Health Leadership & Learning Network

York University Faculty of Health

IV & Infusion Therapy Week 4

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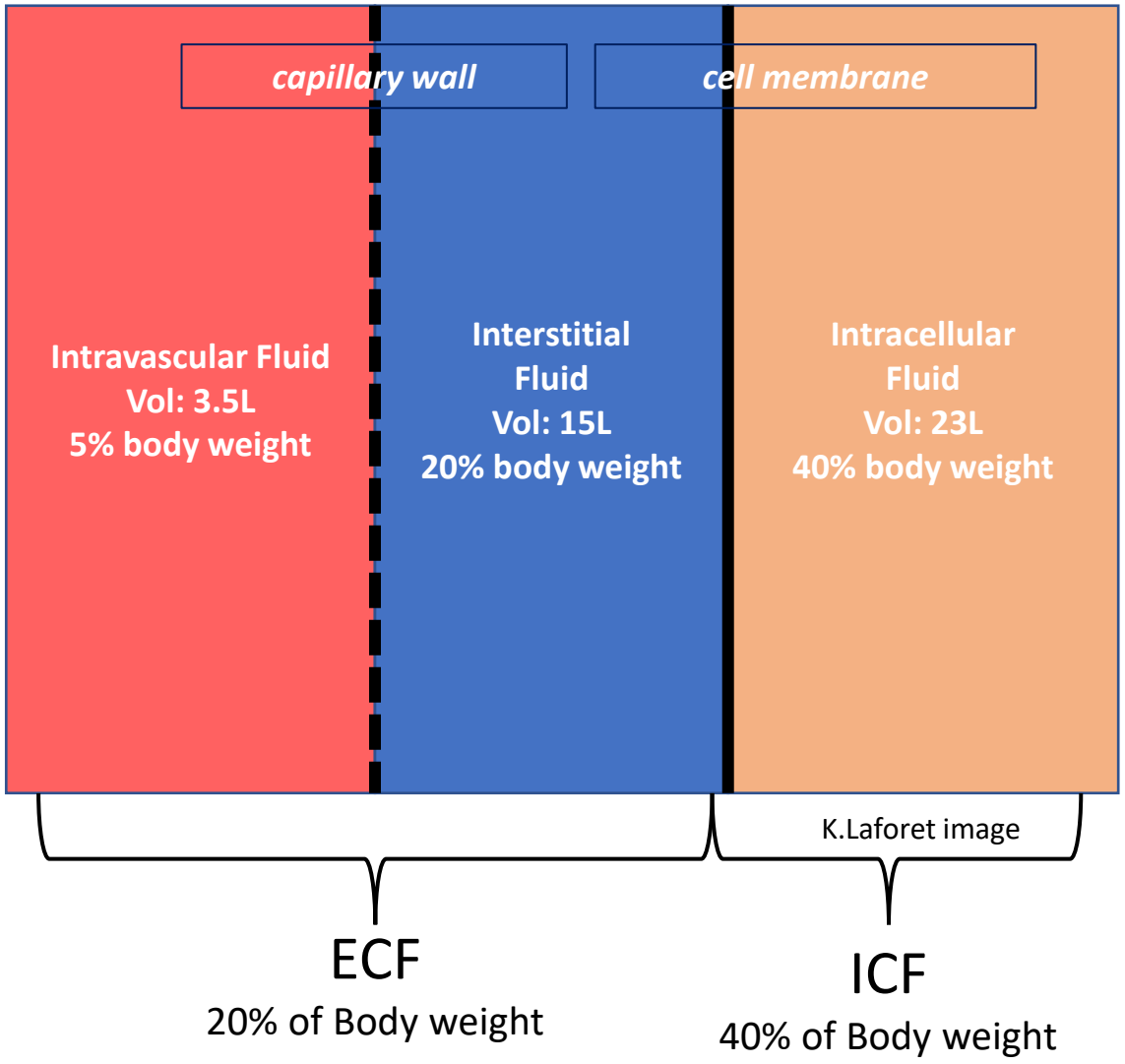
Fluid balance is affected by:

- Fluid volume,
- Distribution of fluids in the body,
- Concentration of solutes in the fluid
- Cell permeability

Body Fluid comprises 60% total body weight and is distributed between two main components: extracellular and intracellular.

