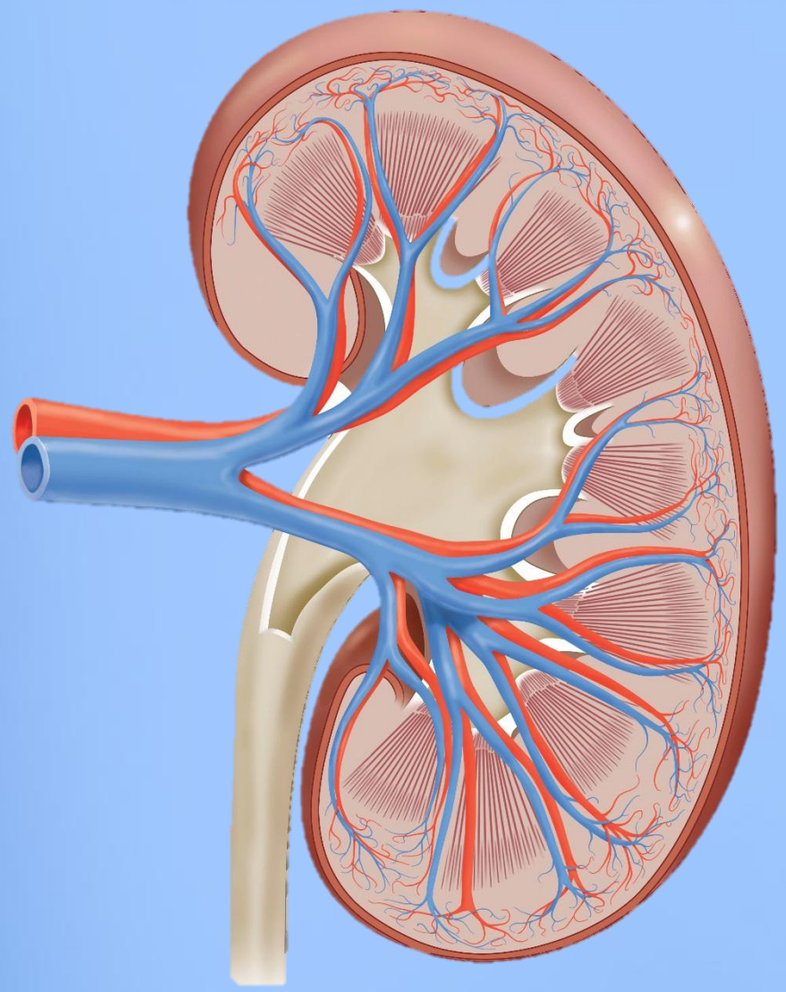
11

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.

- **PCO2= 35-45 mmHg**

If the problem in the *PCO2*, it is respiratory acidosis or alkalosis.

- **HCO3- = 22-26 mEq/L**

If the problem in the *HCO3*, it is metabolic acidosis or alkalosis.

Depending on the underlying problem the compensation mechanisms differ :

Respiratory problem

Kidney can brings

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 HCO3- drops below 22mEq/L.

- **Diabetic ketoacidosis.**
- **Severe diarrahea**.(loss of HCO3).
- **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: pCO_2 is <35mmHg (hypocapnea).

Most common acid-base imbalance.

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

B. Metabolic:

Blood conc. Of HCO3 is > 26mEq/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 CO2 (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

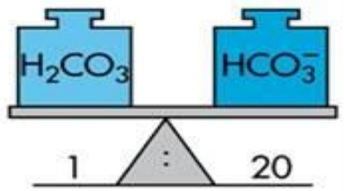
- Kidney excretes alkaline urine and retain H+
- Respiratory compensation difficult – hypoventilation limited by hypoxia

