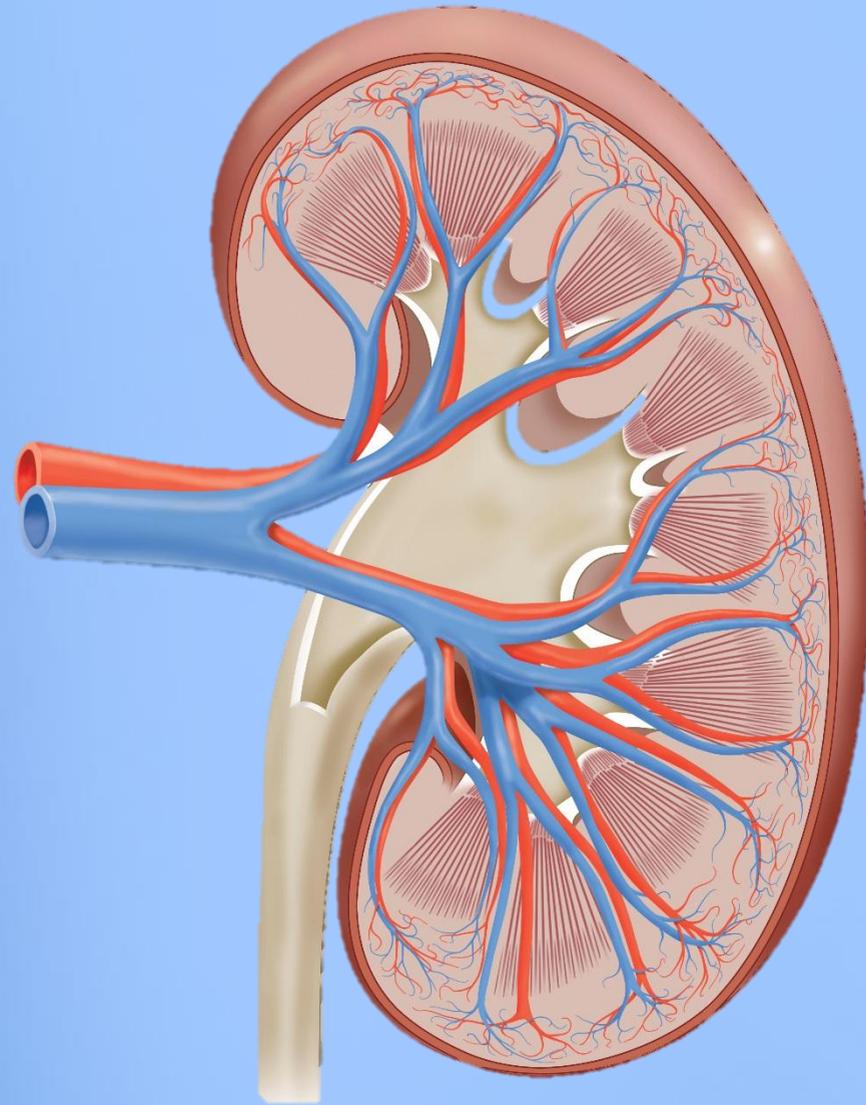


11

ACID-BASE DISORDERS



Renal Block

OBJECTIVES

- I. To explain the principles of blood gas and acid-base analysis.**
- II. To interpret blood gas analysis and diagnose various acid base disorders.**
- III. Describe causes of acid base disorders.**
- IV. Understand use of acid base nomograms.**

▪ $PCO_2 = 35-45$ mmHg

If the problem is in the PCO_2 , it is respiratory acidosis or alkalosis.

▪ $HCO_3^- = 22-26$ mEq/L

If the problem is in the HCO_3^- , it is metabolic acidosis or alkalosis.

Depending on the underlying problem the compensation mechanisms differ :

Respiratory problem



Kidney can bring



Metabolic compensation

Metabolic problem



Respiratory compensation
(hypo/hyperventilation)
+
Buffer system

Compensation: The body response to acid-base imbalance

Complete compensation: if the PH back into the normal limits.

Partial compensation: if the PH still outside the normal range.

