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وزارة التعليم العالي والبحث العلمي
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قسم تقنيات المختبرات الطبية

Clinical Biochemistry

Third stage

Acid-base balance

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Clinical Biochemistry

Acid-base balance

Objective:

- understand mechanism of Acid-base homeostasis
- types of Acid Base imbalance.
- Body compensated to acid –base disorder

Acid-base balance

refers to the mechanisms the body uses to keep its fluids close to neutral pH (that is, neither basic nor acidic) so that the body can function normally. This balance is achieved by buffer system. • Arterial blood pH is normally closely regulated to between 7.35 and 7.45.

Metabolic sources of acids and bases

Two types of acids are dealt within physiological states; fixed acids and volatile acids.

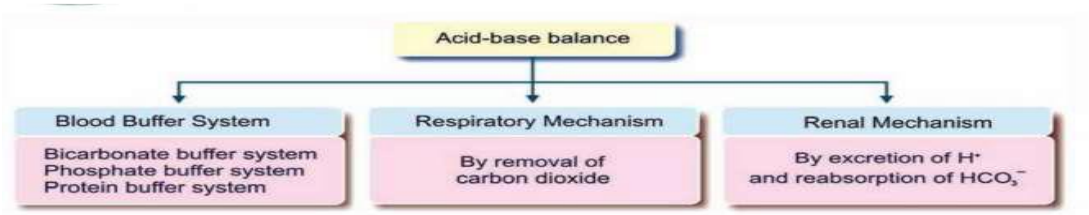
•Fixed acids are:

1. **Non-gaseous acids** such as phosphate (HPO^{-4}) & sulphate (HSO^{-4}), or
2. **Organic acids** such as lactic acid, acetoacetic acid & β-hydroxybutyric acid.

•The physiologically important **volatile acid** is H_2CO_3 .the volatility of H_2CO_3 arises from its ability to dissociate into water and CO_2, which can be released as gas.

Mechanism of regulation of PH

• **The following factors are involved in the regulation of blood PH:**



- The body's acid –base balance is normally tightly regulated by buffering agents, the Respiratory system and the renal system keeping the blood PH between 7.35-7.45
- Buffers are mixtures of weak acids and their salts of strong bases that resist the Change of PH when small amount of strong acid or base is added to it.
- Since the partial pressure of CO_2 in arterial blood is controlled by lungs and called respiratory disturbances.

• The disturbance produced by change in HCO_3^- is controlled by kidney called metabolicdisturbances .

Types of buffers system in blood

1-Bicarbonate buffers

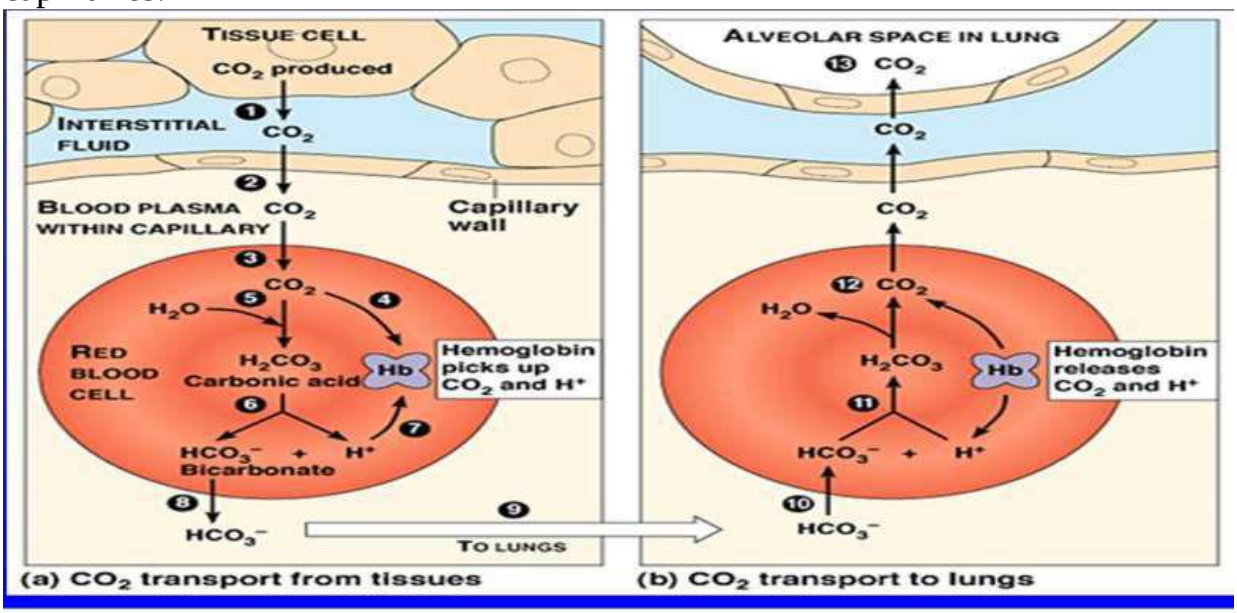
• Bicarbonate buffer system is present in ECF. In the form of salt, i.e. NaHCO3.