Effects of acidosis	Effects of alkalosis
• 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.	• 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
$(Na^+ \bullet HCO_3^-)$
$(K^+ \bullet HCO_3^-)$
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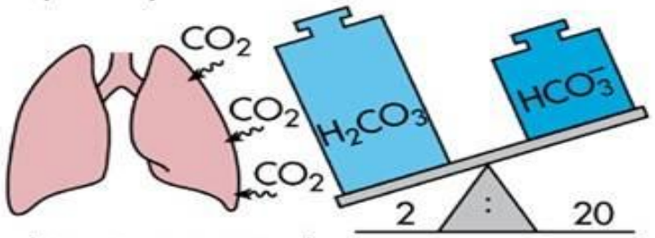
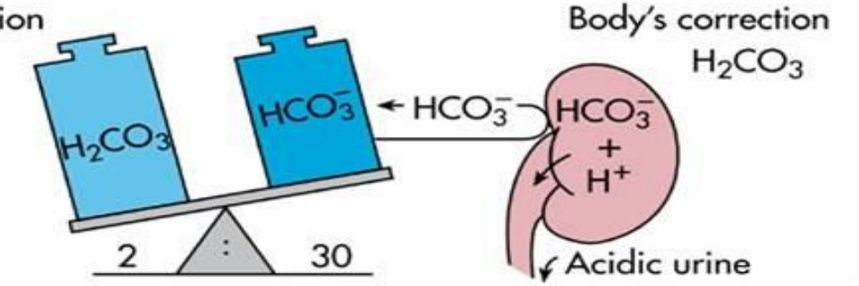
b) Respiratory acidosis



Breathing is suppressed, holding CO_2 in body

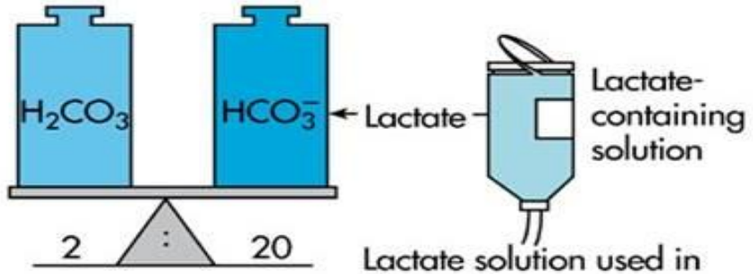
Primary change
pH — decreases
P_{CO_2} — increases
HCO_3^- — no change

c) Body's compensation



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

d) Therapy required to restore metabolic balance



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

From Thibodeau GA, Patton KT: *Anatomy & physiology,* ed 5, St Louis, 2003, Mosby.

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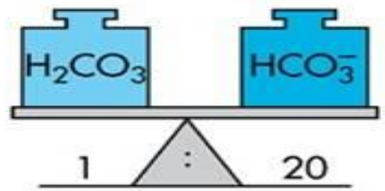

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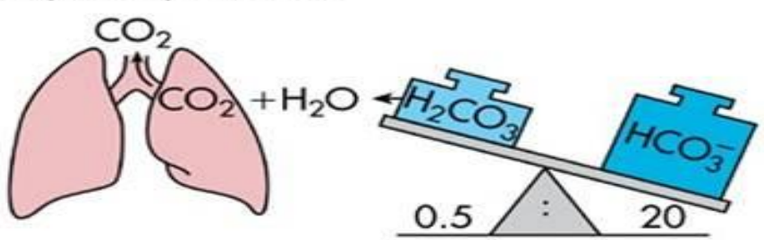
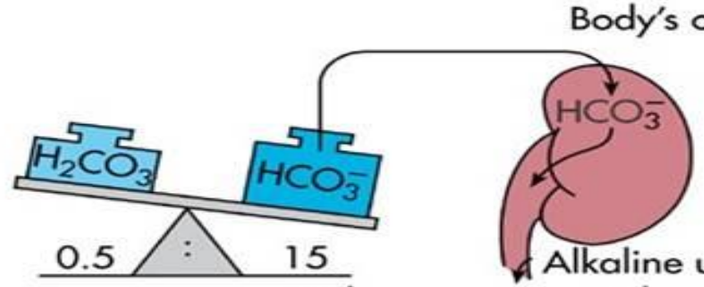