ACID-BASE IMBALANCE: ACIDOSIS

Causes

A- Respiratory:

- **CNS depression** (anaesthesia).
- **Resp muscle paralysis/ diaphragm paralysis, rib fractures, etc..**
- **Obstructive lung diseases** e.g. Emphysema.
- **Pulmonary edema.**

B- Metabolic:

Bicarbonate deficit: blood conc. of HCO_3^- drops below 22mEq/L.

- **Diabetic ketoacidosis.**
- **Severe diarrhea.**(loss of HCO_3^-).
- **Hypoaldosteronism.**
- **Acute renal failure** (fail to excrete H^+).
- **Accumulation of acids.**

Compensation

Carbonic acid excess caused by blood levels of CO_2 above 45 mm Hg.

Kidneys eliminate hydrogen ion and retain bicarbonate ion.

Kidney also generates new bicarbonate.

Increased ventilation.

Renal excretion of hydrogen ions if possible.

K^+ exchanges with excess H^+ in ECF (H^+ into cells, K^+ out of cells).

ACID-BASE IMBALANCE: ALKALOSIS

Causes

A- Respiratory:

Carbonic acid deficit: $p\text{CO}_2$ is $<35\text{mmHg}$ (hypocapnea).

Most common acid-base imbalance.

- **Hyperventilation:**
- **High altitude** (Oxygen deficiency).
- **Hysterical.**
- **Anorexia nervosa.**
- **Early salicylate intoxication.**

B. Metabolic:

Blood conc. Of HCO_3 is $> 26\text{mEq/L}$.

- **Severe vomiting** = loss of stomach acid or heavy ingestion of antacids.
- **Severe dehydration.**
- **Excess antacids & alkaline drugs.**
- **Hyperaldosteronism.** (endocrine disorders).

compensation

Conditions that stimulate respiratory center and wash out CO_2 (Hyperventilation):

Kidneys conserve hydrogen ion.

Excrete bicarbonate ion.

Kidney excretes alkaline urine and retain H^+ .

Respiratory compensation difficult (hypoventilation limited by hypoxia).

Compensation

Respiratory Acidosis

- Kidneys eliminate hydrogen ion and retain bicarbonate ion.
- Kidney also generates new bicarbonate.

Respiratory Alkalosis

Kidneys conserve hydrogen ion
Excrete bicarbonate ion

Metabolic Acidosis

- Increased ventilation
- Renal excretion of hydrogen ions if possible
- K^+ exchanges with excess H^+ in ECF
- (H^+ into cells, K^+ out of cells)

Metabolic Alkalosis

- Kidney excretes alkaline urine and retain H^+
- Respiratory compensation difficult – hypoventilation limited by hypoxia

Effects of acidosis

- Principal effect of acidosis:
 - depression of the CNS through ↓ of synaptic transmission.
 - Generalized weakness.
 - Deranged CNS function the greatest threat.
- * Severe acidosis causes:
 - Disorientation.
 - Coma.
 - Death.

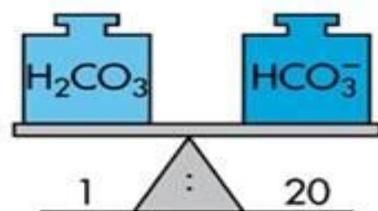
Effects of alkalosis

- Alkalosis causes over excitability of the central and peripheral nervous systems.
 - Numbness.
 - Lightheadedness.
 - It can cause :
 - Nervousness.
 - muscle spasms or tetany .
 - Convulsions .
 - Loss of consciousness.
 - Death.

*almost always the causes of acidosis or alkalosis are respiratory or metabolic.

