

Acid base balance

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Acid base balance

Definition of PH (7.36-7.44)

Acidosis

Alkalosis

Buffer systems: Is a weak acid or base and salt of that acid or base.



Main extracellular buffer is Bicarbonate 65%.

Main intracellular buffer is Proteins 30% Bone, and Phosphates

Acid base balance

Acids

Are molecules that have the ability to **Release H⁺** ions

Fixed acids

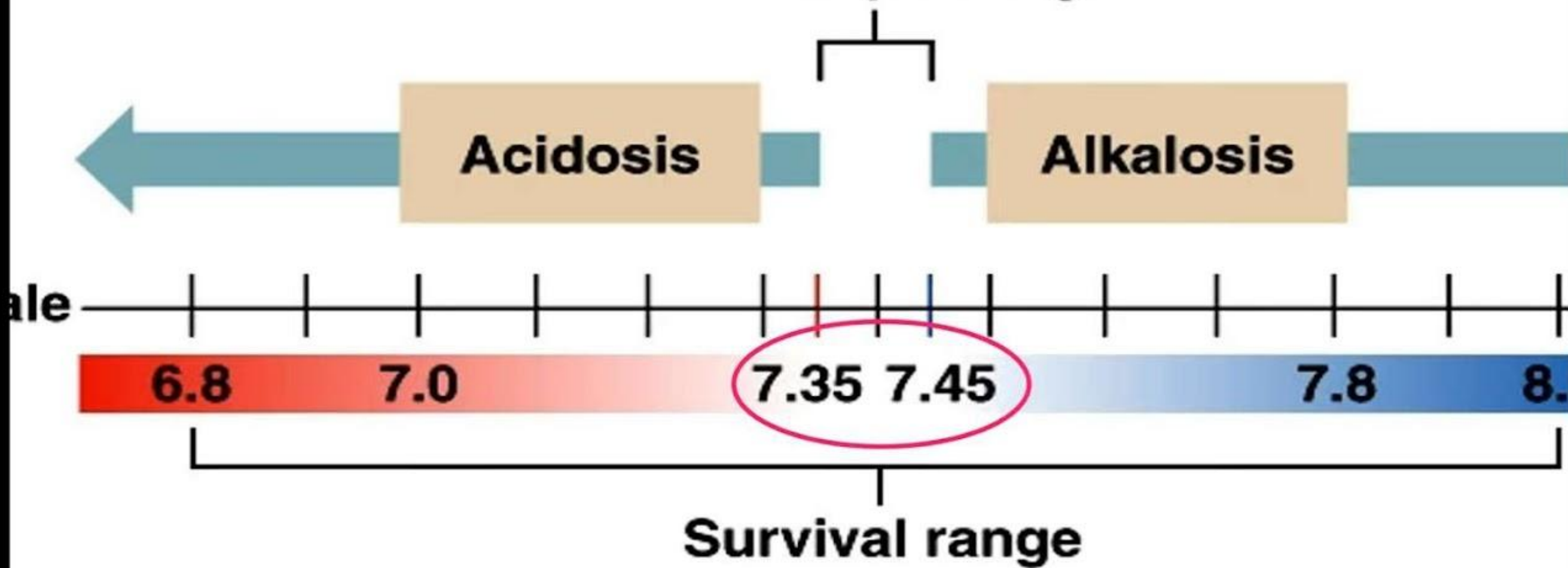
Volatile acids

Bases

Are molecules that have the ability to accept **or Bind with H⁺**
ions.

pH of arterial blood

Normal pH range



BICARBONATE BUFFER SYSTEM



Addition of lactic acid

Exercise

vomiting

Loss of HCl

Continue



Lung control CO₂ level

Kidney control HCO₃ level through.

- ◆ Reabsorption of HCO₃ Proximal renal tubules .
- ◆ Generation of HCO₃ Distal renal tubules .

How does lung control CO_2 level?

Shifting the equation to left .

Medullary ,Carotid body Chemoreceptors stimulate respiration .

CO_2 diffuse 20 times faster than O_2 .

Acid base regulation

Maintenance of acceptable range of PH in ECF is accomplished by Three mechanisms.

