



Renal Block

Physiology Team

11th Lecture

Acid – Base imbalances

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❖ What are acid base imbalance ?

Acid-base imbalance is an abnormality of the human body's normal **balance of acids and bases** that causes the **plasma pH** to deviate out of the normal range (7.35 to 7.45).

❖ How to diagnose Acid-Base Imbalance ?

- Depends **on the pH** (normal value **7.35 to 7.45**)
If low → **acidosis**
If high → **alkalosis**
- If **pCO₂** is abnormal the problem is **respiratory**.
(Normal value **35-45 mmHg**)
If **HCO₃** is abnormal the problem is **metabolic**.
(Normal value **22- 26 mmHg**)
- If pH is within the normal range, there is full compensation.
If it is outside the normal range, the body is partially compensating for the problem.

NOTE : Compensation is the process of counterbalancing any defect in body structure or function (ex : the body response to acid – base imbalance)

❖ Acid-Base Imbalances :

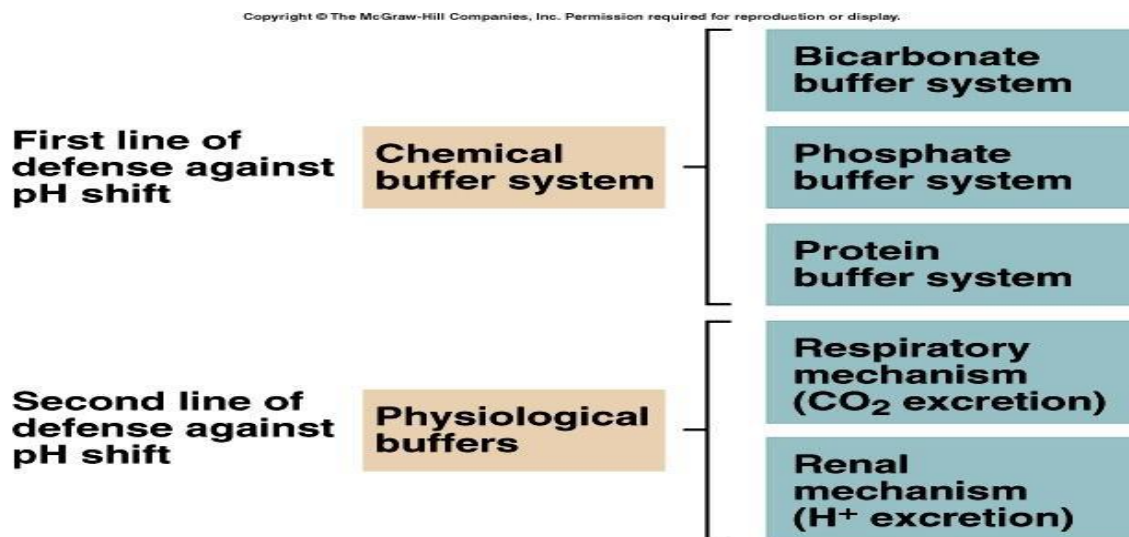
pH < 7.35 acidosis

pH > 7.45 alkalosis

- Compensation May **be complete** if **pH level is brought back within normal limits.**
- **Partial** compensation if pH **range is still above or below normal.**