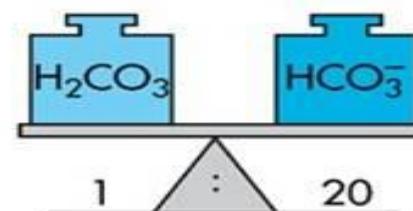
RESPIRATORY: ALKALOSIS AND ACIDOSIS

a) Metabolic balance before onset of acidosis



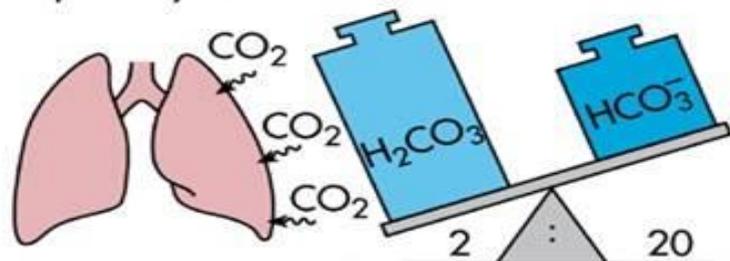
H_2CO_3 : Carbonic acid
 HCO_3^- : Bicarbonate ion
 ($Na^+ \cdot HCO_3^-$)
 ($K^+ \cdot HCO_3^-$)
 ($Mg^{++} \cdot HCO_3^-$)
 ($Ca^{++} \cdot HCO_3^-$)

a) Metabolic balance before onset of alkalosis



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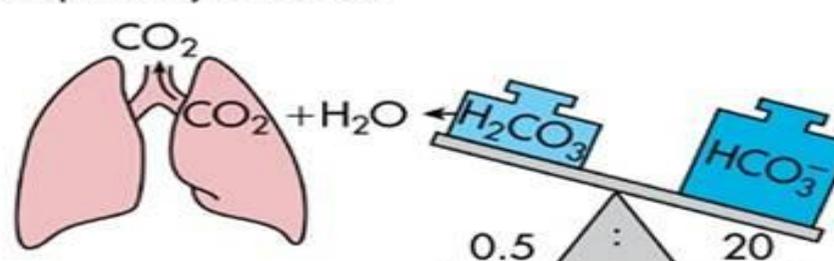
b) Respiratory acidosis



Primary change
 pH — decreases
 PCO_2 — increases
 HCO_3^- — no change

Breathing is suppressed, holding CO_2 in body

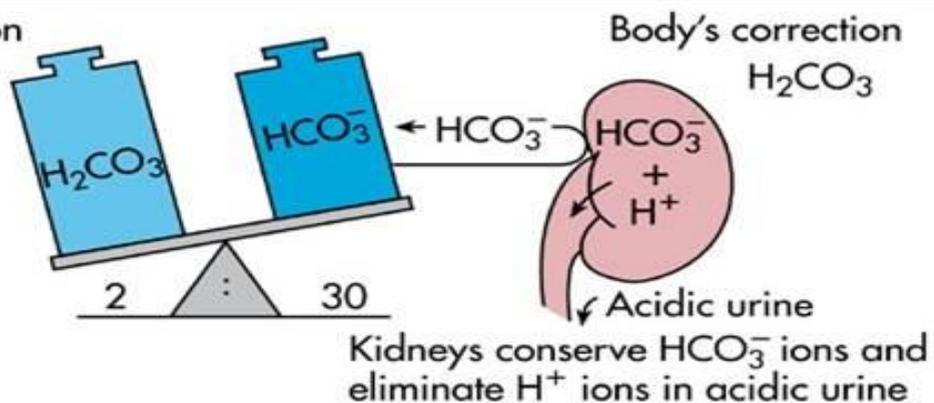
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Primary change
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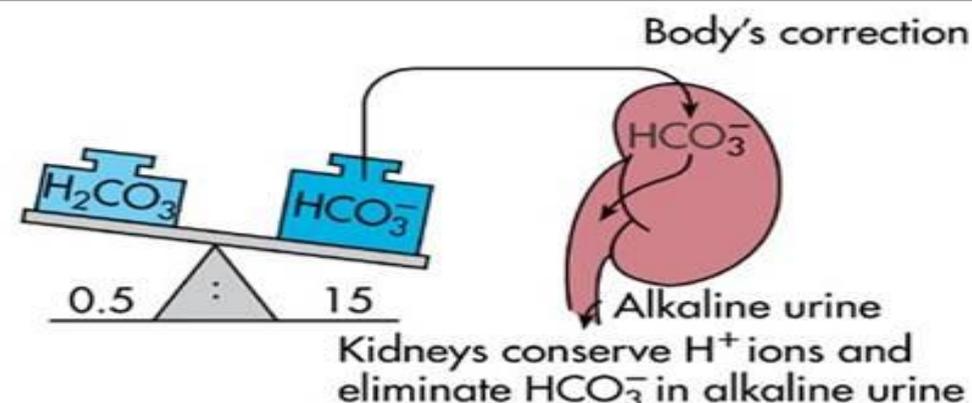
Hyperactive breathing "blows off" CO_2