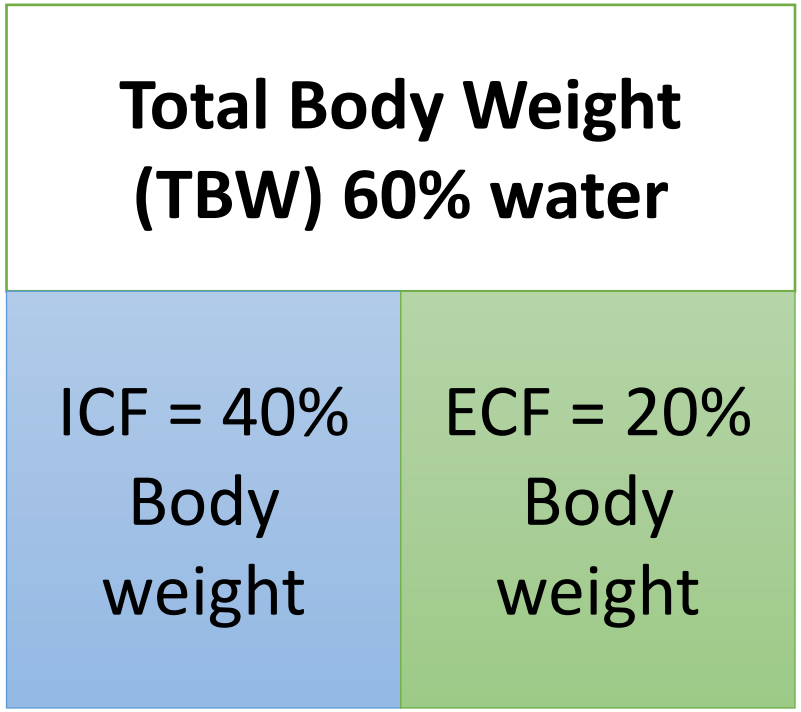
Extracellular fluid (ECF) consists of interstitial fluid and intravascular fluid.

This illustration demonstrates the proportion of body fluid per compartment for a 70 kg adult male (Note: these measures are approximate)



Where's the water?

- Adult body is approximately 60% water
- Older adults are closer to 40 - 50% water
- Most of body's water is intracellular—especially muscle
  - Aging ↓ muscle mass = bodies contain < water



K.Laforet image

Body Fluid Movement

- Continually moving from one compartment to another (ECF- ICF) to maintain homeostasis
- How this is done:
  - Osmosis
  - Diffusion
  - Filtration

Osmolarity

- Osmolarity measures the solute concentration of a solution and is compared to the concentration of particles in plasma.
- Estimation of the concentration of particles in plasma (measured per kilogram of solvent: 282 – 295 mOsm/kg water.

Clinical significance:

- Cell membranes are permeable to water therefore, the osmolarity of the ECF is an estimated equal of the osmolarity of ICF. This is important as it measures changes that may cause problems with normal cell function and volume. This test is ordered to investigate hyponatremia.

