



جامعة تكريت



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# Physiology of Acid-Base Balance

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## Physiology of Acid-Base Balance

### Introduction

- ♣ Acid-base homeostasis is the part of human homeostasis concerning the proper balance between acids and bases, in other words, the pH.
- ♣ Chemical and physiologic processes responsible for the maintenance of the acidity of body fluids.

### ACIDS

- ❖ Acids can be defined as a proton ( $H^+$ ) donor .
- ❖ Hydrogen containing substances which dissociate in solution to release  $H^+$  .
- ❖ Physiologically important acids include:
  - ❖ Carbonic acid ( $H_2CO_3$ )
  - ❖ Phosphoric acid ( $H_3PO_4$ )
  - ❖ Pyruvic acid ( $C_3H_4O_3$ )
  - ❖ Lactic acid ( $C_3H_6O_3$ )

### BASES

- Bases can be defined as:
  - ♥ A proton ( $H^+$ ) acceptor
  - ♥ Molecules capable of accepting a hydrogen ion ( $OH^-$ )
- Physiologically important bases include:
  - ♥ Bicarbonate ( $HCO_3^-$ )
  - ♥ Biphosphate ( $HPO_4^{2-}$ )

### pH SCALE

- pH refers to Potential Hydrogen



- $H^+$  ion is an acid
- $OH^-$  ion is a base
- Normal blood pH is (Venous Blood ) 7.35 - (Arterial Blood) 7.5
- DEATH (6.8) – DEATH (8.0)

- pH range compatible with life is 6.8 - 8.0

### **Acidosis / Alkalosis**

- **Acidosis**

- ♠ A condition in which the blood has too much acid (or too little base), frequently resulting in a decrease in blood pH

- **Alkalosis**

- ♠ A condition in which the blood has too much base (or too little acid), occasionally resulting in an increase in blood pH

- **ACIDOSIS / ALKALOSIS**

- pH changes have dramatic effects on normal cell function

1) Changes in excitability of nerve and muscle cells

2) Influences enzyme activity

3) Influences  $K^+$  levels

➤ **Changes in Cell Excitability**

- pH decrease (more acidic) depresses the central nervous system
  - ❖ Can lead to loss of consciousness
- pH increase (more basic) can cause over-excitability
  - ❖ Tingling sensations, nervousness, muscle twitches
  - **Influences on Enzyme Activity**
    - ❖ pH increases or decreases can alter the shape of the enzyme make it non-functional.
    - ❖ Changes in enzyme structure can result in accelerated or depressed metabolic actions within the cell.
  - **Influences On  $K^+$  Levels**
    - ❖ When reabsorbing  $Na^+$  from the filtrate of the renal tubules  $K^+$  or  $H^+$  is secreted (exchanged).
    - ❖ Normally  $K^+$  is secreted in much greater amounts than  $H^+$
    - ❖ If  $H^+$  concentrations are high (acidosis) than  $H^+$  is secreted in greater amounts.
    - ❖ This leaves less  $K^+$  than usual excreted.
    - ❖ The resultant  $K^+$  retention can affect cardiac function and other systems.

## *Regulation of Acid Base Balance*

- Two types of acids are produced in the body:
- ✓ Volatile acids: CO<sub>2</sub> produced during the metabolism of carbohydrates and lipids
- ✓ Non-volatile acids: metabolism of protein e.g. sulphuric acids

### Acid-base buffer system

- ❖ Maintains the pH by binding with free hydrogen ions.
- ❖ Combination of weak acid and a base (unprotonated compound).
- ❖ Three major chemical buffer systems:
  1. *Bicarbonate system (extracellular )*
  2. *Phosphate system (intracellular)*
  3. *Protein system ( Plasma )*

### BICARBONATE BUFFER SYSTEM

- This system is most important because the concentration of both components can be regulated:
  - ♥ Carbonic acid by the respiratory system
  - ♥ Bicarbonate by the renal system

### PHOSPHATE BUFFER SYSTEM

- ♠ Regulates pH within the cells and the urine
  - Phosphate concentrations are higher intracellular and within the kidney tubules.
  - More phosphate ions are found in tubular fluids .
  - More powerful than bicarbonate buffer system .

### PROTEIN BUFFER SYSTEM

- Proteins are excellent buffers because they contain both acid and base groups that can give up or take up H<sup>+</sup>
- Proteins are extremely abundant in the cell
- The more limited number of proteins in the plasma reinforce the bicarbonate system in the ECF.

### **Chemosensitive Areas**

- Chemo sensitive areas of the respiratory center are able to detect blood concentration levels of CO<sub>2</sub> and H<sup>+</sup>.
- Increases in CO<sub>2</sub> and H<sup>+</sup> stimulate the respiratory center
- The effect is to raise respiration rates
- But the effect diminishes in 1 - 2 minutes

### **Renal Response**

- The kidney compensates for Acid - Base imbalance within 24 hours and is responsible for long term control
- The kidney in response:
  - To Acidosis
    - Retains bicarbonate ions and eliminates hydrogen ions
  - To Alkalosis
    - Eliminates bicarbonate ions and retains hydrogen ions