Hyperactive breathing "blows off" CO_2

Primary change
pH — increases
P_{CO_2} — decreases
HCO_3^- — no change

c) Body's compensation



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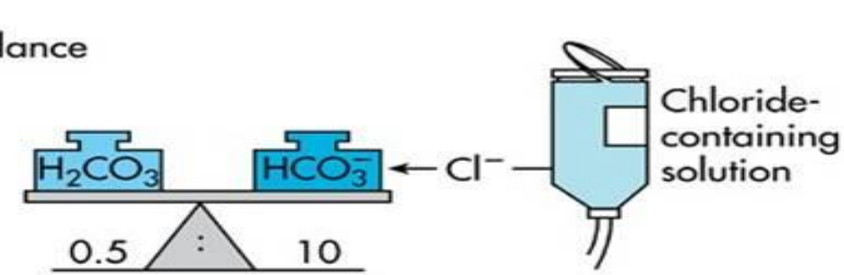

HCO_3^- ions are replaced by Cl^- ions

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METABOLIC: ACIDOSIS AND ALKALOSIS

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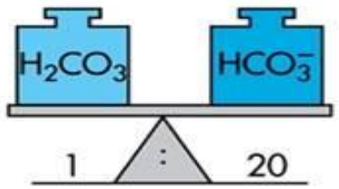

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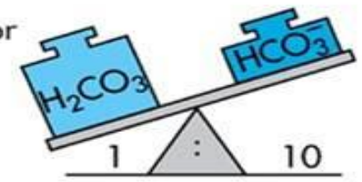
b) Metabolic acidosis
HCO_3^- decreases because of excess presence of ketones, chloride, or organic acid ions



Primary change
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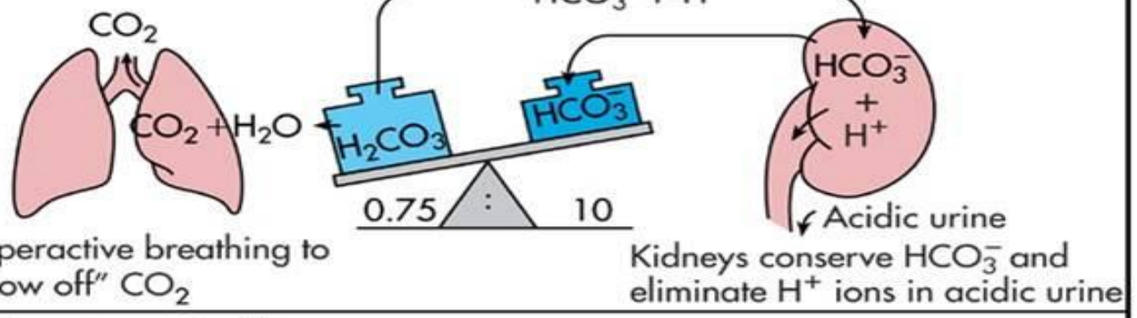
P_{CO_2} — no change
HCO_3^- — decreases

c) Body's compensation



Hyperactive breathing to "blow off" CO_2

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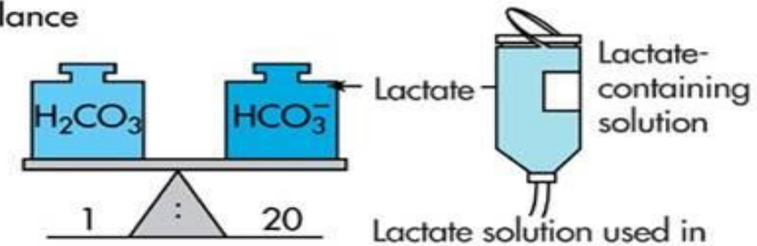

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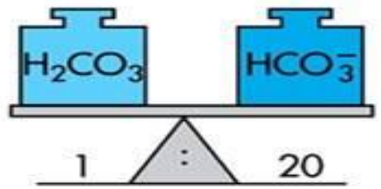

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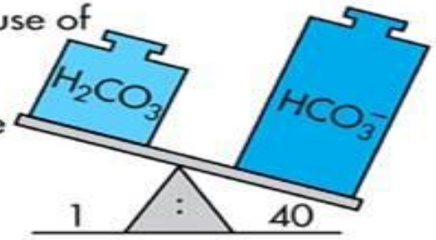
b) Metabolic alkalosis
HCO_3^- increases because of loss of chloride ions or excess ingestion of sodium bicarbonate