c) Body's compensation



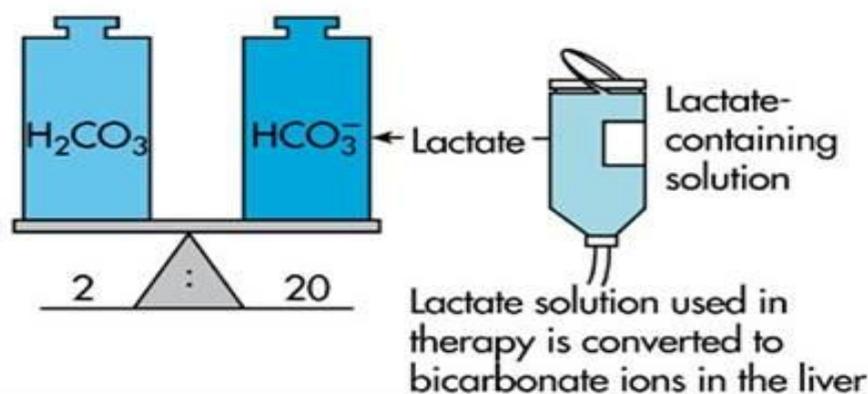
Kidneys conserve HCO_3^- ions and eliminate H^+ ions in acidic urine

c) Body's compensation



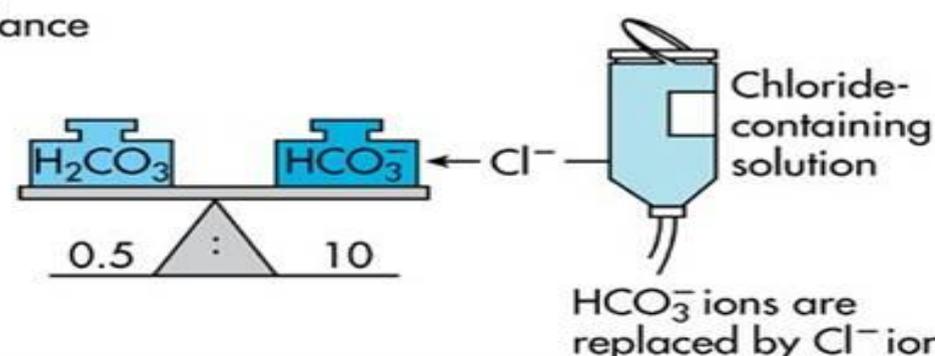
Kidneys conserve H^+ ions and eliminate HCO_3^- in alkaline urine

d) Therapy required to restore metabolic balance



Lactate solution used in therapy is converted to bicarbonate ions in the liver

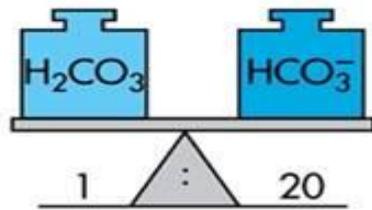
d) Therapy required to restore metabolic balance



HCO_3^- ions are replaced by Cl^- ions

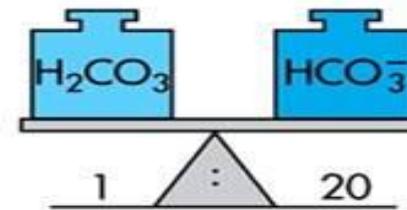
METABOLIC: ACIDOSIS AND ALKALOSIS

a) Metabolic balance before onset of acidosis



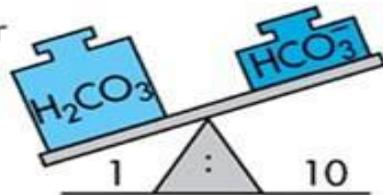
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a) Metabolic balance before onset of alkalosis



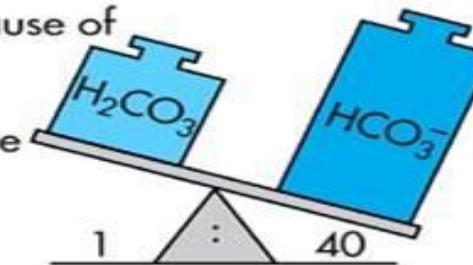
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 ($Mg^{++} \cdot HCO_3^-$)
 ($Ca^{++} \cdot HCO_3^-$)

b) Metabolic acidosis
 HCO_3^- decreases because of excess presence of ketones, chloride, or organic acid ions



