Fluid, Electrolyte & Acid-Base Balance
Water

- 50% to 70% of a person’s weight
- % with young and muscular
- % with increase fat and age
Fluids; constantly lost and replaced

Fluids are not locked into one compartment. There is a constant interchange between compartments as fluid crosses a semi-permeable membrane via diffusion, osmosis, filtration, capillary pressure and activity-transport.
Fluid Compartments

- Intracellular fluid
  - Within the cells
  - Most of the body’s fluid is intracellular
  - 60%, or \( \frac{2}{3}-\frac{3}{4} \) of the body’s fluids is in the cell
  - Potassium- major + intracellular ion (K+)
  - Cation because of it’s + electrical charge
Fluid Compartments (con’t)

- Extracellular fluids (outside the cell)
  - Blood plasma - (liquid part of blood) intravascular
  - Interstitial fluid - (tissue fluid that is located between the cells)
  - Lymph - (constantly filters fluid from the circulatory system)
  - Transcellular fluids - special compartments, (e.g. synovial & CSF)

- The compartment most essential to water balance is the *interstitial fluid*

- Sodium - major + extracellular ion
- Where Na+ goes H2O will follow
Water Balance

- Intake and Output - usually equal

- Average adult intake is approx. 2500 ml/d (2\(\frac{1}{2}\) qts)

- Water is lost through skin, lungs, GI tract, kidneys
Primary Regulators

- The primary regulator of water **output** are the kidneys

- The primary regulator of water **input** is the hypothalamus

- The primary driver of fluid **intake** is thirst, which is stimulated by increased plasma osmolarity (ion concentration) or decreased plasma volume

- Polydipsia = excessive thirst
Water Balance exists when water intake equals water output.
Hormonal Control of Fluid Balance

- When a condition in the body changes, regulatory mechanisms in the body’s major organs start to work to regain a balance.

- **Aldosterone** (from the Adrenal cortex) released in response to ↓ Na+ levels in the ECF, or ↑ Na+ in the urine. Causes Na+ reabsorption

- **ADH-Antidiuretic Hormone** produced by hypothalamus & stored in post. pituitary) released in response to changes in blood osmolarity (ion concentration)

- **ANP-Atrial Natriuretic petide**- secreted by heart cells in response to ↑ B/P & volume. It will inhibit the reabsorption of Na+
Disorders of Body Fluids

(Fluid volume deficit)

- **Dehydration** — severe deficit of body fluids
  - if prolonged, victim will die.
  - **Causes**: vomiting, diarrhea, excessive drainage from burns or wounds, increased sweating, too little fluid intake, fever, hyperventilation, renal failure
  - **SxS**: ↑HR, ↑Resp, Hypotension, weakness, weak pulses, lethargy, poor turgor, dry mouth with fissures, ↓bowel sounds, thirst and ↓urine output
Disorders of Body Fluids
(Fluid volume excess)

- Edema – accumulation of excessive fluid in interstitial spaces
- Intake and retention exceeds requirements
- Usually treated with diuretics
Fluid Replacement Therapy
Intravenous Fluid and Electrolyte Replacement

- Solutions
  - Hypotonic
  - Isotonic
  - Hypertonic
  - Intravenous Additives
  - Plasma Expanders
**Intravenous Fluids**

<table>
<thead>
<tr>
<th>Type</th>
<th>Effect on the cell</th>
<th>Conditions</th>
<th>Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isotonic</td>
<td>Equal with the osmotic pressure of plasma</td>
<td>Emergency or fluid volume expander</td>
<td>Overload</td>
</tr>
<tr>
<td>Hypotonic</td>
<td>Less concentrated, more dilute than ICF, so it pushes water into the cell- causing the cell to swell and eventually, rupture (burst)</td>
<td>Dehydration- where the fluids within the cells have been depleted.</td>
<td>To much can cause water logging/edema</td>
</tr>
<tr>
<td>Hypertonic</td>
<td>More concentrated than plasma- It will pull the water out of the cell will cause it to shrink.</td>
<td>To stabilize blood pressure, increase urine output and reduce edema.</td>
<td>Dehydration</td>
</tr>
</tbody>
</table>
Electrolytes

• Electrolyte balance is essential to life!!!!!!!

• The **kidneys** are key players in regulating electrolyte amounts within the body
Electrolytes & their Functions

- **Electrolytes** are ions that give off an electrical charge when placed in solution.
- **Cations** are + charged  
  **Anions** are - charged
- Move about freely but have their primary locations

**Positive ions (cations)**
- Sodium
- Potassium
- Calcium
- Magnesium

**Negative ions (anions)**
- Phosphate
- Chloride
- Bicarbonate
• **Most abundant positive ion in extracellular fluids**

• Maintains osmotic pressure

• Maintains body fluid volume

• Needed for nerve impulse conduction

• Needed for muscle contractility

• Needed for acid – base balance

Because Na is the major osmotically active ion in the ECF, total body Na content determines ECF volume. Deficiency or excess of total body Na content causes ECF volume depletion or overload. (Merck)
Potassium (K+)

