
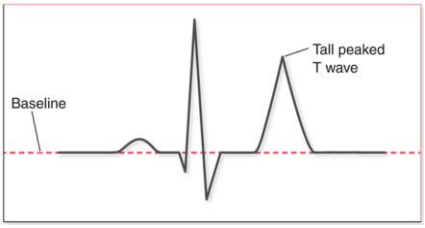
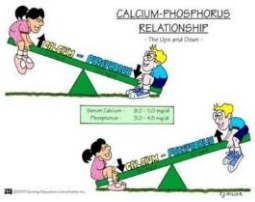
Hypokalemia and Hyperkalemia

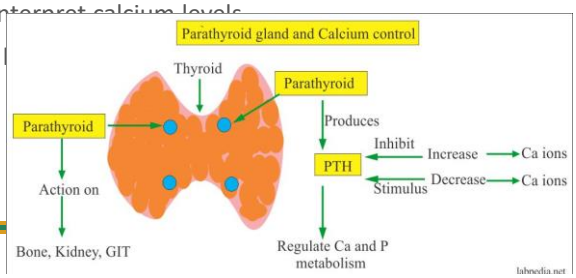




Calcium Imbalances

- Calcium is a mineral that is necessary for life. In addition to building bones and keeping them healthy, calcium enables our blood to clot, our muscles to contract, and our heart to beat. About 99% of the calcium in our bodies is in our bones and teeth.
- Involved with bones, teeth, blood clotting, neuromuscular signaling
- PTH and calcitonin help regulate levels
- Calcium and phosphate levels in blood have inverse relationship
- Calcium exists in free and bound forms
  - Use serum albumin levels to interpret calcium levels
  - Hypoalbuminemia may cause





Calcium Imbalances (continued)

Hypercalcemia

- Less than 8.7 mg/dL
- Neuromuscular excitability
- Paresthesia
- Hypotension, cardiac arrhythmias
- Chronic
  - Bone pain and fragility

Hypocalcemia

- Levels greater than 10 mg/dL
- Causes
  - Elevated PTH
  - Cancer (malignant cells causing bone destruction)
- Decreased neuromuscular excitability (**Tetany** is a disorder of increased neuronal excitability), weakness, renal calculi, cardiac arrhythmias

Signs of Hypocalcemia

excessive neuronal excitability

Chvostek's sign

Trousseau's sign

Phosphate Imbalances

Component of bone, red blood cells, ATP

Hypophosphatemia

- Blood levels less than 2.5 mg/dL
- Due to decreased intestinal absorption, increased excretion by kidneys, intracellular shift
- Tremors, muscle weakness, hyporeflexia

Hyperphosphatemia

- Blood levels greater than 4.5 mg/dL
- Most common cause is kidney failure
- Hypocalcemia often accompanies (signs and symptoms often related to hypocalcemia)

Magnesium Imbalances

Primarily stored in bone

Hypomagnesemia

- Blood levels less than 1.5 mEq/L
- Magnesium released from bone in exchange for increased uptake of calcium
- Usually occurs in conjunction with hypocalcemia and hypokalemia
- Causes: sepsis, burns, laxative abuse

Hypermagnesemia

- Blood levels greater than 2.5 mEq/L
- Magnesium can be used to treat cardiac disorders and pregnancy eclampsia, levels must be monitored
- Most common cause: renal dysfunction
- Muscular and cardiac manifestations