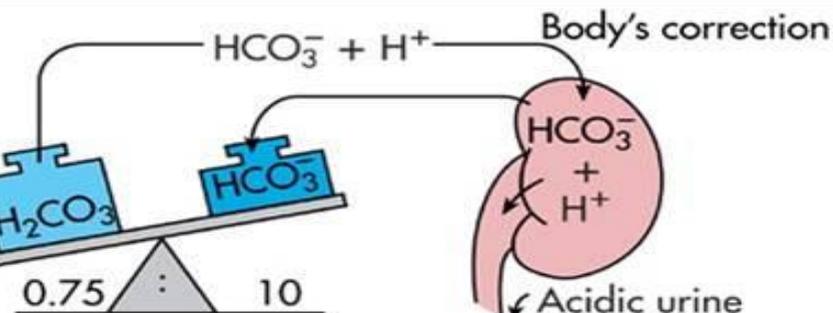
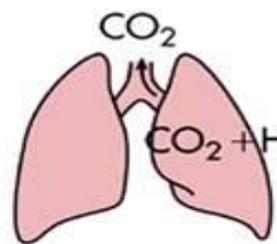
Primary change
 pH — decreases
 PCO_2 — no change
 HCO_3^- — decreases

b) Metabolic alkalosis
 HCO_3^- increases because of loss of chloride ions or excess ingestion of sodium bicarbonate



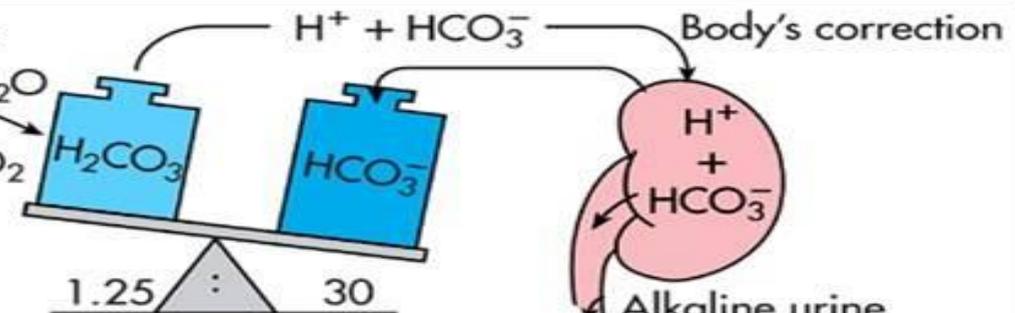
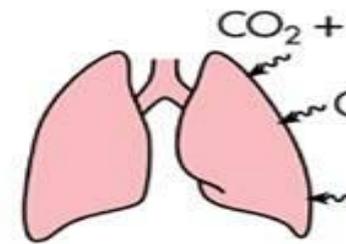
Primary change
 pH — increases
 PCO_2 — no change
 HCO_3^- — increases

c) Body's compensation



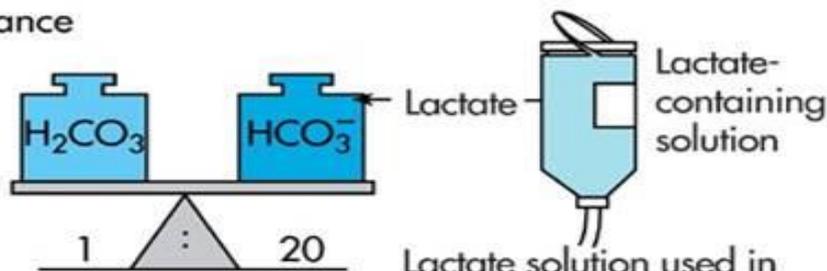
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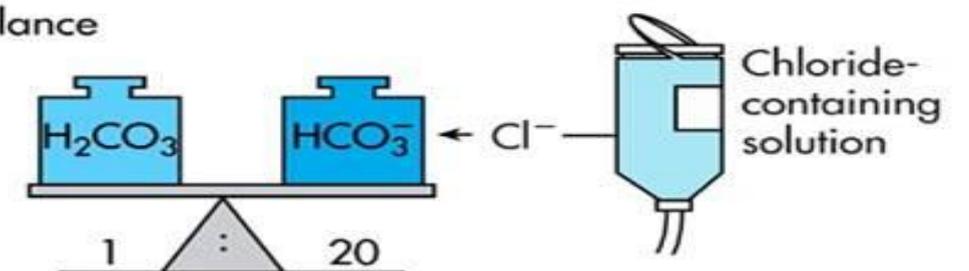
Kidneys conserve H^+ ions and eliminate HCO_3^- in alkaline urine