Chemical buffers

React Very Rapidly Seconds to minutes.

Respiratory regulations

Reacts Rapidly minutes to hours .

Renal regulations

Reacts Slowly Hours to days.

**First line of
defense against
pH shift**

**Chemical
buffer system**

**Bicarbonate
buffer system**

**Phosphate
buffer system**

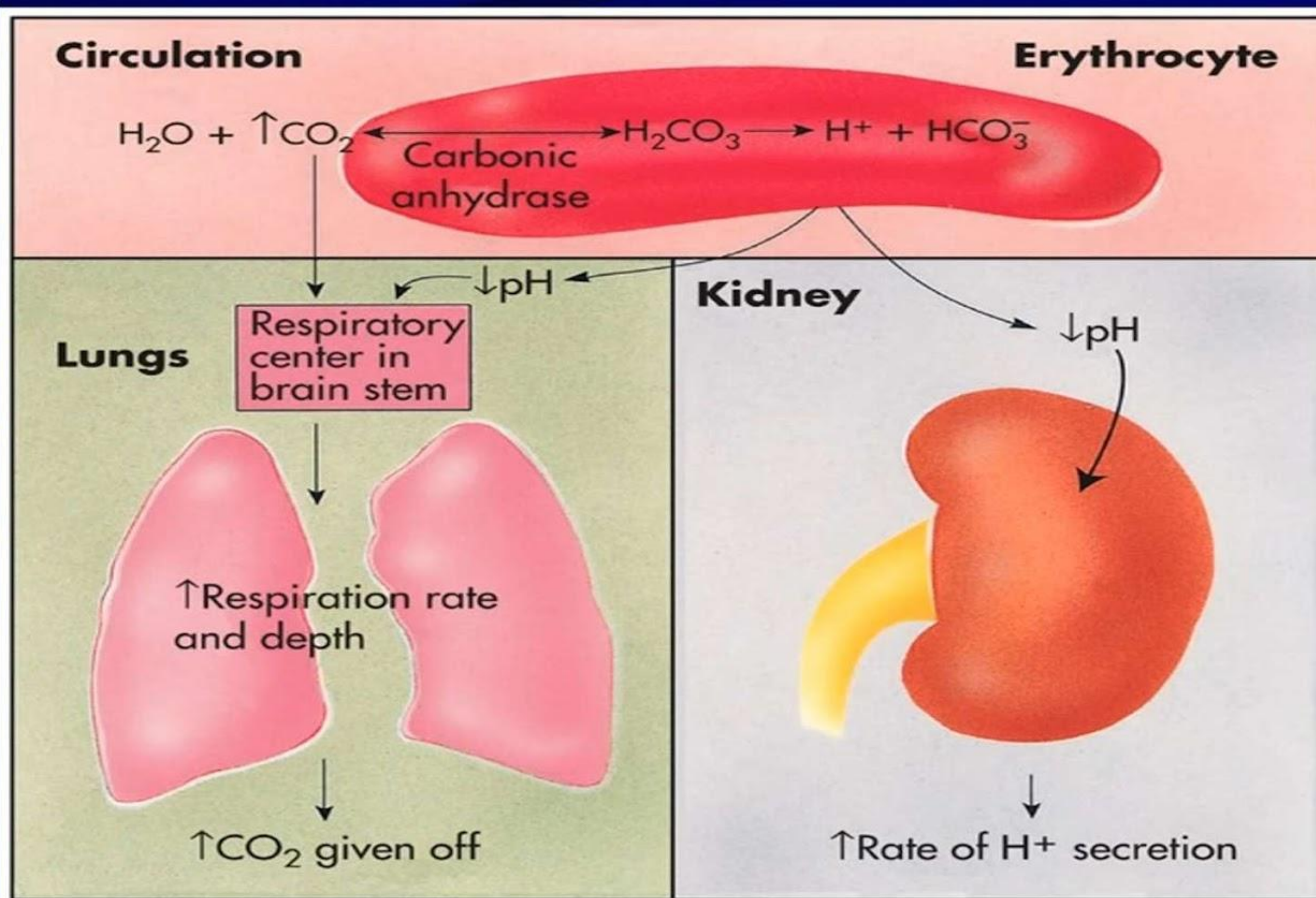
**Protein
buffer system**

**Second line of
defense against
pH shift**

**Physiological
buffers**

**Respiratory
mechanism
(CO₂ excretion)**

**Renal
mechanism
(H⁺ excretion)**