Definitions

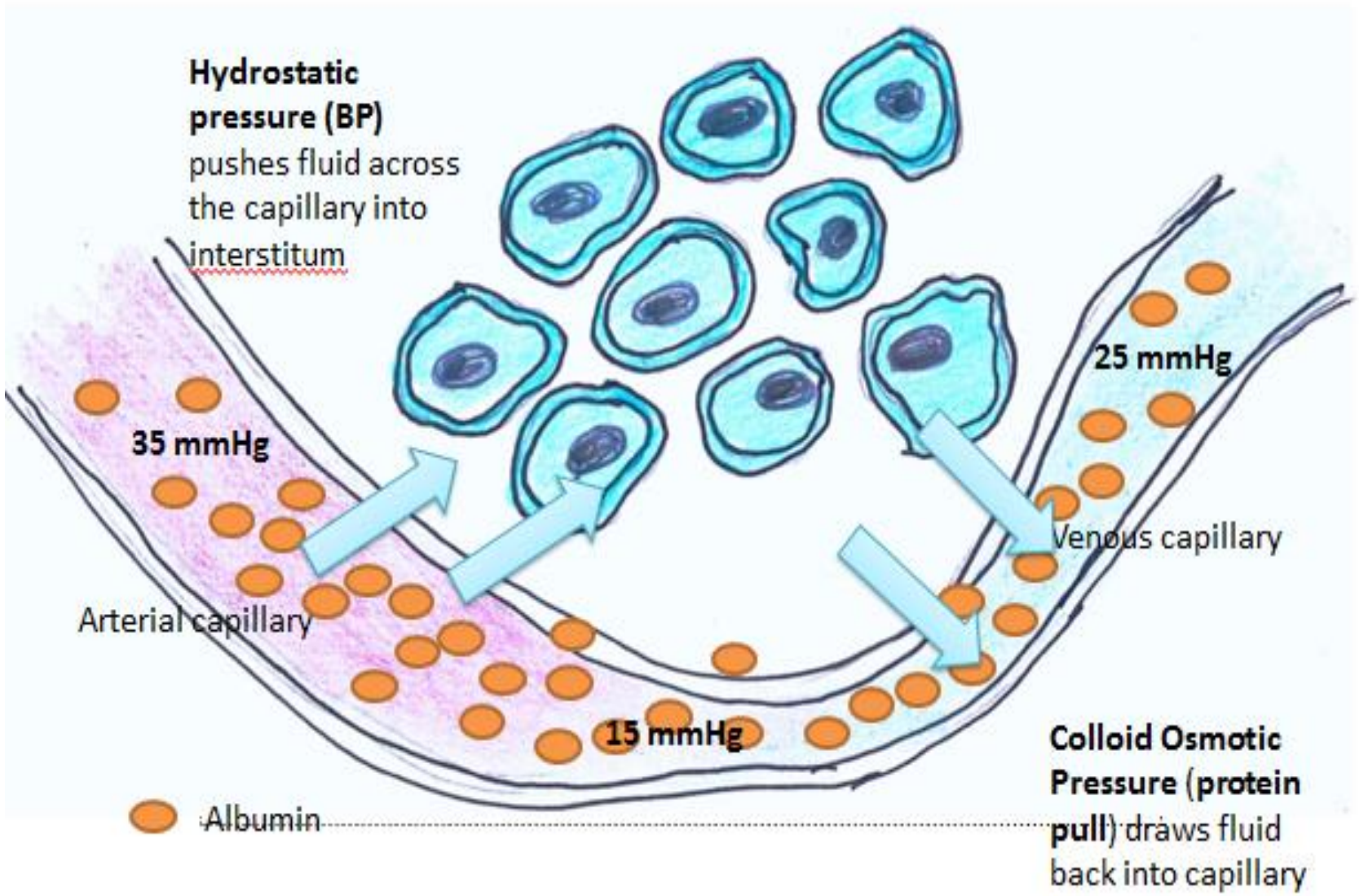
- **Osmosis:** Movement of fluid across a semi-permeable membrane where fluid moves from an area of low solute concentration to an area of high concentration.
  - Process continues until solutions on both sides are of equal concentration
- **Diffusion**: random movement of molecules and ions from an area of higher concentration to an area of lower concentration: e.g. O^2/CO^2 exchange
  - Two processes: simple that occurs through a lipid bilayer of protein channel or facilitated using carrier proteins to move substances thru a membrane
- **Filtration:** movement of solutes and water thru a selectively permeable membrane always moving from an area of higher concentration to an area of lower concentration. Movement is in relation to hydrostatic pressure.

- **Osmosis and Diffusion are in response to concentrations.**
- **Filtration is in response to pressure.**

Filtration & Reabsorption

- Opposing forces
- Hydrostatic pressure (in arterial end) drives fluid out of capillary
  - Internal pressure high on arterial end; low on venous end
- Colloid osmotic pressure (COP) due to weight of proteins draws fluid into capillary
  - Albumin (plasma proteins) plentiful in the intravascular compartment (blood)

Filtration & Reabsorption



Electrolyte Balance

Solutes—dissolved particles

- Electrolytes: charged
  - Cations +ve: Na^+, K^+, Ca^+ H^+
  - Anions –ve: Cl^-, HCO_3^- PO_4^-

