



Acid-Base Balance

Medical bioChemistry
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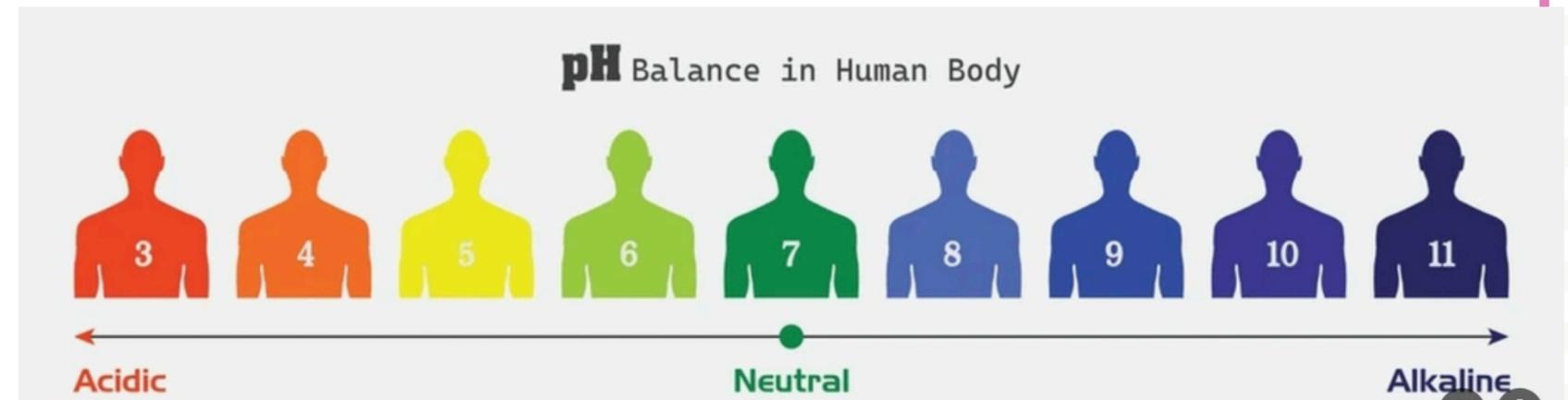
Importance

Maintaining normal body pH is essential for life.

It affects:

- enzyme activity
- oxygen delivery by hemoglobin
- nerve and muscle function
- metabolic reactions

Even small deviations in pH can be life-threatening.



Definitions of Acid, Base & Salt

Acid: substance that donates H^+ ions

Examples: carbonic acid, lactic acid

Base: accepts H^+ or releases OH^-

Examples: bicarbonate, ammonia

Salt: formed from neutralization reaction

Examples: sodium chloride, potassium chloride

Concept of pH

pH expresses hydrogen ion concentration.