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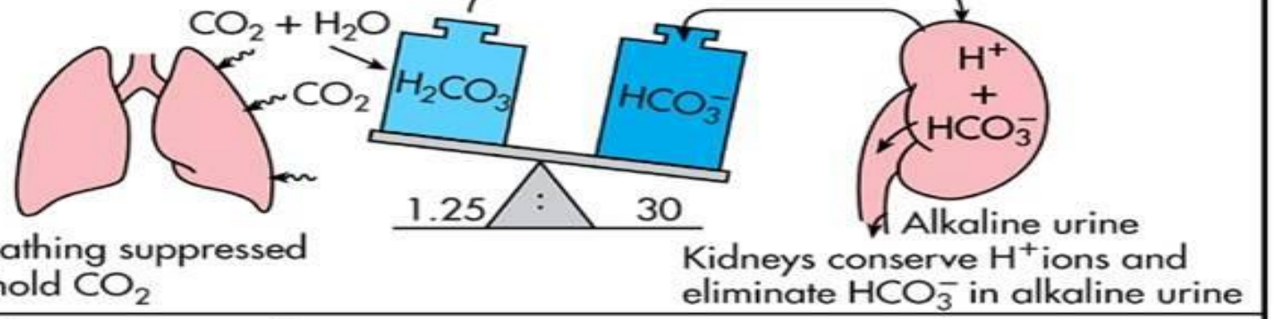
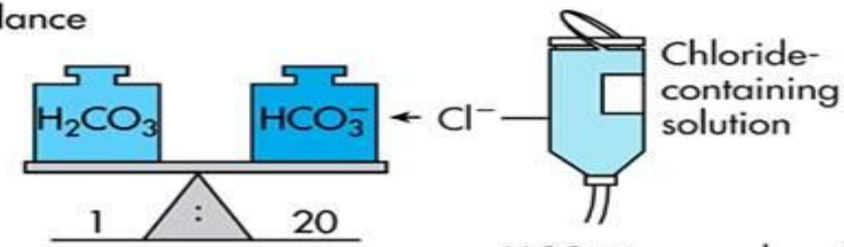


Breathing suppressed to hold CO_2

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

d) Therapy required to restore metabolic balance



HCO_3^- ions replaced by Cl^- ions

From Thibodeau GA, Patton KT: *Anatomy & physiology,* ed 5, St Louis, 2003, Mosby.

Diagnosis of Acid-Base Imbalances :

1) Note whether the pH is low (acidosis) or high (alkalosis)
2) Decide which value, pCO_2 or HCO_3^- , is outside the normal range **and** could be the **cause** of the problem.
If the cause is a change in $\underline{pCO_2}$, the problem is respiratory.
If the cause is $\underline{HCO_3^-}$ 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 PCO2>45 = Respiratory acidosis
If PCO2<35= Respiratory alkalosis
If HCO3-< 22= Metabolic acidosis.
If HCO3-> 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:

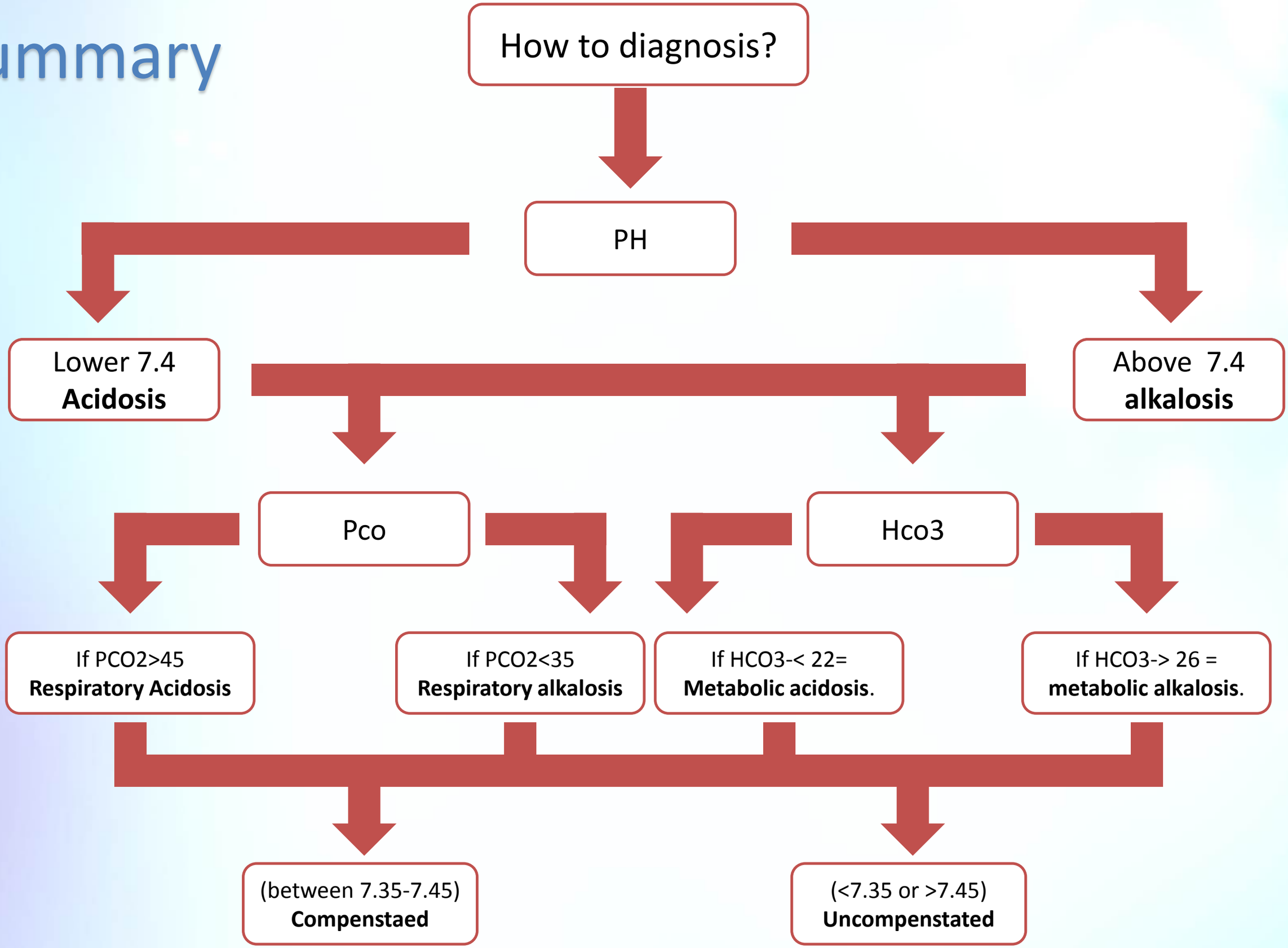
the answer : respiratory, acidosis, compensated

Example 3:

pH =7.38, PCO2= 38, HCO3- = 25:

The answer : normal

Summary


How to diagnosis?
PH
Lower 7.4
Acidosis
Above 7.4
alkalosis
Pco
Hco3
If PCO2>45
Respiratory Acidosis
If PCO2<35
Respiratory alkalosis
If HCO3-< 22=
Metabolic acidosis.
If HCO3-> 26 =
metabolic alkalosis.
(between 7.35-7.45)
Compenstaed
(<7.35 or >7.45)
Uncompenstated

MCQs

Q1.which of the following cause acidosis? A. Hyperaldosteronism B. Sever vomiting C. Hyperventilation D. Sever diarrhea	**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?** A. Respiratory Acidosis B. Respiratory Alkalosis C. Metabolic Acidosis D. Metabolic Alkalosis	**Ans : 1.D 2.A 3.D 4.B**
Q2.How the kidney compensate alkalosis ? A. The kidney conserves H+ And excretes CHO- B. K+ exchanges with excess H+ in ECF C. Hyperventilation D. A+C	**Q4.In the conversion from acute to chronic respiratory alkalosis, what happen to blood PH ?** A. Increase B. Decrease to normal C. Severe decreasing D. Constant	

Questions

Q1.How does the kidney compensate of respiratory acidosis? Kidney will eliminate H+ ions and retain HCO3- ions , also generates new HCO3-	**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.
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 .	**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