- Non electrolytes: no charge
  - Proteins, urea, glucose, O_2, CO_2

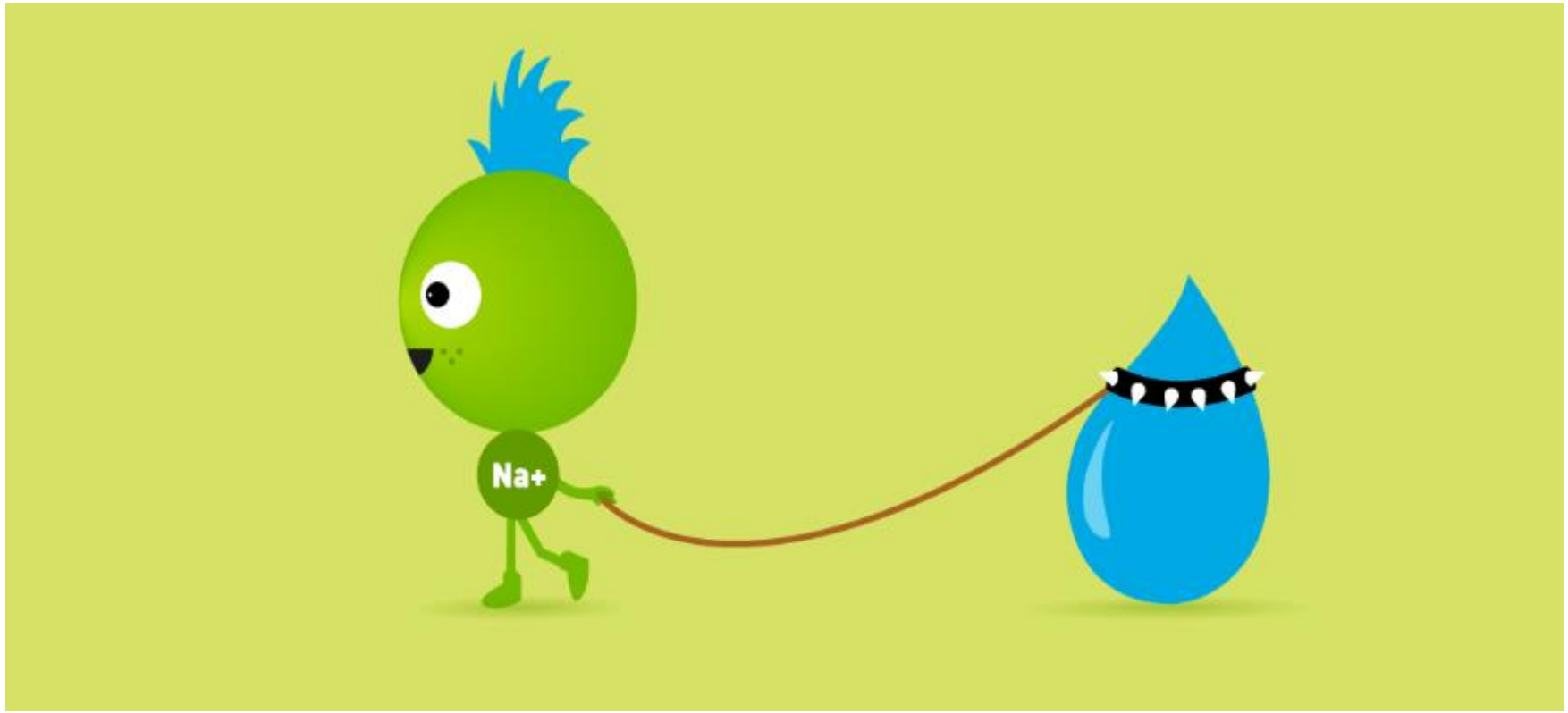
Understanding electrolytes

- Six major electrolytes play important roles in maintaining chemical balance: sodium, calcium, potassium, chloride, phosphorus, and magnesium.