$$\text{pH} = -\log [\text{H}^+]$$

- Low pH → high acidity
- High pH → alkalinity

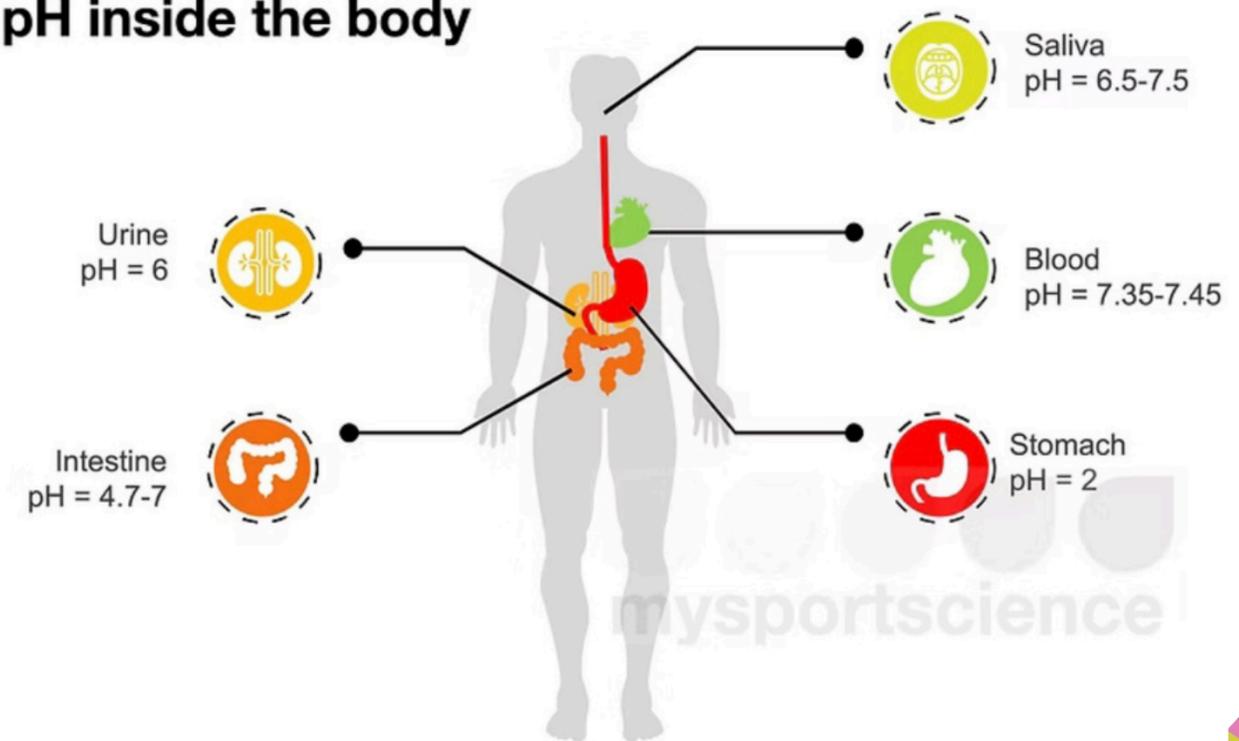
Normal blood pH:

- ✓ 7.35 – 7.45

Acidemia < 7.35

Alkalemia > 7.45

pH inside the body



Buffers & Henderson-Hasselbalch

A buffer = weak acid + conjugate base.

Function:

resists sudden pH changes
effective at $\text{pH} \approx \text{pKa}$

Henderson-Hasselbalch equation:

$$\text{pH} = \text{pKa} + \log \left(\frac{\text{HCO}_3^-}{\text{CO}_2} \right)$$

Very important in clinical interpretation of blood gases.

Bicarbonate Buffer System

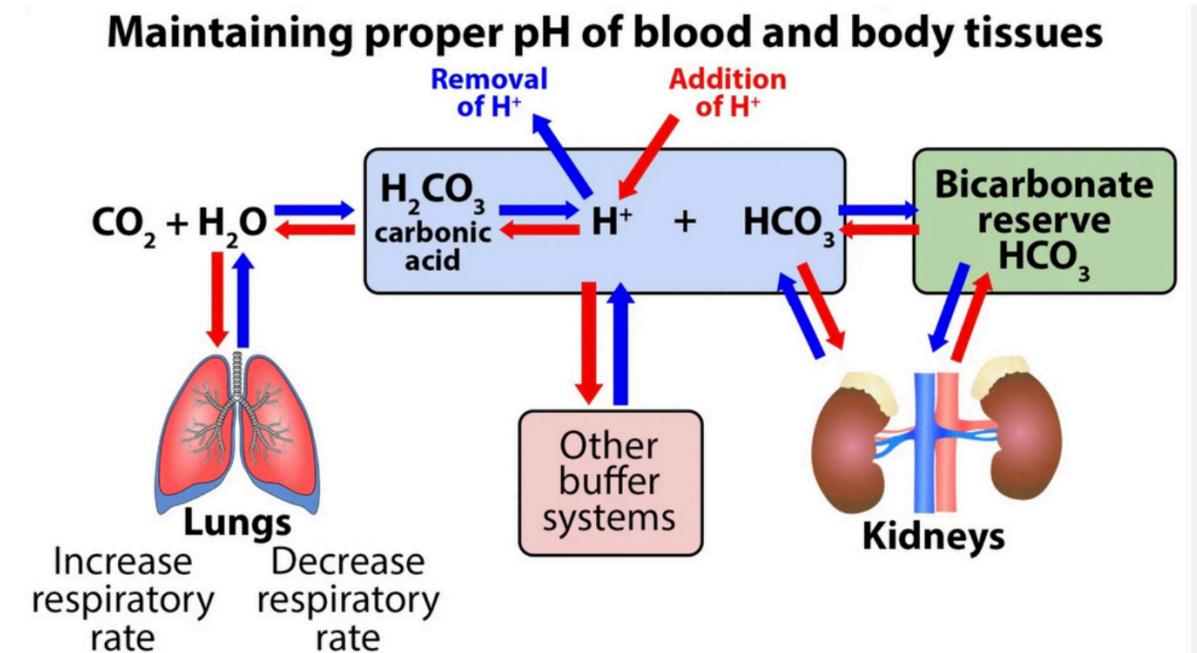
Main extracellular buffer system:



Normal values:

- $\text{HCO}_3^- \approx 24\text{--}25 \text{ mmol/L}$
- $\text{PCO}_2 \approx 40 \text{ mmHg}$

Maintains stable blood pH.



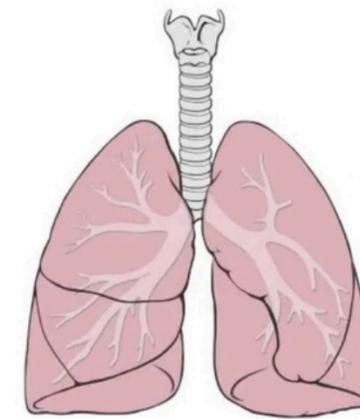
Role of the Lungs

The lungs control CO_2 (respiratory component).

\uparrow Ventilation \rightarrow \downarrow CO_2 \rightarrow \uparrow pH
 \downarrow Ventilation \rightarrow \uparrow CO_2 \rightarrow \downarrow pH

Rapid compensation (minutes).

Respiratory Control of pH



If blood becomes acidic (increase in H^+)-- respiratory rate increases

Role of the Kidneys

Kidneys regulate the metabolic component

They:

- **reabsorb filtered bicarbonate**
- **secrete H^+**
- **generate new bicarbonate**
- **use phosphate and ammonia buffers**

Slow but powerful compensation (hours–days).

Respiratory Acidosis

Cause: hypoventilation → CO₂ retention.

