Fluid, Electrolyte, and Acid-Base Homeostasis

Water, acid, base, and electrolyte levels are maintained within a very narrow range – To do this many systems must be directly involved

Urinary
Respiratory
Gastrointestinal
Integumentary
Endocrine

Others are indirectly involved
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- Body Fluids – divided into two major compartments

![Fluid compartments diagram]

- Total body water volume = 40 L, 60% body weight
- Extracellular fluid volume = 15 L, 20% body weight
- Intracellular fluid volume = 25 L, 40% body weight
- Interstitial fluid volume = 12 L, 80% of ECF
- Plasma volume = 3 L, 20% of ECF
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• Composition of Body Fluids
  
  – Electrolytes and Nonelectrolytes

  – Electrolyte concentrations measured in millequivalents per liter (mEq/L) – *the number of electrical charges in a liter of solution* – to determine concentration of an electrolyte

\[
m\text{Eq/L} = \frac{\text{(ion conc. mg/l)} \times \# \text{ of electrical charges on one ion}}{\text{atomic weight of ion}}
\]

\[
\text{Na}^+ \quad \text{Ca}^{2+}
\]

\[
\frac{3300 \text{ mg/l}}{23} \times 1 = 143 \text{ mEq/L}
\]

\[
\frac{100 \text{ mg/L}}{40} \times 2 = 5 \text{ mEq/L}
\]
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- Comparison of Extracellular and Intracellular Fluids

Key to fluids:
- Red = Blood plasma
- Blue = Interstitial fluid
- Yellow = Intracellular fluid

Key to symbols:
- \( \text{Na}^+ \) = Sodium
- \( \text{K}^+ \) = Potassium
- \( \text{Ca}^{2+} \) = Calcium
- \( \text{Mg}^{2+} \) = Magnesium
- \( \text{HCO}_3^- \) = Bicarbonate
- \( \text{Cl}^- \) = Chloride
- \( \text{HPO}_4^{2-} \) = Hydrogen phosphate
- \( \text{SO}_4^{2-} \) = Sulfate

Total solute concentration (mEq/L)
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- Fluid Movements Among Compartments

As blood flows through lungs, CO$_2$ is removed and O$_2$ is added.

Kidneys clear plasma filtrate of nitrogenous wastes, ion excesses, etc.

CO$_2$ and metabolic wastes move out of cells.

Nutrients and O$_2$ move into cells.
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- Water Balance and ECF Osmolarity
Fluid, Electrolyte, and Acid-Base Homeostasis

• Regulation of Water Intake

  – Thirst Mechanism

    • Increasing osmolarity of blood (2 – 3 %)

      – Stimulates osmoreceptors in hypothalamus

      – Less saliva produced

        » Dry mouth

    • Decrease in Fluid Volume

      – Angiotensin II
Fluid, Electrolyte, and Acid-Base Homeostasis
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• Regulation of Water Output
  - Obligatory Water Loss – loss is unavoidable
    • Insensible
    • Feces
    • Sensible Water Loss – amount needed to remove waste products (approx. 500 ml/day)

• Influence of ADH
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- Disorders of Water Balance

  - Dehydration – water output exceeds water intake

  - Hemorrhage
  - Severe burns
  - Prolonged vomiting
  - Diarrhea
  - Profuse sweating
  - Water deprivation
  - Diabetes mellitus
  - Diabetes insipidus

(a) Mechanism of dehydration
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- Hypotonic Hydration – typically this doesn’t happen but can occur during

  - Renal disease
  - Overhydration, *hyptonic hydration*
  - Results in hyponatremia and water moves into cells
  - Must be corrected quickly frequently via the use of mannitol
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- Edema – review discussion from capillary exchange as to causes

- Electrolyte Balance – usually pertains to salts in the body – most important

  Sodium

  Potassium

  Calcium