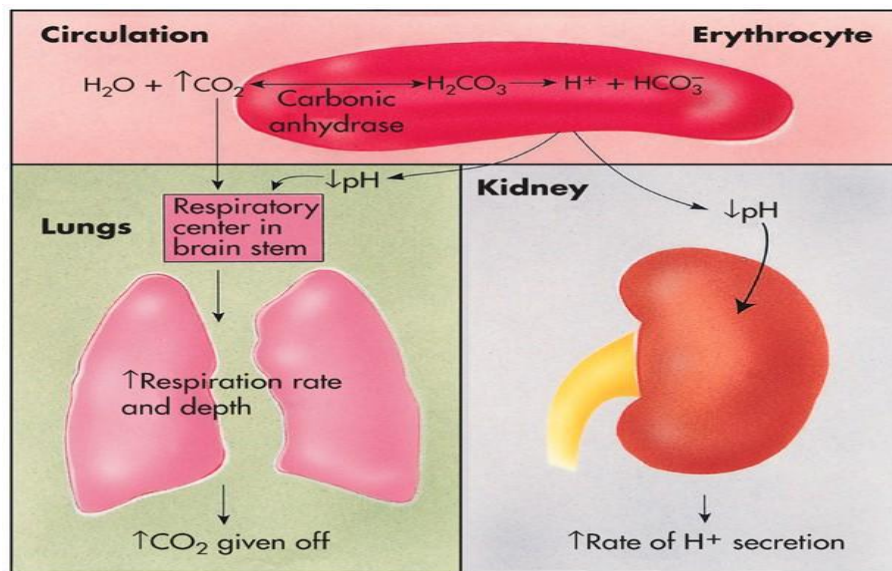
❖ Compensation

- If underlying problem is **metabolic** (metabolic acidosis or alkalosis), hyperventilation or hypoventilation can help : **respiratory compensation** (increase or decrease ventilation).
- If underlying problem is **respiratory** (respiratory alkalosis or acidosis), renal mechanisms can bring about **metabolic compensation** (the ability of the kidneys to decrease or increase HCO_3 excretion ,which require several days to compensate for the disorder).



❖ Rates of correction

- Buffers function almost immediately .
- Respiratory mechanisms take several minutes to hours (rapid)
- Renal mechanisms may take several hours to days (slow)



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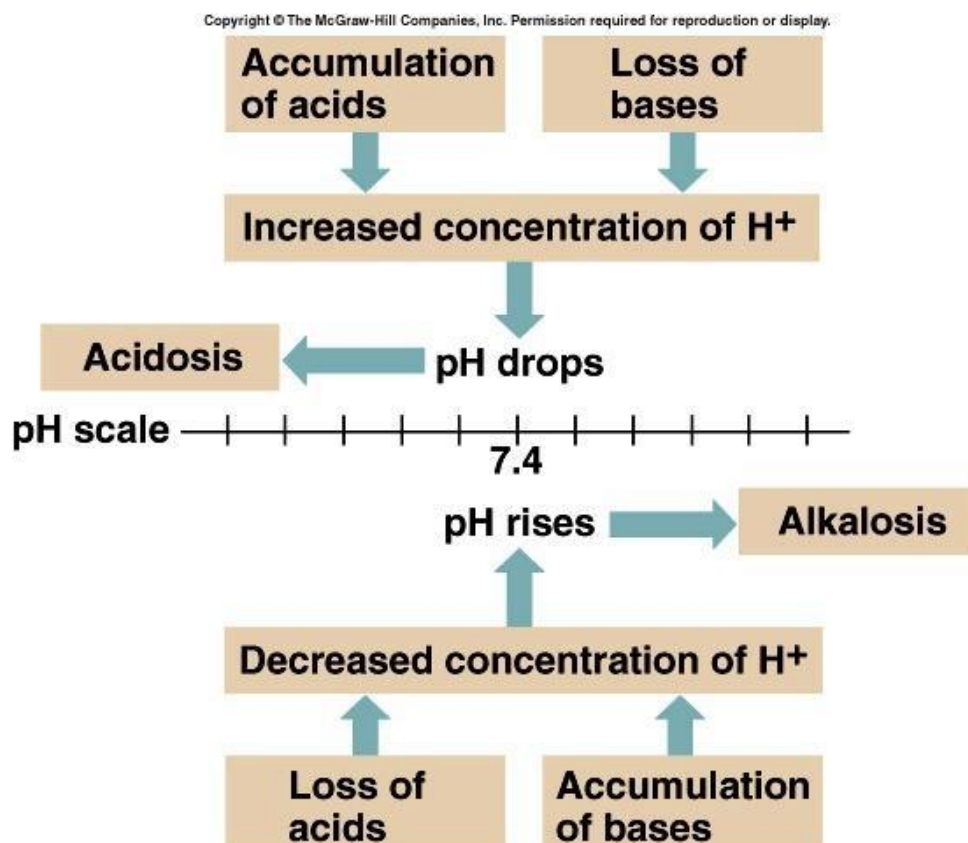
❖ Types of Acid Base Imbalance :