- **Major positive ion in intracellular fluids**
- Needed for transmission of nerve impulses
- Needed for muscle contractility
- Assists in protein synthesis from amino acids and in carbohydrate metabolism
- Needed for acid – base balance
- Helps regulate chemical reactions

Normal plasma potassium level ranges between 3.5 and 5.0 mEq/L.
Calcium ($\text{Ca}^{2+}$)

- Required for bone formation
- Necessary for muscle contractions
- Required for nerve impulse transmission
- Needed in blood clotting
- Activation of enzymes

Best levels of calcium are at a range of 9.0 to 10.5 mg/dL
Magnesium ($\text{Mg}^{2+}$)

- Another major cation intracellular
- Needed for bones and teeth (50% found here)
- Nerve transmission, muscle contraction
- Needed for metabolic reactions (ATP production)
  - Carbohydrate metabolism
  - DNA and protein synthesis

Plasma levels of free magnesium range from 1.3 to 2.1 mg/dL.
Phosphorous (P)

- Essential in metabolism of carbohydrates, proteins, and lipids
- Activates B-complex vitamins
- Assist in cell division
- Needed in bone formation
- Found in both DNA and RNA
- Involved in acid-base balance

Normal levels of phosphorous range from 3.0 to 4.5 mg/dL
Chloride (Cl)

- Necessary for formation of HCl in stomach
- Aids in acid-base balance
- Chief extracellular anion
- Involved in extracellular volume control

The normal plasma concentration of chloride ranges from 98 to 106 mEq/L.
Bicarbonate $\text{HCO}_3^-$

- Important buffer in the blood

- Prevents blood from becoming too acidotic or alkalotic by accepting or releasing hydrogen
Electrolyte Imbalances

- Hyponatremia
- Hypernatremia
- Hypokalemia
- Hyperkalemia
- Hypocalcemia
- Hypercalcemia
- Hypomagnesemia
- Hypomagnesemia
Treating Electrolyte Imbalance

K+ is too low-
- give supplements, enhance diet, or IV K+
- K+ overdose/toxic levels give calcium gluconate or calcium

K+ is too high-
- Restrict K+ sources in the diet
- If on a K+ sparing change to Non-K+ sparing
- If severe-give glucose and insulin (pushes K+ into the cell)
Treating Electrolyte Imbalance

**Na+ is too low**
- Give supplements, enhance diet, IV NS
- Give loop diuretic- will cause isotonic diuresis thus removing the fluid overload that caused the hyponatremia

**Na+ is too high**
- Low Na+ diet
- if related to hypovolemia give hypotonic solution (D5, or ).45% NaCl
- Diuretic to remove Na+
ACID-BASE BALANCE
pH Balance Maintenance

*Buffers
*Respiratory System
*Kidneys
Buffer Systems

• Prevent sharp changes in the pH of body fluids by chemically reacting with strong acids or bases.
• Thus preventing sharp changes in hydrogen ion concentrations
• A buffer system consists of a weak acid and a weak base that react with strong acids or bases.
• Main ones include bicarbonate, phosphate, and proteins (RBCs, plasma proteins)
  • Bicarbonate- Important in blood and tissue fluid
  • Phosphate- important in the kidney’s blood pH
  • Proteins- important in the intracellular fluid
Respiration

- Release of carbon dioxide acts to make the blood more alkaline by reducing the amount of carbonic acid formed.

- Decrease of carbon dioxide release makes the blood more acidic.

- Changes in resp. rate is a short term adjustment.
Kidney Function

- Regulates the pH by reabsorbing or eliminating hydrogen ions as necessary
- Kidney can reabsorb or eliminate bicarbonate as needed
- Responsible for long term regulation
Abnormal pH

- Acidosis = a drop of pH (below 7.35)
- Alkalosis = an increase in pH (above 7.45)
- Respiratory or Metabolic
- Both are dangerous and can be life threatening
Sodium Bicarbonate

- Drug of choice for acute metabolic acidosis
- Acts as a base to quickly neutralize acids in blood or other body fluid
- Results in pH increase - alkalinity
- Careful monitoring
Common causes of Acidosis

- **Respiratory**
  - COPD
  - Sedative/barbituate overdose
  - Chest wall abnormality
    - eg. Obesity
  - Atelectasis
  - Severe pneumonia
  - Resp muscle weakness
    - Eg. Guillain-Barre syndrome
  - Mechanical hypoventilation

- **Metabolic**
  - Diabetic ketoacidosis
  - Lactic acidosis
  - Starvation
  - Severe diarrhea
  - Renal tubular acidosis
  - Renal failure
  - GI fistulas
  - shock
Common Causes of Alkalosis

• **Respiratory**
  - Hyperventilation
    • Eg. Hypoxia, anxiety, PE, fear, pain, exercise, fever
  - Stimulated resp center caused by
    • Septicemia, brain injury, encephalitis, salicylate poisoning
  - Mechanical hyperventilation

• **Metabolic**
  - Severe vomiting
  - Excess NG suctioning
  - Diuretic therapy
  - K deficit
  - Excess NaHCO3 intake
    • Baking soda
  - Excessive mineral-corticoids