Acid-Base Balance

• pH
  ✓ Normal cellular function
  ✓ Enzyme activity
  ✓ Membrane stability
• Many nutrition therapies address this metabolic change
Acid-Base Balance

- Acids
  - Donate or give up H+ ions
  - Volatile acids
    - Can be converted to gaseous form and eliminated by the lungs
    - Carbonic acid - H$_2$CO$_3$
    - CO$_2$ - indirect measure - partial pressure
Acid-Base Balance

• Acids
  ✓ Donate or give up H+ ions
  • Nonvolatile acids or fixed acids
    – Inorganic acids that occur through metabolism of CHO, protein, lipid
    – Average amount 50-100 mmol/day
    – Proteins contribute the most
    – Lungs cannot eliminate
Acid-Base Balance

- Bases
  - Can accept or receive H+ ions
    - Bicarbonate HCO₃
    - Kidneys provide primary regulation
Acid-Base Balance

- **Buffers**
  - React with acid or base to decrease effect
- **pH**
  - Measures relative acidity or alkalinity of a fluid... ratio of acids to bases
  - 1 (acidic) - 14 (basic)
  - Water is neutral - 7.0
  - Normal serum pH 7.35-7.45
Acid-Base Balance

- pH
  - Acidosis
    - Accumulation of acid or loss of base
  - Acidemia
    - pH < 7.35
  - Alkalosis
    - Accumulation of base or loss of acid
  - Alkalemia
    - pH > 7.45
Regulation of Acid-Base Balance

- Chemical buffers
- Respiratory regulation
- Kidney regulation
Regulation of Acid-Base Balance

- Chemical buffers
  ✓ Table 9.1
  ✓ Bicarbonate-carbonic acid buffer system
    • Increases rate and depth of breathing
    • Increased expiration of CO₂
    • Reabsorption or regeneration of HCO₃ in the kidneys
Regulation of Acid-Base Balance

• Other Chemical buffers
  ✓ Disodium/monosodium phosphate buffer system
  ✓ Proteins intracellularly
  ✓ Hemoglobin within the RBC
Regulation of Acid-Base Balance

- Respiratory regulatory control
  - Change in respiration rate
  - Depth of breathing
  - Release or retention of CO₂
Regulation of Acid-Base Balance

- Renal regulatory control
  - Control of \( \text{HCO}_3^- \) by the kidneys
  - Increased or decreased based on need
  - Formation of dibasic phosphate and sulfur in the urine
    - Accepts H+
ca = Carbonic anhydrase

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Regulation of Acid-Base Balance

- Electrolyte Balance
  - Hydrogen and bicarbonate both electrolytes
  - Other electrolytes affected to maintain electroneutrality
  - Potassium, chloride, sodium
Assessment of Acid-Base Balance

• Body attempts to self-correct changes in pH – making assessment difficult
• Common lab measures
  ✓ ABGs
  ✓ Serum chemistries
  ✓ See Table 9.3
• pH alone not adequate – why?
Acid-Base Disorders

- 4 major types
  - Respiratory acidosis
  - Respiratory alkalosis
  - Metabolic acidosis
  - Metabolic alkalosis
Acid-Base Disorders

• Respiratory acidosis
  ✓ Excess acid in blood secondary to carbon dioxide retention
  ✓ Hypercapnia
  ✓ Common causes - see Table 9.5
  ✓ d/t respiratory dysfunction – renal regulatory systems compensate
Acid-Base Disorders

- Respiratory acidosis
  ✓ Labs
    • Decreased pH, elevated pCO\(_3\)
    • Slightly elevated bicarbonate
    • Increase in serum Ca, K, Cl
  ✓ Hypoxemia
  ✓ Restlessness, apprehension, lethargy, muscle twitching, tremors, convulsions, coma
Acid-Base Disorders

• Respiratory acidosis
  ✔ Treatment
    • Correct underlying condition
    • Increase oxygenation
    • Mechanical ventilation
Acid-Base Disorders

- Respiratory alkalosis
  - Relative excess amount of base d/t reduction of CO₂
  - Hyperventilation
  - Common causes - see Table 9.6
  - Shift of acid from ICF to ECF
  - Bicarbonate moved into cells in exchange for chloride – renal compensation
Acid-Base Disorders

- Respiratory alkalosis
  - pH > 7.45
  - Plasma HCO₃ low in chronic, PaCO₃ low in acute
  - Cardiac, CNS, respiratory symptoms
  - Treat underlying cause
  - Correction of hypoxia
Acid-Base Disorders

- Metabolic Acidosis
  - All types not caused by excessive CO$_2$
  - Common causes - see Table 9.7
    - Diarrhea most common cause
  - d/t excessive loss of bicarbonate – bicarbonate-carbonic acid buffer system is stimulated
ca = Carbonic anhydrase

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Acidemia

H⁺ Excess
Extracellular Fluid

Alkalemia

H⁺ Deficit
Extracellular Fluid

=⇒ H⁺
⇐ k⁺
Acid-Base Disorders

- Metabolic Acidosis
  - Kussmaul breathing
  - Cardiac and neurological
  - Treat underlying cause
  - Raise pH to safe level – not too quickly
Acid-Base Disorders

- Metabolic Alkalosis
  - Excess amount of base
  - Fluid imbalance – with volume decrease
  - Without fluid imbalance – without volume decrease
  - Common causes - see Table 9.9
  - Underlying event determines pathophysiology
Acid-Base Disorders

• Metabolic Alkalosis
  ✓ No specific signs and symptoms
  ✓ pH >7.45, elevated HCO₃
  ✓ Look at electrolytes and volume
  ✓ Volume imbalance corrected with isotonic saline with KCl
  ✓ Treat underlying condition
  ✓ Carbonic anhydrase in severe cases
Acid-Base Disorders

- Mixed Disorders
  - See Table 9.10
  - Likely when $\text{PaCO}_2$ and $\text{HCO}_3$ not consistent with pH
  - Or compensatory response exaggerated