Identifying Fluid Imbalances		
Signs & Symptoms	**Fluid Deficit**	**Fluid Excess**
Clinical Observations	Dry mucous membranes; sunken eyes; pale; skin cool to touch; ↓ sweat; tongue furrows	Periorbital edema; puffy eyelids
Urine Output	↓ < 30 mL/hour	↑ ; polyuria
Heart Rate	↑ at rest; thready	Bounding pulse
Respiratory	↑ rate	↑ rate; dyspnea; moist crackles or rales (indicative of > 1L excess fluid)
Blood Pressure	↓ by 10mmHg; orthostatic hypotension	May be elevated
Central Venous Pressure CVP	↓; flat neck veins in supine position	↑; Distended internal jugular at 30º
Vascular	Capillary refill > 2 seconds; slow filling of hand veins when arm lowered	↓ emptying of hand veins when arms elevated
Skin Integrity	Lack of moisture in axillae & groin; ↓ skin tugor	Dependent edema; anasarca; pitting edema
Mental Status	Status changes	Headache; lethargy; weakness; seizures
Patient symptoms	Thirst; dry mouth; weakness,	Cramps; nausea; vomiting
Haematocrit	↑	↓
Electrolytes	↑ Serum Sodium;	↓ Serum Sodium;
Renal Status	↑ Urine SG >1.010; ↑ Urine Osmolarity	↓ Urine SG <1.010 ↓ Urine Osmolarity
BUN (Urea)	↑	↓
Osmolarity	↑	↓

Sodium+

Electrolyte	Principal functions	Signs and symptoms of imbalance
Sodium (Na^+) ● Chief cation in ECF ● Plasma Level: 135 - 145 mEq/L (135 – 145 mmol/L)	● Controls distribution of water throughout body ●Maintains normal fluid balance ● Affects concentration, excretion, and absorption of potassium and chloride ● Helps regulate acid-base balance ● Essential for electrical activity of neurons & muscle cells	**Hyponatremia**: Lethargy, apprehension, abdominal cramps, muscle twitching,headache, confusion, tremor, seizures, coma, ↓ skin tugor **Hypernatremia**: intense thirst, fever, flushed skin, oliguria, disorientation/restlessness, excitement, dry, sticky mucous membranes, hypotension, tachycardia,



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Where sodium goes, water follows

Potassium +

Electrolyte	Principal functions	Signs and symptoms of imbalance
Potassium (K^+) ● Major cation in intracellular fluid (ICF) ● Normal serum level: 3.5-5.0 mEq/L (3.5 –5.1 mmol/L (adult)	● Major cation in ICF ●Necessary for cell function ● Essential for electrical activity of neurons & all muscle cells ● Maintains cell electroneutrality ● Plays a major role in acid-base balance	**Hypokalemia**: ↓ reflexes (muscle atony); lethargy; muscular cramps; postural hypotension; ↓ BP; ↓ bowel motility; paralytic ileus, arrhythmias (tachycardia, irregular pulse) H**yperkalemia**: Dysrhythmias, decreased tendon reflexes; muscle twitches, cramps & paresthesias; **peaked and elevated T waves; flat P waves; abdominal cramping**; irritability; anxiety

Calcium++

Electrolyte	Principal functions	Signs and symptoms of imbalance
Calcium (Ca^{++}) ● Major cation in ECF ● Normal serum level: total: 8.4-10.6 mg/dl (2.10-2.5 mmol/L)	● Vital function for formation & function of bones & teeth ● Necessary for cell membrane structure, function, and permeability ● Maintains normal excitability of neurons & muscle cells. ● Essential for blood clotting ● Activates serum complement in immune system function	**Hypocalcemia:** muscle tremors & cramps; Trousseau's sign (earliest most sensitive sign); hyper-reflexia; bleeding, excessive irritability; numbness or tingling in fingers, toes, and area surrounding the mouth Chvostek's sign—facial spasm **Hypercalcemia:** lethargy; fatigue; weakness, nausea, constipation anorexia; (shortened QT interval and widened T wave), bradycardia, degrees of Heart block

