**Acid-Base Balance**

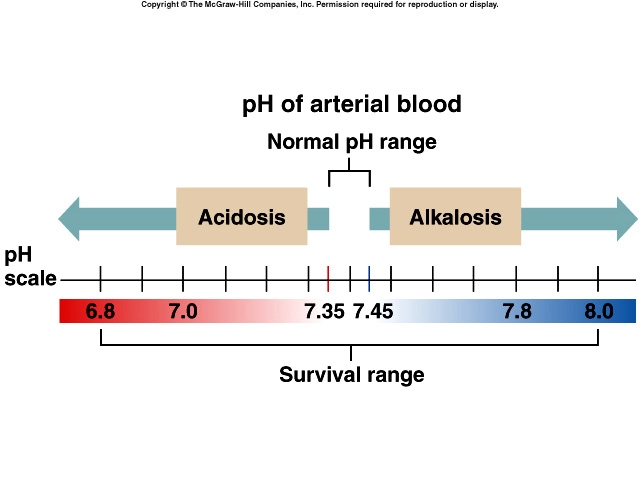
**Dr. Gary Mumaugh**

**Introduction**

* Acid-base balance is one of the most important of the body’s homeostatic mechanisms
* Acid-base balance refers to regulation of hydrogen ion (H+) concentration in body fluids
* Precise regulation of pH at the cellular level is necessary for survival
* Slight pH changes have dramatic effects on cellular metabolism

**Mechanisms That Control pH of Body Fluids**

* Review of pH concept
  + pH indicates degree of acidity or alkalinity of a solution - range is from 0 - 14
  + If [H+] is high, solution is acidic; pH < 7
  + If [H+] is low, solution is basic or alkaline ; pH > 7
  + Acidosis describes arterial blood pH of less than 7.35
  + Alkalosis describes arterial blood pH greater than 7.45

**Small changes in pH can produce major disturbances**

* Most enzymes function only with narrow pH ranges
* Acid-base balance can also affect electrolytes (Na+, K+, Cl-)
* Can also affect hormones

**The body produces more acids than bases**

* Acids take in with foods
* Acids produced by metabolism of lipids and proteins
* Cellular metabolism produces CO2
  + CO2  + H20 ↔ H2CO3 ↔ H+ + HCO3

**Mechanisms That Control pH of Body Fluids**

* Types of pH control mechanisms
* Chemical: rapid-action buffers
  + Bicarbonate buffer system
  + Phosphate buffer system
  + Protein buffer system
* Physiological: delayed-action buffers
  + Respiratory response
  + Renal response
* Summary of pH control mechanisms
  + Buffers
  + Respiration
  + Kidney excretion of acids and bases

**Buffer Mechanisms for Controlling pH of Body Fluids**

* Buffers
  + Substances that prevent a marked change in pH of a solution when an acid or base is added to it
  + Buffer pairs present in body fluids: mainly carbonic acid, proteins, hemoglobin, acid phosphate, and sodium and potassium salts of these weak acids
* Buffer systems
  + Take up H+ or release H+ as conditions change
    - Buffer pairs – weak acid and a base
    - Exchange a strong acid or base for a weak one
    - Results in a much smaller pH change
  + Types of buffer systems
    - Bicarbonate buffers
      * Sodium Bicarbonate (NaHCO3) and carbonic acid (H2CO3)
      * Maintain a 20:1 ratio : HCO3- : H2CO3
      * HCl + NaHCO3 ↔ H2CO3  + NaCl
      * NaOH + H2CO3  ↔ NaHCO3 + H2O
    - Phosphate buffers
      * Major intracellular buffer
      * H+ + HPO42- ↔ H2PO4-
      * OH- + H2PO4- ↔ H2O + H2PO42-
    - Protein Buffers
      * Includes hemoglobin, work in blood and ISF
      * Carboxyl group gives up H+
      * Amino Group accepts H+
      * Side chains that can buffer H+ are present on 27 amino acids.