2-phosphate buffer system

Phosphate buffer system is useful in intracellular fluid, in red blood cells or other cells, as the conc .of phosphate more in ICF than in ECF.

3-protein buffer system

Protein buffer system are present in the blood both in the plasma and erythrocyte Protein buffer in erythrocytes (Hb).Hemoglobin has about six time more buffering capacity than plasma proteins. When Hb molecule becomes deoxygenated in the capillaries, it easily binds with H^+, which are released when CO_2 enters the capillaries.



The Respiratory system: (Figure above)

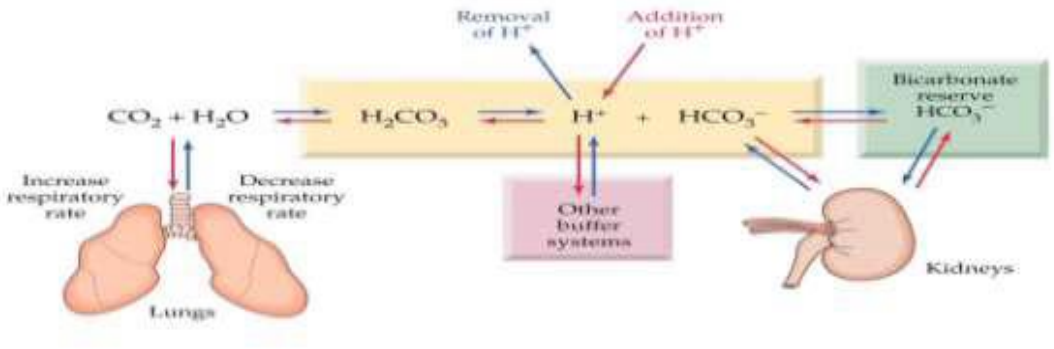
The lungs regulate the concentration of CO_2 (acidic gas) in the blood.

Respiratory

Chemoreceptors in the brain stem respond to changes in the concentration of carbon dioxide in blood, causing increased ventilation (breathing) if carbon dioxide concentration rises and decreased ventilation if carbon dioxide falls.

Increased ventilation: faster deeper breathing eliminates CO_2 from the lungs and less H2CO3 is formed and PH increases. At the lungs bicarbonate converted back to CO2 and eliminated

$H^+ + HCO^-_3 \rightarrow H_2CO_3 \rightarrow CO_2 + H_2O$



The Renal system

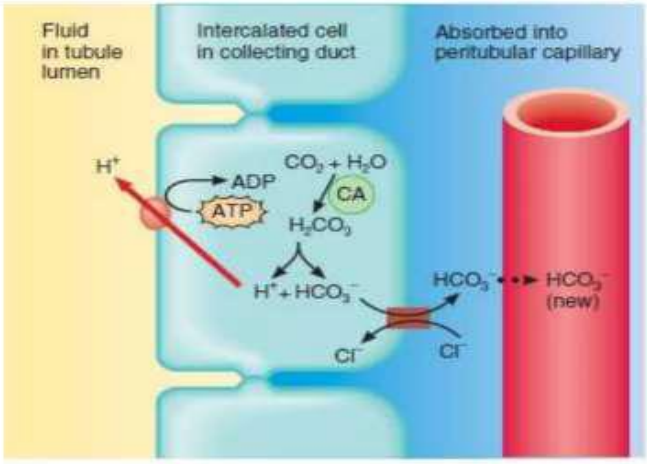
• **The kidneys** keep the acid-base balance by performing two physiological Functions:

1-reabsorb the filtered HCO^{-}_{3} : a function principally of the proximal tubule

2-excretion of daily produced H + originated from non-volatile acids. A Function of the collecting duct.