Chloride-

Electrolyte	Principal functions	Signs and symptoms of imbalance
Chloride (Cl^-) ● Chief anion in ECF ● Normal serum level: 96-106 mEq/L (96-106 mmol/L)	● Provides electroneutrality particularly with sodium ● Helps regulate osmotic pressure ● Combines with major cations to create important compounds, such as sodium chloride (NaCl), hydrogen chloride (HCl), potassium chloride (KCl), and calcium chloride ($CaCl_2$)	**Hypochloremia**: deficiency in chloride leads to deficiency in potassium. Muscle twitching; sweating; shallow depressed breathing; tetany; high fever **Hyperchloremia:** dehydration; fluid loss; stupor; Kussmaul's breathing (rapid and deep breathing); muscle weakness; diminished cognitive ability; coma

Phosphorus-

Electrolyte	Principal functions	Signs and symptoms of imbalance
Phosphorus (P) ● Chief anion in ICF (85% in bones/teeth) ● Normal serum phosphate level: 3-4.5 mg/dl (1.0-1.5 mmol/L)	● Helps maintain bones and teeth ● Major role in acid-base balance (as a urinary buffer) ● Building block for cell membranes., DNA, RNA, ATP and phospholipids ● Plays essential role in muscle, red blood cell, and neurologic function	**Hypophosphatemia:** disorientation, seizures, paresthesias (circumoral and peripheral), lethargy, speech defects (such as stuttering or stammering), muscle dysfunction and weakness including respiratory failure, cardiomyopathies **Hyperphosphatemia:** muscle cramps and spasms, neuroexcitability to tetany and seizures; prolonged state results in calcification of soft tissues (lungs, kidneys, joints)

Magnesium

Electrolyte	Principal functions	Signs and symptoms of imbalance
Magnesium (Mg^{++}) ● Major cation found in ICF (closely related to Ca^{++} and P) ● Normal serum level: 1.3-2.1 mg/dL (0.65-1.05 mmol/L)	● 50% found in bone ● Primary role in enzyme activity ● Metabolizes carbohydrates & proteins ● Essential for ATP production and activity of neurons and muscle cells ● Facilitates Na^{+} and K^{+} movement across all membranes ● Influences Ca^{++} levels	**Hypomagnesemia:** Common imbalance in critically ill patients; neuromuscular irritability; increased reflexes; nystagmus; tetany; leg and foot cramps; disorientation; mood changes **Hypermagnesemia**: muscle weakness; drowsiness; lethargy; coma; arrhythmias; slow weak pulse; hypotension; vague neuromuscular changes (such as tremor), vague GI symptoms (such as nausea), peripheral vasodilatation