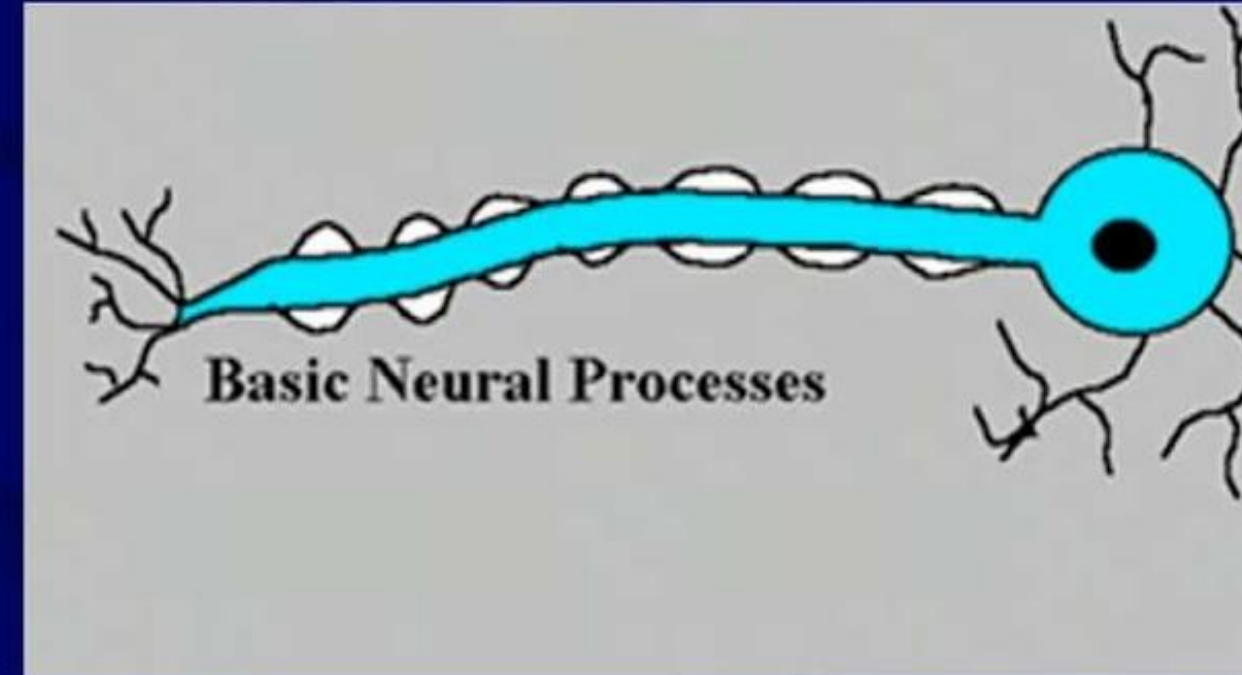


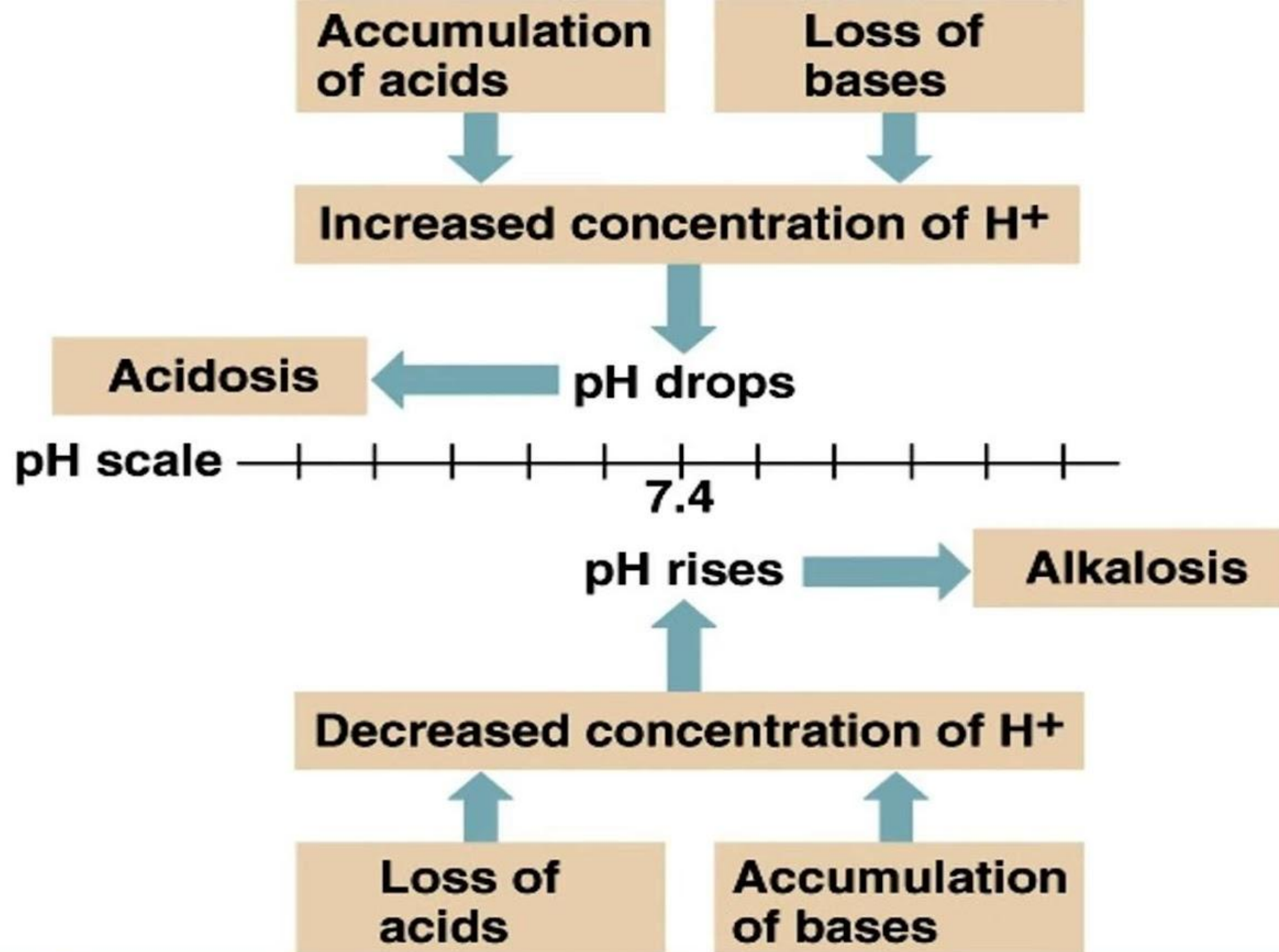
From Thibodeau GA, Patton KT: *Anatomy & physiology*, ed 5, St Louis, 2003, Mosby.

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Acidosis/alkalosis

- PH changes has dramatic effects on cell functions.
- Change in excitability of nerve and muscle cell.
- Influence enzyme activity.
- Influence K^+ levels .





Henderson-Hasselbach equation

$$\text{pH} = \text{pK} + \log \frac{\text{BHCO}_3}{\text{H}_2\text{CO}_3} = \frac{24\text{mEq/L}}{1.2\text{mEq/L}} = \frac{20}{1} = 7.4$$

The pH is Dictated by Ratio of HCO_3 to CO_2 .

If ratio is 20 :1 PH is 7.4.

Increase HCO_3 increase CO_2 to keep ratio constant.



H_2CO_3 : Carbonic Acid

HCO_3^- : Bicarbonate Ion

$(\text{Na}^+) \text{HCO}_3^-$

$(\text{K}^+) \text{HCO}_3^-$

$(\text{Mg}^{++}) \text{HCO}_3^-$

$(\text{Ca}^{++}) \text{HCO}_3^-$

-metabolic balance before onset of acidosis

-pH 7.4

Respiratory Control Mechanisms:

Works Within Minutes to control pH : maximal in 12-24 hours.