**Respiratory mechanisms**

* Respiratory mechanism – limited to adjustments of CO2.
  + With every exhalation CO2 and H2O leaves the body
  + Hypoventilation causes respiratory acidosis, and hyperventilation cause respiratory alkalosis
  + Respiratory control centers “sense” and regulate RR and depth
  + Changes in respiratory rate and depth also can partially correct metabolic disturbances
* Respiratory Mechanisms of pH Control
  + Explanation of respiratory mechanisms
    - Amount of blood carbon dioxide (CO2) directly relates to the amount of carbonic acid and therefore to the concentration of H+
    - With increased respirations, less CO2 remains in blood, hence less carbonic acid and fewer H+; with decreased respirations, more CO2 remains in blood, hence more carbonic acid and more H+
  + Respirations adjustment to counter pH imbalance of arterial blood
* Principles that relate respirations to pH value
  + Prolonged hyperventilation, by decreasing blood H+ excessively, may produce alkalosis
  + Alkalosis causes hypoventilation, which tends to correct alkalosis by increasing blood CO2 and therefore blood H2CO3 and H+
  + Prolonged hypoventilation, by eliminating too little CO2, causes an increase in blood H2CO3 and consequently in blood H+, thereby possibly producing acidosis

**Kidney Excretion**

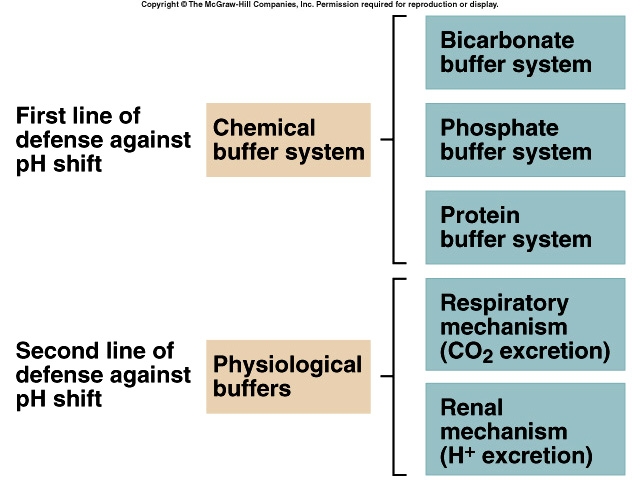
* Urinary mechanism - greatest capacity to adjust pH changes
* Slow to begin but long-lasting
  + The kidneys are the most effective regulators of blood pH
  + Eliminates much larger amounts of acid than the lungs, and if necessary can excrete excess base which the lungs cannot do
  + Renal Failure – acid base control fails

**Urinary Mechanisms That Control pH**

* General principles concerning urinary mechanisms
  + Play vital role in acid-base balance because kidneys can eliminate more H+ from the body while reabsorbing more base when pH lowers
* Mechanisms that control urine pH
  + Secretion of H+ into urine: when blood CO2, H2CO3, and H+ increase above normal
  + Secretion of NH3: when blood H+ concentration increases, distal tubules secrete more NH3

**Rates of correction**

* Buffers function almost instantaneously
* Respiratory mechanisms take several minutes to hours
* Renal mechanisms may take several hours to days
* Evaluation of the role of buffers in pH control: cannot maintain normal pH without adequate functioning of the respiratory and urinary pH control mechanisms



**Acid Base Disturbances**

* Metabolic Acidosis – to little bicarbonate
  + Acidosis – may be related to kidney disease, uncontrolled diabetes mellitus, excessive diarrhea, vomiting or use of diuretics.
    - Increased H+ stimulate respiratory centers and RR increases
    - Effects/symptoms of acidosis – depresses CNS, confusion, coma, and perhaps death
* Metabolic Ketoacidosis
  + Occurs in diabetic patients ( and those on the Atkin’s diet) when fats and proteins are used for energy instead of glucose
  + The use of fats without some glucose is inefficient and ketones accumulate in the blood making it acid
* Metabolic Alkalosis - to much bicarbonate
  + Alkalosis – rare but can occur with ingestion of too many antacids, vomiting of stomach contents only
    - Effects/symptoms – affects the PNS, irritability, muscle spasms, convulsions

**Respiratory Disturbances**

* Acidosis – to much carbonic acid
  + Seen in pneumonia and emphysema which retains CO2 in blood
  + Also seen in drug abuse and decreased breathing
* Alkalosis – to little carbonic acid
  + Seen in hyperventilation

**Language of Medicine – Ch. 30**

* Bicarbonate loading
* Emesis
* Hyperkalemia
* Lactic acidosis
* Metabolic acidosis
* Metabolic alkalosis
* Pernicious vomiting
* Respiratory acidosis
* Respiratory alkalosis