d) Therapy required to restore metabolic balance



Lactate solution used in therapy is converted to bicarbonate ions in the liver

d) Therapy required to restore metabolic balance



HCO_3^- ions replaced by Cl^- ions

Diagnosis of Acid-Base Imbalances :

- 1) Note whether the pH is low (acidosis) or high (alkalosis)
- 2) Decide which value, $p\text{CO}_2$ or HCO_3^- , is outside the normal range **and** could be the **cause** of the problem.

If the cause is a change in $p\text{CO}_2$, the problem is **respiratory**.

If the cause is HCO_3^- the problem is **metabolic**.

The change in PH :

If pH is normal (between 7.35-7.45) **Compenstaed**

If pH is abnormal (<7.35 or >7.45) **uncompenstated**.

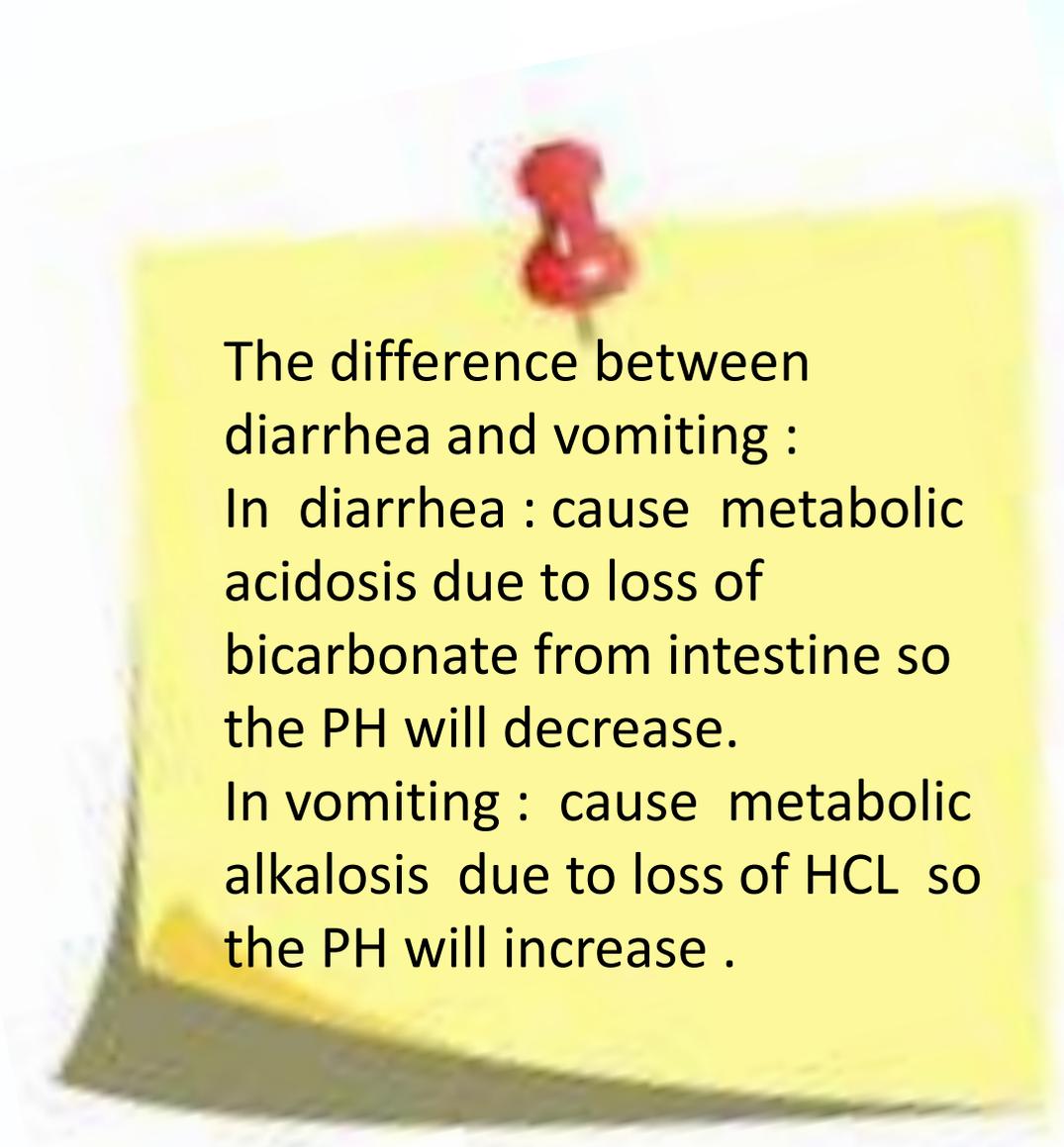
Is the cause Respiratory or metabolic?