What is acid-base balance

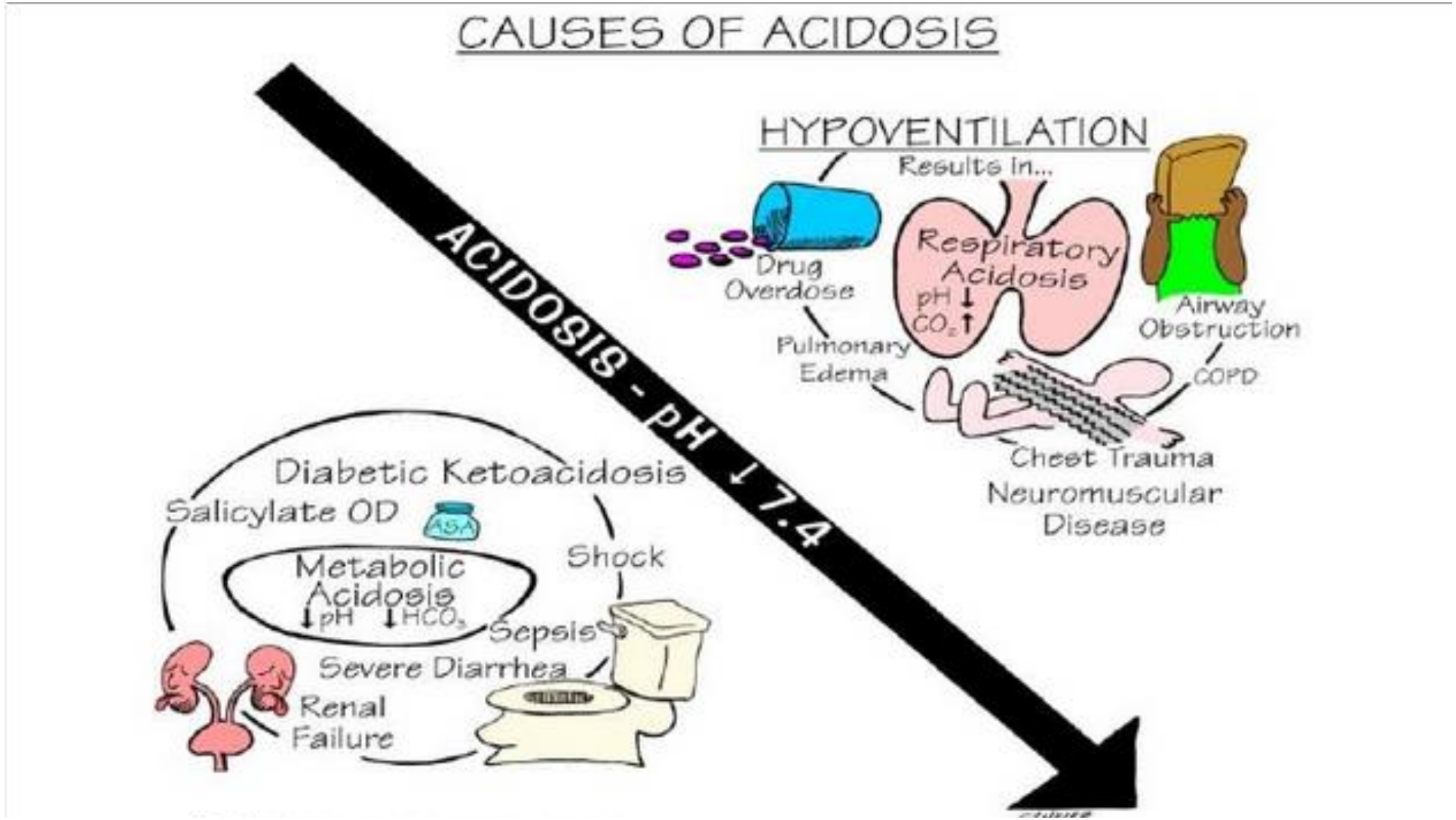
- pH = measure of acidity
  - Really about H+ ions however will use the term “acid”
- Body needs pH: 7.35 – 7.45 to maintain homeostasis
  - 0.5 points in either direction incompatible with life
- Acid-base balance is keeping the body not too acidic or not too alkaline...like Goldilocks—we want the pH just right