3- REGULATION OF ACID-BASE BALANCE BY RENAL MECHANISM:

- Kidney maintains the acid-base balance of the body by the secretion of H+ and by the retention of HCO3–.



Urinary buffers

(bicarbonate, ammonia, and phosphate) play a special role in maintaining of Acid-base homeostasis, as they provide the major mechanism for excretion of H^{+} from the Body and are important for the generation of HCO_3^{-}.

Parameters	Normal Values (Range)
pH	7.35 - 7.45
pO_2	80 - 100 mmHg
pCO_2	35 - 45 mmHg
HCO_3^-	22 - 26 mmol/l

Acid base imbalance

• **Acidosis:** means accumulation of acids or loss of alkali, this condition occurs when the PH of the blood falls (below) 7.35. There are two types of acidosis (a) Respiratory acidosis. (b) Metabolic acidosis.
• **Alkalosis** means accumulation of alkali or loss of acids, this condition occurs when the PH of the blood above 7.45. There are two types of acidosis
(a) Respiratory Alkalosis (b) Metabolic Alkalosis.

• **Metabolic acidosis**
Metabolic acidosis is characterized by a drop plasma pH due to decrease in HCO_3^- concentration and compensatory drop in the partial pressure of carbon dioxide (pCO_2).
• Metabolic acidosis caused by either the addition of hydrogen ion or loss of HCO_3^-
• Most common causes of metabolic acidosis are un-controlled diabetes mellitus with ketosis, renal failure, poisoning with acid substances, severe diarrhea with loss of HCO^-_3 , lactic acidosis and severe dehydration.
• Compensated by increase rate of respiration (hyperventilation) and the kidneys Respond by excreting H^+, primary as NH_4^+.

Metabolic alkalosis:

• Is characterized by increase in plasma pH, an increase in HCO^-_3 concentration and **compensatory** increase in pCO 2 . Metabolic alkalosis is caused by a **losses of H + or a retention of HCO^-_3**

Causes of Metabolic Alkalosis:

1. The excessive loss of HCl from stomach is associated with high intestinal Obstruction, pyloric obstruction.
2. K^+ &Na^+ are retained in the body in the form of bicarbonate due to loss of Cl^- from the blood. Thus, a neutral salt (NaCl) is replaced by an alkaline salt ($NaHCO_3$) & Excessive intake of bases like $NaHCO_3$,
3. Potassium deficiency.
4. Excessive vomiting.

Respiratory acidosis:

Is characterized by a decrease in plasma pH, **an increase in pCO 2** . Respiratory acidosis is due to impaired ventilation, CO_2 accumulate in the Blood where it react with water to form carbonic acid some common causes of the chronic form are: · Asthma, chronic obstructive pulmonary disease (COPD, Some drugs (e.g., morphine and barbiturates) can cause respiratory acidosis
By depressing the respiratory center in the brain.

- **Respiratory alkalosis**

This is characterized by an increase in plasma pH, a drop in pCO_2 .due to alveolar hyperventilation and increase loss of CO_2 from the body then decrease H_2CO_3 formation. Examples here include **severe anemia**, **pulmonary embolism** and **adult respiratory syndrome**. Hyperventilation sufficient to cause respiratory alkalosis can be a feature of anxiety attacks and response to severe pain.

Acid-base imbalance	Plasma pH	Primary disturbance	Compensation
Respiratory acidosis	Low	Increased pCO_2	Increased renal net acid excretion with resulting increase in serum bicarbonate
Respiratory alkalosis	High	Decreased pCO_2	Decreased renal net acid excretion with resulting decrease in serum bicarbonate
Metabolic acidosis-	Low	Decreased HCO_3^-	Hyperventilation with resulting low pCO_2
Metabolic alkalosis-	High	Increased HCO_3^-	Hypoventilation with resulting increase in pCO_2

Compensation

Is the physiological response to any acid-base disturbance, which tends to eliminate the change in pH caused by the primary process. Respiratory disorders (change in pCO2) are compensated by change in renal HCO^{-}_{3} reabsorption. This results in a change of blood [HCO^{-}_{3}] in the same direction as pCO_2 was changed. Similarly, metabolic acid-base disorder causing in change in blood HCO^{-}_{3} concentration is followed by respiratory compensation, which changes pCO_2 concurrently with the changes in [HCO^{-}_{3}].