If $\text{PCO}_2 > 45$ = Respiratory acidosis

If $\text{PCO}_2 < 35$ = Respiratory alkalosis

If $\text{HCO}_3^- < 22$ = Metabolic acidosis.

If $\text{HCO}_3^- > 26$ = metabolic alkalosis.



The difference between diarrhea and vomiting :

In diarrhea : cause metabolic acidosis due to loss of bicarbonate from intestine so the PH will decrease.

In vomiting : cause metabolic alkalosis due to loss of HCL so the PH will increase .

Example 1:

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 = 7.21, PCO₂ = 42, HCO₃⁻ = 12:

To answer it List the condition

First : : acidosis or alkalosis,

Second : metabolic or respiratory

Third : compensated or uncompensated?

The answer : Metabolic acidosis, uncompensated

Example 1:

A 50 year-old man with history of type 2 diabetes was admitted to the emergency department with history of polyuria. On examination he had rapid and deep breathing. Blood analysis showed glucose level of 400 mg/dl.

The following is the arterial blood analysis report of this patient:

pH = 7.1, PCO₂ = 40 mmHg and HCO₃⁻ = 18 mmol/L

The answer : Metabolic acidosis, uncompensated

Example 2 :

pH = 7.36, PCO₂ = 54, HCO₃⁻ = 32:

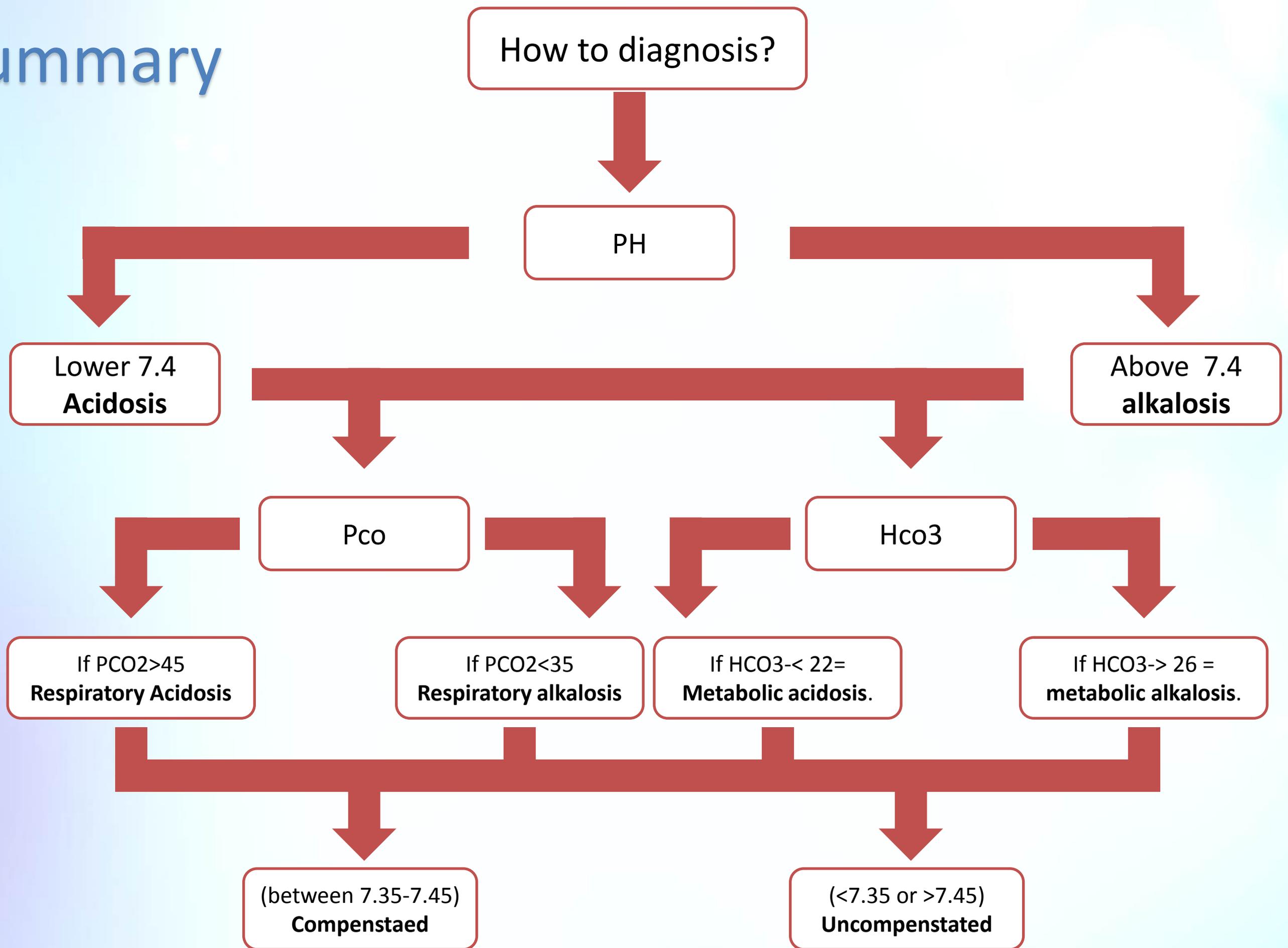
the answer : respiratory, acidosis, compensated

Example 3:

pH = 7.38, PCO₂ = 38, HCO₃⁻ = 25:

The answer : normal

Summary



MCQs

<p>Q1. which of the following cause acidosis?</p> <p>A. Hyperaldosteronism B. Sever vomiting C. Hyperventilation D. Sever diarrhea</p>	<p>Q3. A patient is seen in the emergency department with following blood value PH=7.8, HCO₃⁻ =29, PCO₂ =38 what is the acid-base disorder?</p> <p>A. Respiratory Acidosis B. Respiratory Alkalosis C. Metabolic Acidosis D. Metabolic Alkalosis</p>	<p>Ans : 1.D 2.A 3.D 4.B</p>
<p>Q2. How the kidney compensate alkalosis ?</p> <p>A. The kidney conserves H⁺ And excretes CHO⁻ B. K⁺ exchanges with excess H⁺ in ECF C. Hyperventilation D. A+C</p>	<p>Q4. In the conversion from acute to chronic respiratory alkalosis, what happen to blood PH ?</p> <p>A. Increase B. Decrease to normal C. Severe decreasing D. Constant</p>	

Questions

<p>Q1. How does the kidney compensate of respiratory acidosis? Kidney will eliminate H⁺ ions and retain HCO₃⁻ ions , also generates new HCO₃⁻</p>	<p>Q3. What is “ Anorexia nervosa” ? An emotional disorder characterized by an obsessive desire to loose weight by refusing to eat , so it will cause alkalosis.</p>
<p>Q2. what is the difference between vomiting and diarrhea an acid-base imbalance ? Vomiting : is combined with excessive loose of acid . Diarrhea : is combined with low absorption of HCO₃⁻ due to high flow fluid go out .</p>	<p>Q4. a patient is in ER because she travels to high Altitude for 5hrs . The report as following . PH=7.49 PCO₂=25 PHCO₃=21 What is the diagnosis ? Respiratory alkalosis uncompensated</p>