Acid-Base Balance

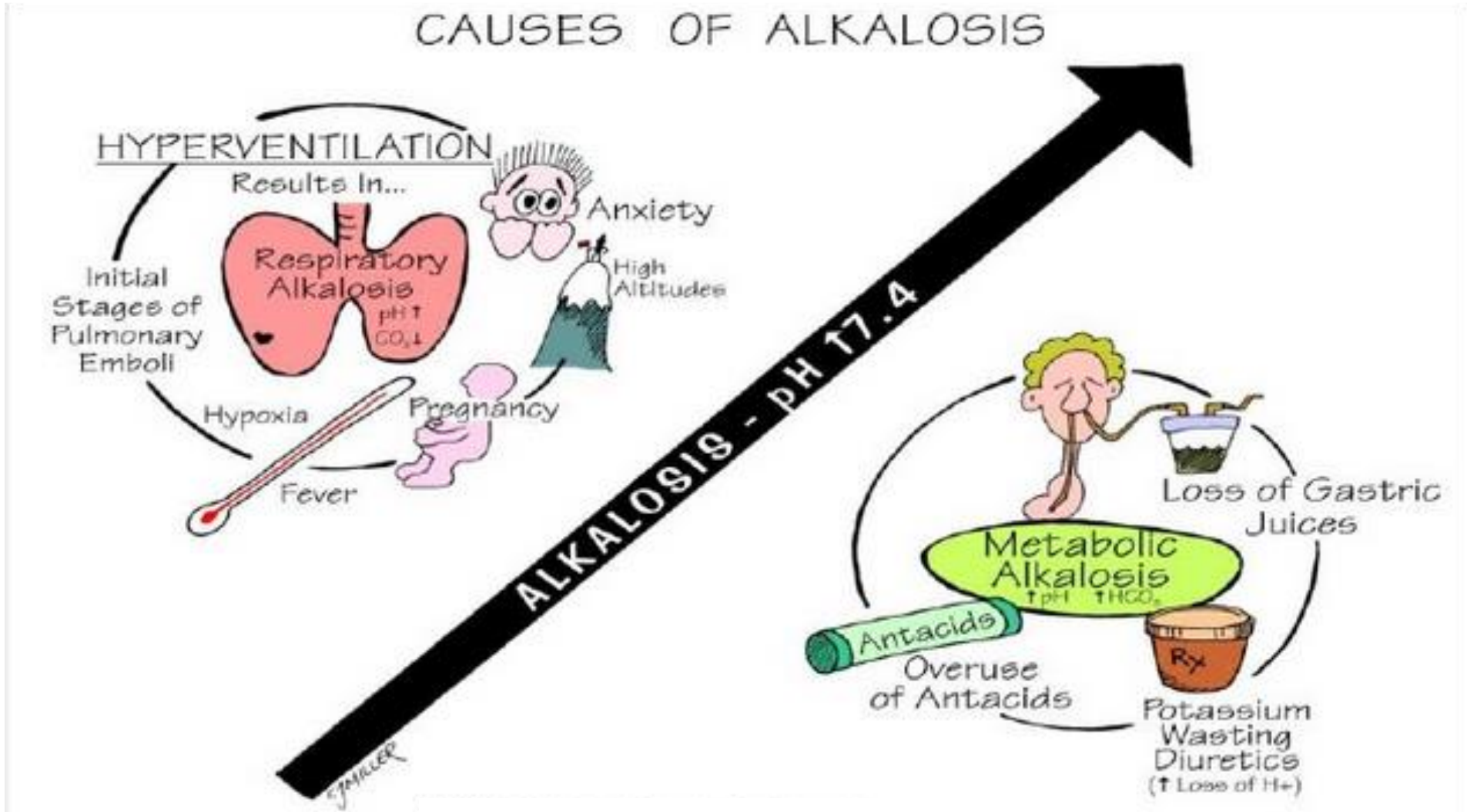
- Alkalinity or acidity based on H+ concentration
- ↑ H+ = acidosis
- ↓ H+ = alkaline
- Ph 7.4 = neutral
- ECF is 7.35 – 7.45
- ECF and ICF contain a buffer system to maintain acid-base balance

Buffer systems

1. Buffers:
   - Most important buffer is HCO_3 – H_2HCO_3 (Bicarb/Carbonic Acid)
2. Respiratory System
3. Renal System



C. Washington RN



C. Washington RN

If pH & CO_2 are the same direction = Metabolic

If they're reversed = Respiratory

Acid-base imbalance

	pH	pCO2	HCO3
Respiratory Acidosis	↓	↑	Normal or ↑
Respiratory Alkalosis	↑	↓	Normal or ↓
Metabolic Acidosis	↓	↓	↓
Metabolic Alkalosis	↑	↑	↑

Nursing Implications

- Know patients at risk:
  - Significant electrolyte imbalances
  - Net gain or loss of acids or bases
  - Ventilation abnormalities
  - Abnormal kidney function
- Vital signs—esp. respirations
- Level of consciousness: confusion an early sign of acid-base imbalance
- Correlate findings with patient diagnosis

Treatment

- **Metabolic acidosis**: treat underlying cause
  - DKA: glucose, insulin; poisoning, sepsis
  - IV fluids such as Lactated Ringer's (lactate ion is metabolized in the liver to HCO3) for mild acidosis, bicarb IV if severe
- **Metabolic alkalosis**: treat underlying cause
  - Electrolyte imbalance, replace fluids, 0.9%NaCl (acidifying agent). When chloride is infused HCO3 ↓. Ammonium Cl acidifying agent
  - Replace Na+ and K+ (KCL additive to infusion)

Treatment

- **Respiratory acidosis**: improve ventilation
  - Bronchodilators, mechanical ventilation
- **Respiratory alkalosis**: slow breathing rate
  - Anxiety: encourage patient to breathe slower, paper bag raises CO2