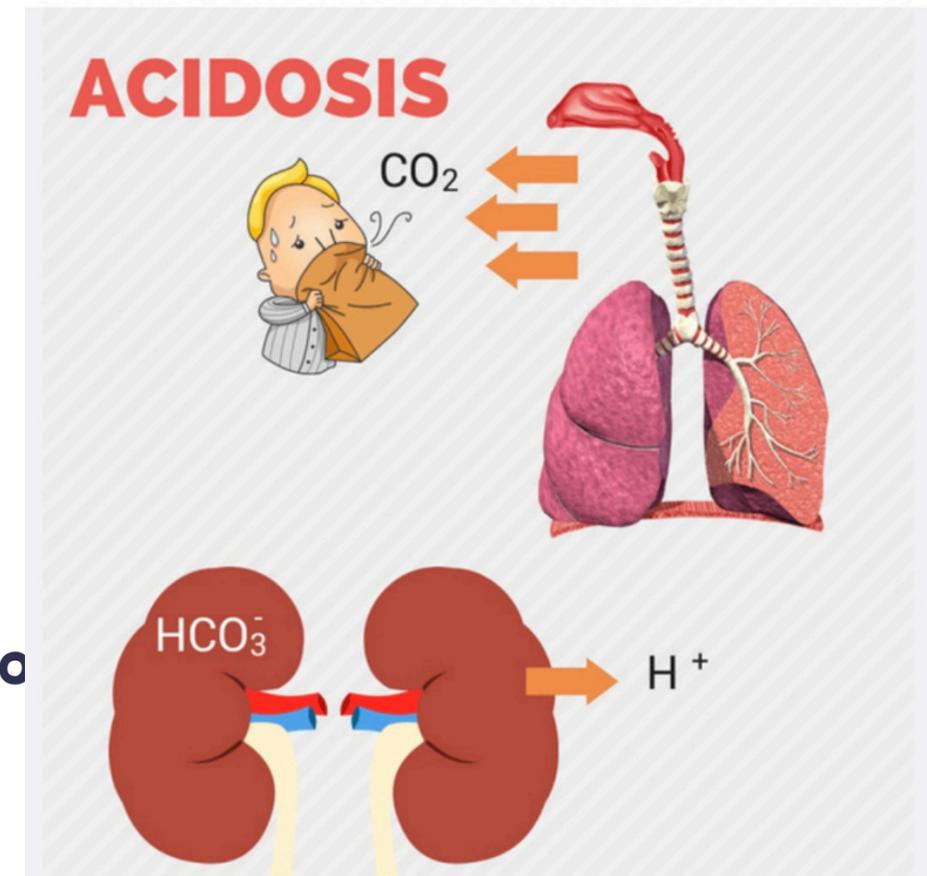
Example

- COPD
- severe asthma
- drug overdose (respiratory depression)

Compensation: kidneys increase bicarbonate retention

symptoms:

confusion, headache, drowsiness.