1. Acidosis

Cause	Low pH
Types	<ul style="list-style-type: none"> –Metabolic causes : Metabolic Acidosis –Respiratory causes : Respiratory Acidosis
Principal effect	Principal effect of acidosis is depression of the CNS through ↓in synaptic transmission.
symptoms	Generalized weakness
Complications of severe acidosis	<ul style="list-style-type: none"> –Disorientation –coma –death

2. Alkalosis

cause	High pH
types	Metabolic causes :Metabolic Alkalosis Respiratory causes :Respiratory Alkalosis
Principal effect	Alkalosis causes over excitability of the central and peripheral nervous systems.
symptoms	–Numbness –Lightheadedness
complication	–Nervousness –muscle spasms or tetany –Convulsions –Loss of consciousness –Death



Respiratory Acidosis

- Low pH (less than 7.3)
- it is caused by Alveolar hypoventilation leads to an increased PaCO₂ (hypercapnia). The increase in PaCO₂, in turn, decreases the bicarbonate (HCO₃⁻)/PaCO₂, decreasing the pH.
- Called respiratory acidosis due to abnormality in respiration .

➤ Causes of Respiratory Acidosis :

- Acute conditions:
 - Adult Respiratory Distress Syndrome .
 - Pulmonary edema.
 - Pneumothorax .
- Chronic conditions:
 - Depression of respiratory center in brain that controls breathing rate .
 - drugs or head trauma.
 - Paralysis of respiratory or chest muscles.
 - Emphysema.

➤ Signs and Symptoms of Respiratory Acidosis

- **Breathlessness**
- Restlessness
- Lethargy (a lowered level of consciousness with drowsiness).
- disorientation (a state of mental confusion as to time, place, or identity).
- Tremors (involuntary trembling), convulsions, coma .
- Respiratory rate rapid, then gradually depressed.
- **Skin warm and flushed due to vasodilation caused by excess CO₂**

The patient's mental status may be depressed if he or she has severe elevations of PaCO₂.

➤ Compensation for Respiratory Acidosis :

- In respiratory acidosis, the rise in the extracellular fluid PCO₂ results in excess H ions in the tubular fluid and also stimulates H ions secretion.
- Thus, the excess of H ions in tubular fluid helps eliminate excess H ions and increases HCO₃ and this increases the bicarbonate part of the buffer system and this will help raise the extracellular pH.

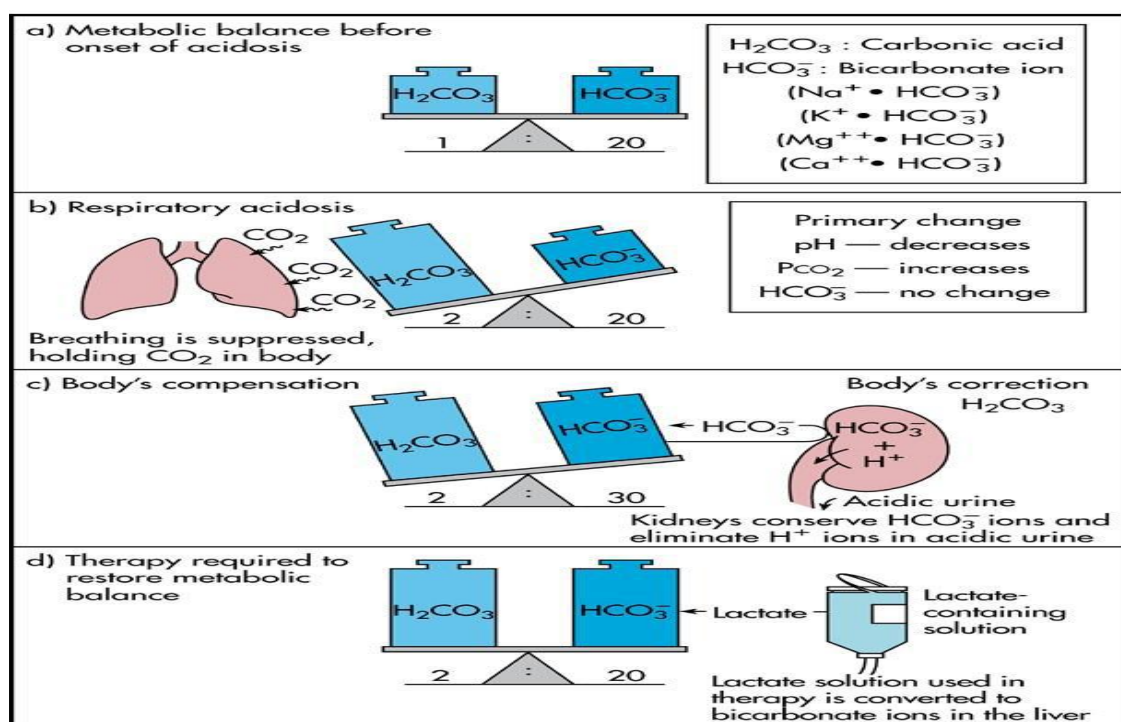
To understand :