Only about 50-75% effective in returning pH to normal .

Excess CO_2 & H^+ in the blood act directly on respiratory centers in the brain, carotid body .

CO_2 readily crosses blood-brain barrier reacting w/ H_2O to form H_2CO_3 .

H_2CO_3 splits into H^+ & HCO_3^- & the H^+ stimulates an increase or decrease in respirations.

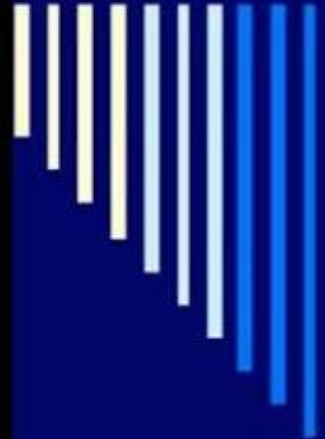
Renal control mechanisms

Don't work as fast as respiratory mechanisms , functions for Days to restore PH to normal level .

Regulate PH through exerting Acidic or Alkaline urine , excreting excess H^+ , and Regeneration and Reabsorption of HCO_3 .

Excreting acidic urine decrease acidity of EC fluid, excreting alkaline urine remove base .





Normal Arterial Blood Gas (ABG) Lab Values:

- Arterial pH: 7.35 – 7.45
- HCO_3^- : 22 – 26 mEq/L
- PaCO_2 : 35 – 45 mmHg
- TCO_2 : 23 – 27 mmol/L
- PaO_2 : 80 – 100 mmHg
- SaO_2 : 95% or greater (pulse ox)
- Base Excess: -2 to +2
- Anion Gap: 7 – 14

ACIDOSIS / ALKALOSIS

Acidosis and Alkalosis are categorized as Metabolic or respiratory depending on their Primary Cause .

■ Metabolic Acidosis and Metabolic Alkalosis

Caused by an imbalance in the production and excretion of Acids or Bases by the Kidneys .

■ Respiratory Acidosis and Respiratory Alkalosis

Caused primarily by Lung or breathing disorders.

NB : 90% of ICU patients has Acid base disturbance

Disorders of Acid-Base Metabolism

Is due to lack of balance between rate

Production of acid and base .

Body ability to compensate.

E: **Rapid rate of production of acid or base , or defect in physiological compensatory mechanisms.**

Metabolic acidosis

uses

Increase acid production

Exogenous acids

Shock (lactic acid).

Diabetes (keto acids).

Renal failure (Sulfuric, Phosphoric acid) .

Endogenous acids

Methanol , Ethyl alcohol.

Increase alkali excretion(GIT-Kidney)

Diarrhea, small bowel, pancreatic fistula.

Uretero – sigmoidostomy.

Renal tubular acidosis .

What is the most common cause M A in surgical patients?

- Shock & Sepsis → Decrease tissue perfusion →
lactic Acidosis → Anaerobic metabolism →
wide anion gap.
- Severe anemia.
- Severe hypoxemia.

What is anion gap(AG)

Definition

AG is the Difference between measured Cations and measured Anions.

$$AG = Na - (Cl^- + HCO_3^-) = 8 \pm 4 \text{ MEQ / L}$$

Increase acid production increase AG.

Increase alkali loss normal AG.

VB : Hypo albuminemia Reduce AG

Each 1 gm decrease albumin decrease gap by 2.5.

Na ⁺	Cl ⁻
	HCO ₃ ⁻
	AG

Anion gap metabolic acidosis

- Methanol
- Uremia
- Diabetic ketoacidosis
- Propylene glycol
- Isoniazid
- Lactic acid
- Ethylene glycol
- Rhabdomyolysis
- Salicylates

Non anion gap metabolic acidosis

Fistula (pancreatic).

Uretro - enterostomy.

Saline administration.

Endocrine (hyperparathyroidism).

Diarrhea.

Carbonic anhydrase inhibitors.

Ammonium chloride

Renal tubular acidosis

Spironolactone

Symptoms

Lethargy , headache.

