Fluid, Electrolyte, and Acid-Base Homeostasis

Measures of Concentration

- Percent (grams/100ml or gm/dl)
- Millimoles/liter (based on molecular weight in milligrams/liter of solution)
- Milliequivalents/liter (based on equivalent number of positive or negative charges in a millimole/liter solution) - important for measuring electrolytes
- Milliosmoles/liter (based on number of dissociated particles in a millimole/liter solution)

Body Fluids

- Females - 55%, males -60%
- Interrelationship between intracellular fluid (65%), interstitial fluid (28%) and blood plasma (7%)
  - Other extracellular fluids e.g. CSF, synovial, lymph, glomerular filtrate, etc.
  - Compartmentalization by membrane (plasma or epithelial)
  - Fluid balance maintained across membranes
- Primarily water and solutes (primarily electrolytes)
  - Movement of water dependent on the other

Relative Fluid Volumes (graphic)

Body Water

- 45-75% of body weight
  - Lean - about 60%
  - Fat contains little water, thus % is lower for obese
  - Up to 2 yrs. - about 75%
- Water source - ingested 2300 ml/day, metabolic 200 ml/day
- Water loss - urine - 1500 ml/day, skin - 600 ml/day, lungs 300 ml/day, feces 100 ml/day
- Total 2500 ml/day

Fluid Regulation

- Little control over metabolic water
- When loss > source - thirst (hypothalamic thirst center)
  - Reduced saliva → dry mouth
  - Increased osmotic pressure → stimulates osmoreceptors in hypothalamus
  - Decreased blood volume → stimulates renin release by juxtaglomerular cells → angiotensin II → aldosterone → increased Na⁺, Cl⁻ and water reabsorption
    - Angiotensin II also stimulates hypothalamus
  - Increased tonicity or decreased blood volume (blood pressure) → stimulates ADH release
- When source > loss → excess water
– Increased blood volume → atrial stretching → atrial natriuretic hormone →
  increased diuresis and Na⁺, Cl⁻ excretion
– Reduced secretion of other hormones (renin, angiotensin II and aldosterone)

**Effects of Dehydration (graphic)**

**Effects of Excess Water (graphic)**

**Electrolytes**

- Electrolytes vs. non-electrolytes
- Electrolyte proportions in body fluids (Fig. 27.6)
- Effects of electrolytes
  - Play role in osmotic water movement between fluid compartments
  - Affect and manage pH balance
  - Electrolyte movement causes current flow
- Na⁺, Cl⁻, K⁺, HCO₃⁻, Ca²⁺, HPO₄²⁻, Mg²⁺
- Electrolyte imbalances (Table 27.2)

**Electrolyte Concentrations (graphic)**

**Effects of Excess Water w/o Electrolytes (graphic)**

**Fluid Movement**

- Between plasma and interstitial fluid by vesicular transport, diffusion or bulk flow
- Between interstitial fluid and intracellular fluid by osmosis, dependent on…
  - Na⁺ - regulated by aldosterone, ADH and ANP
  - K⁺ - regulated by aldosterone (inc. secretion)

**Acid-Base Balance**

- Important to enzyme activity
- H⁺ source largely from diet (high protein) and metabolic reactions
- pH maintained 7.35-7.45
  - Maintained by buffering, exhalation of CO₂, and kidney excretion of H⁺
- Buffering agents - protein buffer (in blood and cells), carbonic acid-bicarbonate buffer (in ECF including blood), phosphate buffer (in cells and urine)

**Control of Blood pH (graphic)**

**Acidosis vs. Alkalosis**

- If imbalance is due to metabolic causes (due to changes in HCO₃⁻), pH may be maintained by regulating CO₂ ventilation - respiratory compensation
- If imbalance is due to respiratory causes (due to pCO₂ in blood), pH may be maintained by H⁺ secretion & HCO₃⁻ reabsorption – renal compensation
- Acidosis depresses CNS via synapse – ultimately to a coma
- Alkalosis overexcites nervous system – ultimately to convulsions
- Increased pCO₂ - respiratory acidosis
- Decreased pCO₂ - respiratory alkalosis
  - Inhale/exhale into a paper bag
• Decreased $\text{HCO}_3^-$ - metabolic acidosis
• Increased $\text{HCO}_3^-$ - metabolic alkalosis
• Table 27.4
• Diagnosis – blood pH then blood $p\text{CO}_2$ and $\text{HCO}_3^-$ levels