The body's compensation occurs in 2 steps.

The initial response is cellular buffering that occurs over minutes to hours. Cellular buffering elevates plasma bicarbonate values, but only slightly, approximately 1 mEq/L for each 10-mm Hg increase in PaCO₂. The second step is renal compensation that occurs over 3-5 days. With renal compensation, renal excretion of H⁺ is increased and bicarbonate reabsorption is increased (**low HCO₃ in urine**)

➤ Treatment of Respiratory Acidosis:

- Restore ventilation
- IV lactate solution
- Treat underlying dysfunction or disease



Respiratory Alkalosis

- high pH
- Respiratory alkalosis results from alveolar hyperventilation. Alveolar hyperventilation leads to decrease partial pressure of carbon dioxide (PCO_2 less than 35 mmHg, hypocapnea). In turn, the decrease in PCO_2 increases the ratio of bicarbonate concentration to PCO_2 and increases the pH level.

➤ Causes of Respiratory Alkalosis :

- Oxygen deficiency at high altitudes (low oxygen content stimulates respiration which causes excess loss of CO_2)
- Pulmonary disease and Congestive heart failure –caused by hypoxia
- Acute anxiety
- Fever, anemia (Hypoxia-related)
- Early salicylate intoxication (stimulation, excitement, or stupefaction caused by any group of related compounds derived from salicylic acid which inhibit prostaglandin synthesis and have analgesic, antipyretic, and anti-inflammatory activity).
- Cirrhosis (Cirrhosis is a chronic degenerative disease in which normal liver cells are damaged and are then replaced by scar tissue)
- Gram-negative sepsis.

➤ Signs and symptoms of Respiratory Alkalosis : (for your own knowledge)