Deep rapid breathing Kussmaul's breathing.

Cardiac arrhythmias , Decrease CO.

Depression of CNS , Coma.

eatment

Treat the Cause .

In severe cases give NaHCO_3 .



PH less than 7.2

Hco_3 less than 12

EFFECTS OF pH

♥ The most general effect of pH changes are on enzyme function

♠ Also affect excitability of nerve and muscle cells

↓ pH ↓ Excitability

↑ pH ↑ Excitability

0.3X Wt x Base Deficit

$$0.3 \times 70 \times 10 = 210 \text{mEq/l NaHCO}_3$$

Give half over 20 minute, rest over 4 h

$$8.4 \% \text{NaHco}_3 \quad 1\text{ml} = 1\text{mmol}$$

$$4.2 \% \text{NaHco}_3 \quad 1\text{ml} = 1/2 \text{ mmol}$$

$$0.6 \times \text{Wt} \times (15 - \text{plasma HCO}_3)$$

What is compensated MA

- Look for $paco_2$ $\longrightarrow$ expected pco_2 $\longrightarrow$

$$\underline{1.5 \times HCO_3 + 8}$$

Yes compensated MA.

No added Respiratory Acidosis.

Metabolic alkalosis

- **Loss of acid from GIT, or Kidney
(Vomiting, Over diuresis , Ascites)**
- **Diuretic therapy**
- **Excessive alkali Administration**
- **Massive blood transfusion**
- **Severe K depletion**
- **Mineralocorticoid excess**



**Chloride
Sensitive**



**Chloride
Resistance**

Patient with alkalosis is always K Deficit

K move into cell

K is lost in urine

So always give potassium

Urine should be adequate first.

Symptoms

Increase neuromuscular excitability , parathesia.

Carmo - pedal spasm.

Keynes-stokes breathing with period of apnea 5-30 s

Arrhythmias.

Muscle weakness paralytic ileuas.

Decrease cerebral blood flow confusion.

What is paradoxical aciduria ?

Early in pyloric obstruction patient is losing acid, kidney excrete HCO_3 , so urine is alkaline.

Later, volume depletion, Hypokalemia, lead increase K Reabsorption and H secretion leading to paradoxical aciduria .

Treatment of metabolic alkalosis

Most of alkalosis is *Volume Responsive*.

Treatment by volume expansion by NaCl

Add KCl

$PaCO_2$ in metabolic alkalosis is $0.7 \times HCO_3 + 40$

Respiratory acidosis

Retention of CO₂ ↓ (alveolar ventilation).

Air way obstruction, pneumonia, pleural effusion, fracture rib
asthma.

Depression of respiratory center (Morphine -CNS injury)

Upper abdominal incisions.

Tense ascites, distension.

Large PE, fever.

Myopathy.

Symptoms of respiratory acidosis?

CO₂ NARCOSIS

- Headache , blurred vision.
- Anxiety , restless , tremors.
- Coma.

RESPIRATORY ACIDOSIS

• Decreased CO_2 removal can be the result of:

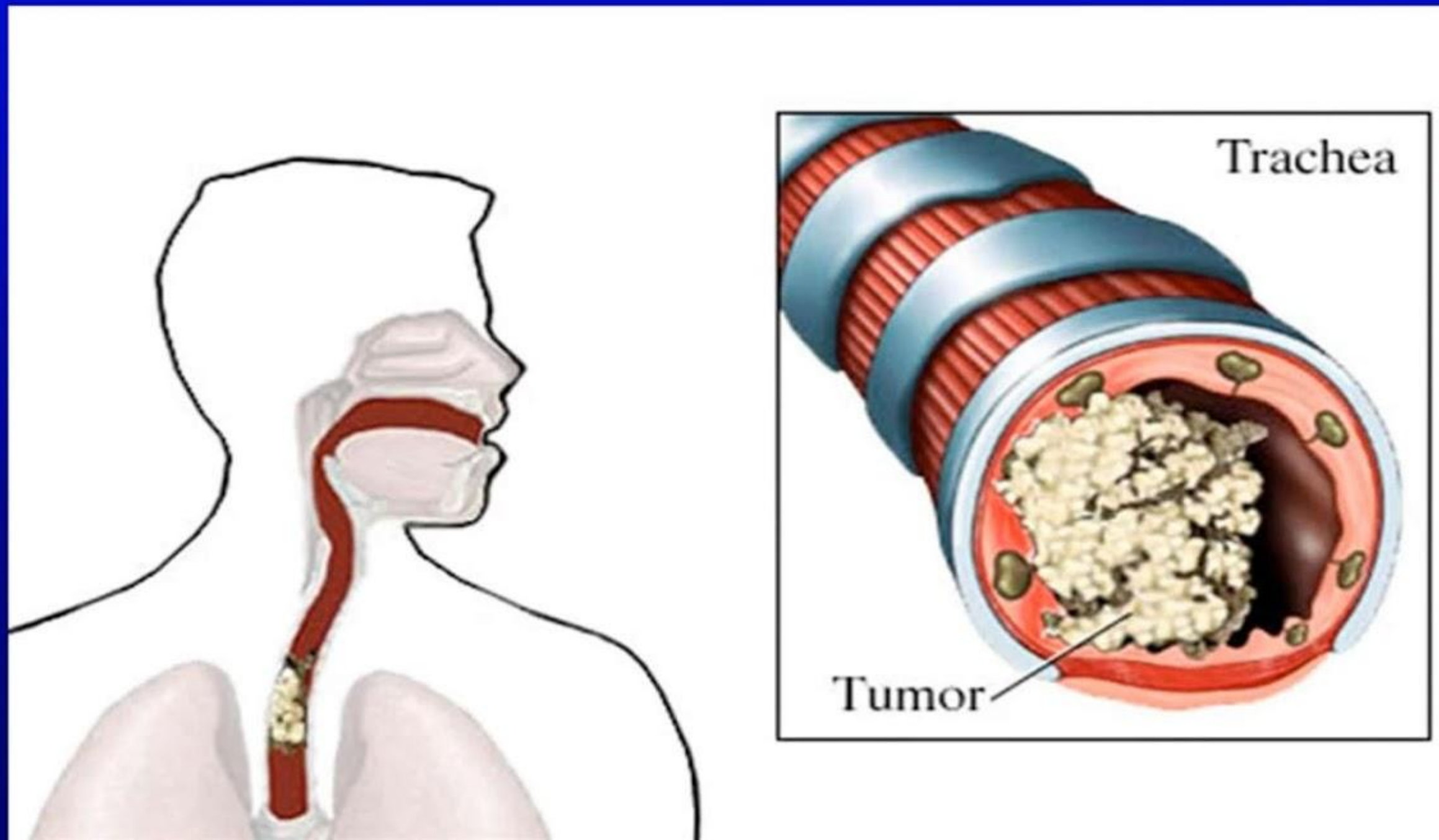
- 1) Obstruction of air passages
- 2) Decreased respiration (depression of respiratory centers)
- 3) Decreased gas exchange between pulmonary capillaries and air sacs of lungs
- 4) Collapse of lung



RESPIRATORY ACIDOSIS

♥ 1) Obstruction of air passages

♠ Vomit, anaphylaxis, tracheal cancer



RESPIRATORY ACIDOSIS

♥ 2) Decreased Respiration

- ♠ Shallow, slow breathing

- ♠ Depression of the respiratory centers in the brain which control breathing rates

 - ♦ Drug overdose



RESPIRATORY ACIDOSIS

♥ 3) Decreased gas exchange between pulmonary capillaries and air sacs of lungs

♠ Emphysema

♠ Bronchitis

♠ Pulmonary edema



RESPIRATORY ACIDOSIS

♥ 4) Collapse of lung

♠ Compression injury, open thoracic wound

Left lung
collapsed



Respiratory alkalosis

Hyperventilation

- **Fever, pain , sepsis.**
- **Assisted ventilation.**
- **Head injury.**
- **Respiratory center lesion stroke, tumor**
- **Hysterical.**
- **Salicylate poisoning.**
- **Hypoxia, hypotension high altitude.**
- **Pulmonary embolism.**