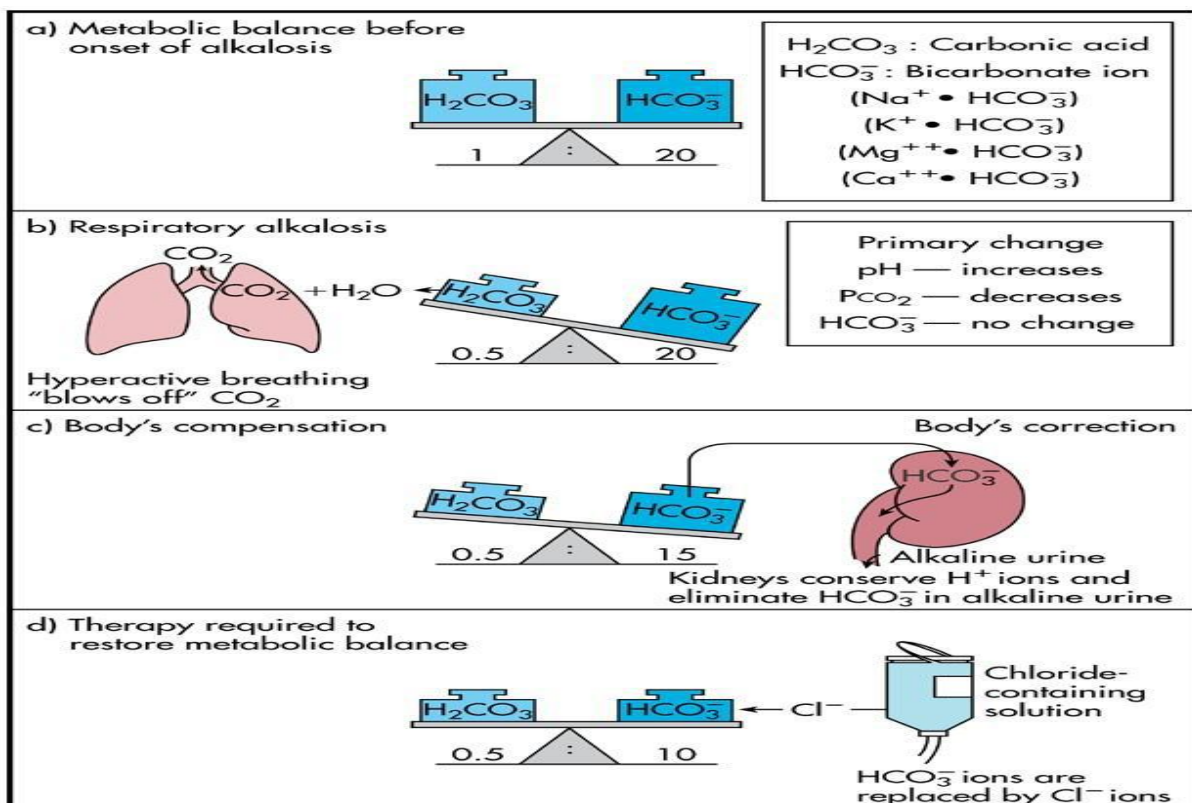
- hypocapnia can cause cerebral vasoconstriction. Therefore, an acute decrease in PCO_2 reduces cerebral blood flow and can cause neurologic symptoms, including dizziness, mental confusion,
- chest pain or tightness, dyspnea.

➤ Compensation of Respiratory Alkalosis :

- Respiratory alkalosis is renally compensated by a decrease in bicarbonate reabsorption (**excretion of more bicarbonate ion so high HCO_3 in urine**). The kidneys respond more to the decreased PCO_2 rather than the increased pH. Kidney compensation may take several days and requires normal kidney function and intravascular volume status.
- Kidneys conserve hydrogen ion.

➤ Treatment of Respiratory Alkalosis :

- Treat underlying cause
- Breathe into a paper bag
- IV Chloride containing solution – Cl^- ions replace lost bicarbonate ions



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Metabolic Acidosis

- Low pH
- Metabolic acidosis results from decreased extracellular fluid bicarbonate concentration (less than 22 mEq/L) with normal PCO₂.

➤ Causes of Metabolic Acidosis:

- Loss of bicarbonate through diarrhea (feces contains large amount of bicarbonate so diarrhea will cause loss of HCO₃ / severe diarrreaha is the most frequent cause of metabolic acidosis) or renal dysfunction
- Accumulation of acids (lactic acid or ketones)
- Failure of kidneys to excrete H⁺ or reabsorb HCO₃.
- Production of ketoacid (with severe diabetes mellitus causes severe metabolic acidosis and to compensate for that , large amount of acid are excreted in urine)
- Production of Lactic acid (anerobic metabolism)

➤ Symptoms of Metabolic Acidosis :

- Headache, lethargy
- Nausea, vomiting, diarrhea

➤ Complications :

- Coma
- Death

➤ Compensation for Metabolic Acidosis :

- Stimulation of ventilation (hyperventilation) → decrease PCO₂ and increase pH back to normal value
- Renal excretion of hydrogen ions if possible
- K⁺ exchanges with excess H⁺ in ECF (H⁺ into cells, K⁺ out of cells)
- Blood picture

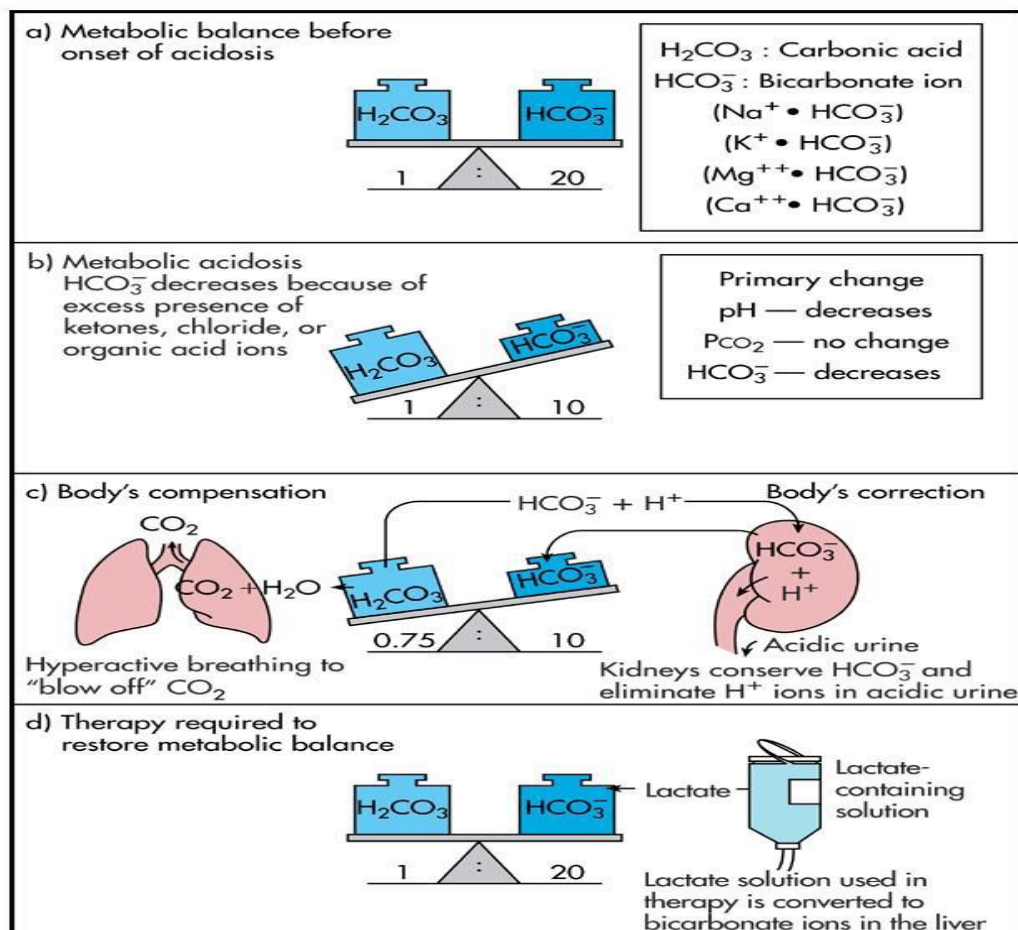
-pH = ~N

-HCO₃⁻ = Low

-PCO₂ = Low compensation

➤ Treatment of Metabolic Acidosis

- IV lactate solution



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Metabolic Alkalosis

- high pH
- metabolic alkalosis is caused by increase extracellular fluid Bicarbonate concentration (more than 26 mEq/L) with normal PCO₂.

➤ Causes of Metabolic alkalosis:

- Excessive intake of alkali (antacid) (for treatment of gastric ulcer)
- Excess vomiting = loss of stomach acid (HCL)
- Excessive use of alkaline drugs
- Certain diuretics (diuretics cause increase fluid flow along the tubules , causing increase flow in the distal tubules and collecting tubules . This results in increased Na⁺ reabsorption and enhanced sodium reabsorption which leads to increased H⁺ secretion and increase in HCO₃ reabsorption).
- Endocrine disorders (excess aldosterone , aldosterone promotes extensive reabsorption of the Na⁺ and stimulation of H⁺ secretion)
- Severe dehydration

➤ Symptoms of Metabolic Alkalosis

- Respiration slow and shallow
- Hyperactive reflexes tetany
- Often related to depletion of electrolytes
- Atrial tachycardia
- Dysrhythmias

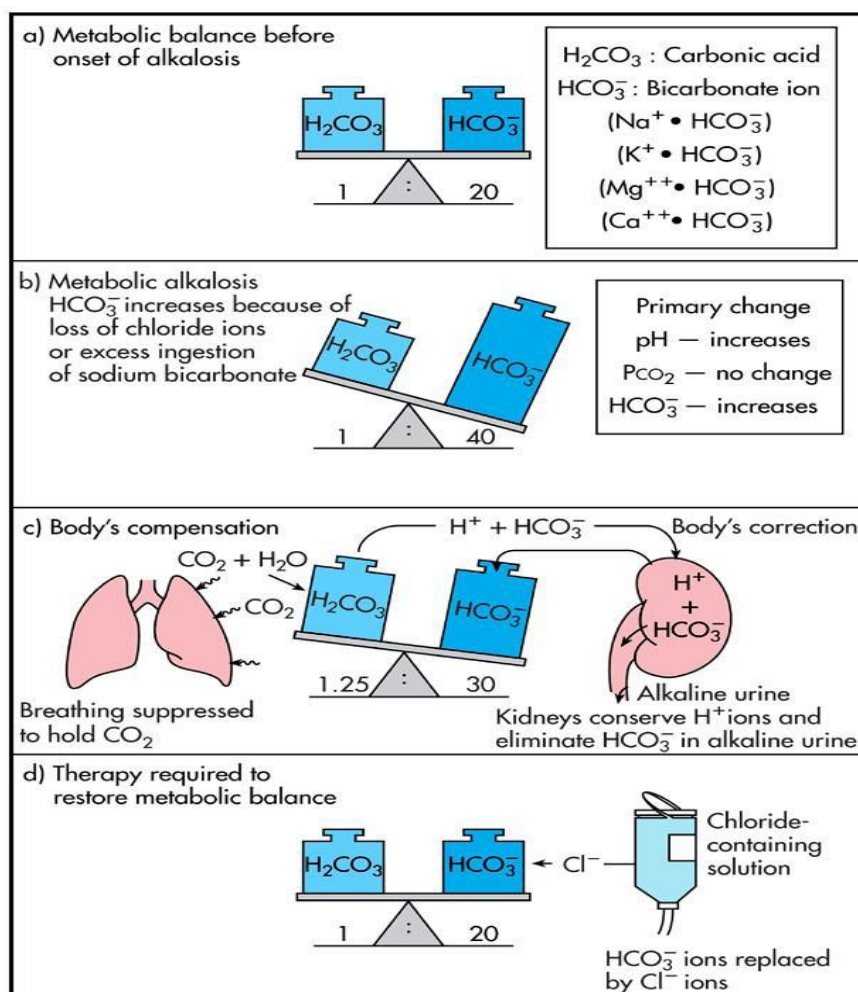
➤ Compensation for Metabolic Alkalosis :

- Correction
 - depress ventilation → increase blood PCO₂ → decrease pH back to normal value (limited by hypoxia)

- Alkalosis most commonly occurs with renal dysfunction, so can't count on kidneys
- Blood picture
 - pH = ~7.4
 - HCO_3^- = High
 - PCO_2 = High compensation

➤ Treatment of Metabolic Alkalosis

- Electrolytes to replace those lost
- IV chloride containing solution
- Treat underlying disorder



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❖ Example:

- A patient is in intensive care because he suffered a severe myocardial infarction 3 days ago. The lab reports the following values from an arterial blood sample:

–pH 7.3

–HCO₃⁻ = 20 mEq/ L (22 -26)

–pCO₂ = 32 mm Hg (35 -45)

- **Diagnosis :** Metabolic acidosis With compensation

Summary

- **Acidosis :**

pH	decrease	constant	decrease	constant
PCO ₃	increase	increase	constant	decrease
HCO ₃	constant	increase	decrease	decrease
Type	Respiratory	respiratory	metabolism	metabolism
correction	no	Yes metabolism	no	Yes respiratory

- **Alkalosis:**

pH	increase	constant	increase	constant
PCO ₃	decrease	decrease	constant	increase
HCO ₃	constant	decrease	increase	increase
Type	Respiratory	respiratory	metabolism	metabolism
correction	no	Yes metabolism	no	Yes respiratory