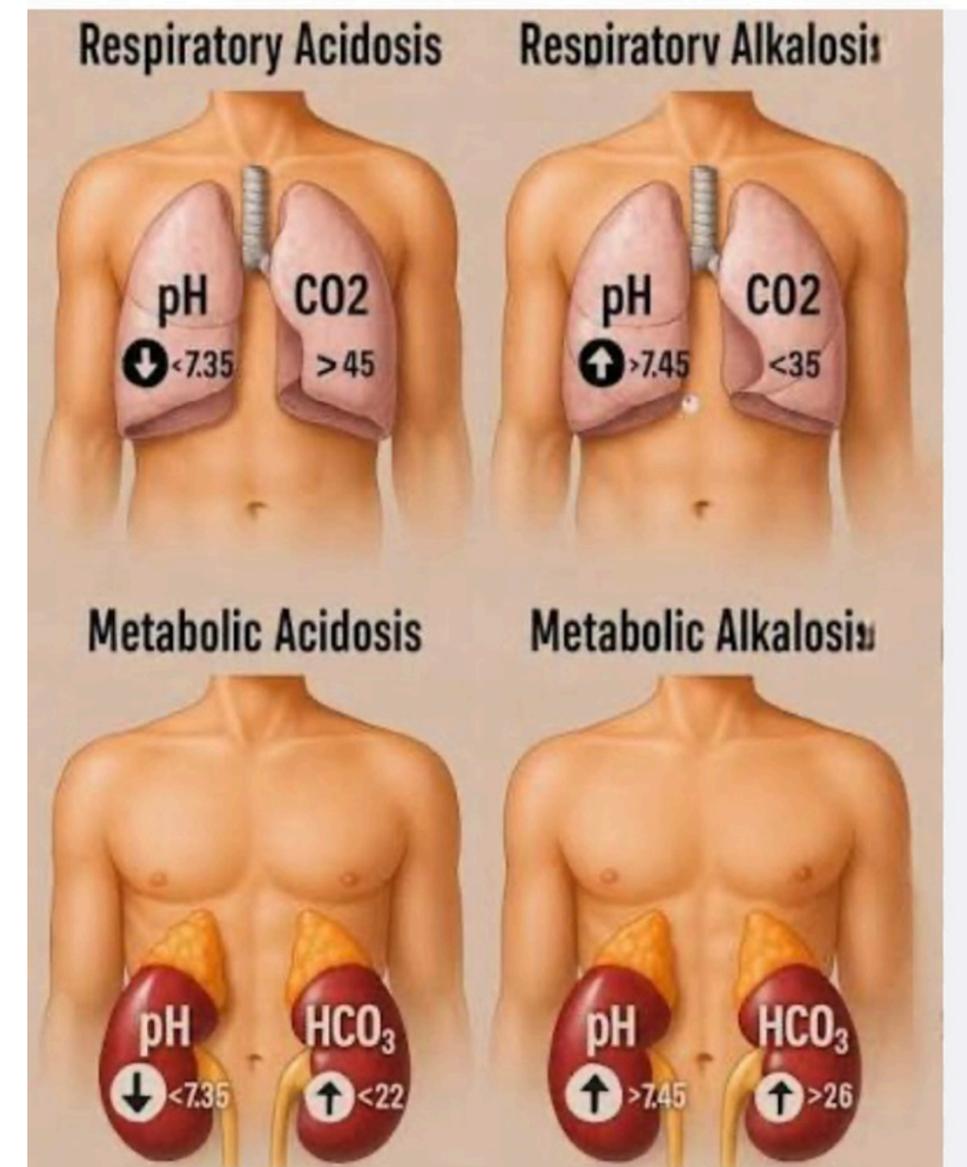
Respiratory Alkalosis

Cause: hyperventilation → excessive CO₂ losses

Common triggers

- anxiety panic attack
- fever
- high altitude , pregnancy

Compensation:
kidneys excrete bicarbonate.



Metabolic Acidosis

Cause: decreased bicarbonate or excess acid.

- **Examples:**
- diabetic ketoacidosis (DKA)
- renal failure
- severe diarrhea
- lactic acidosis (shock)

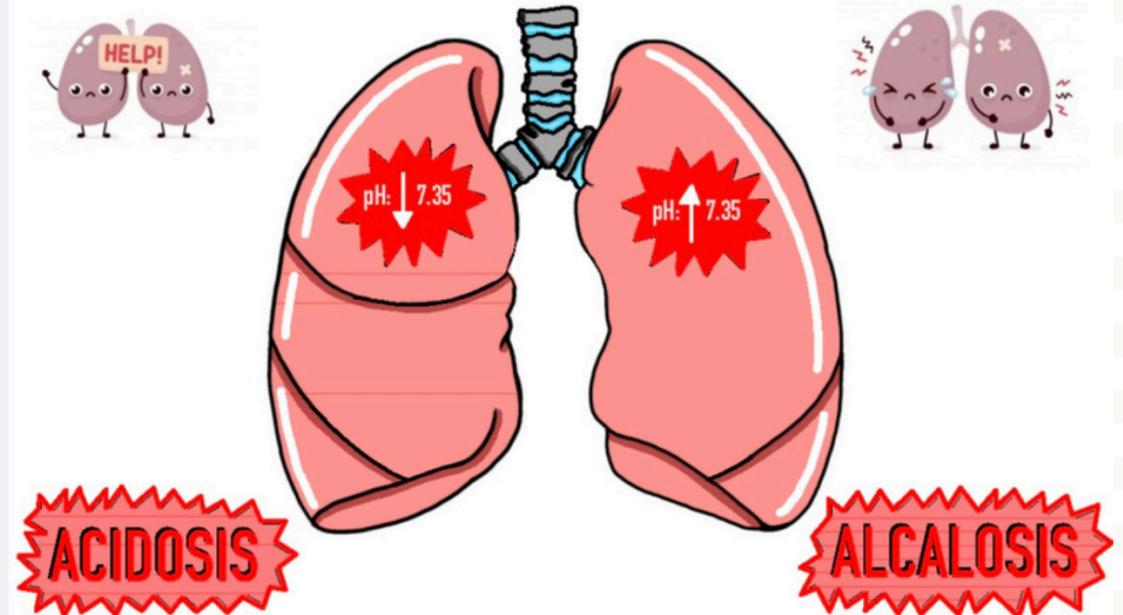
Compensation:

deep rapid breathing (Kussmaul respiration).

Life-threatening if severe.

ACIDOSIS - ALCALOSIS RESPIRATORIA

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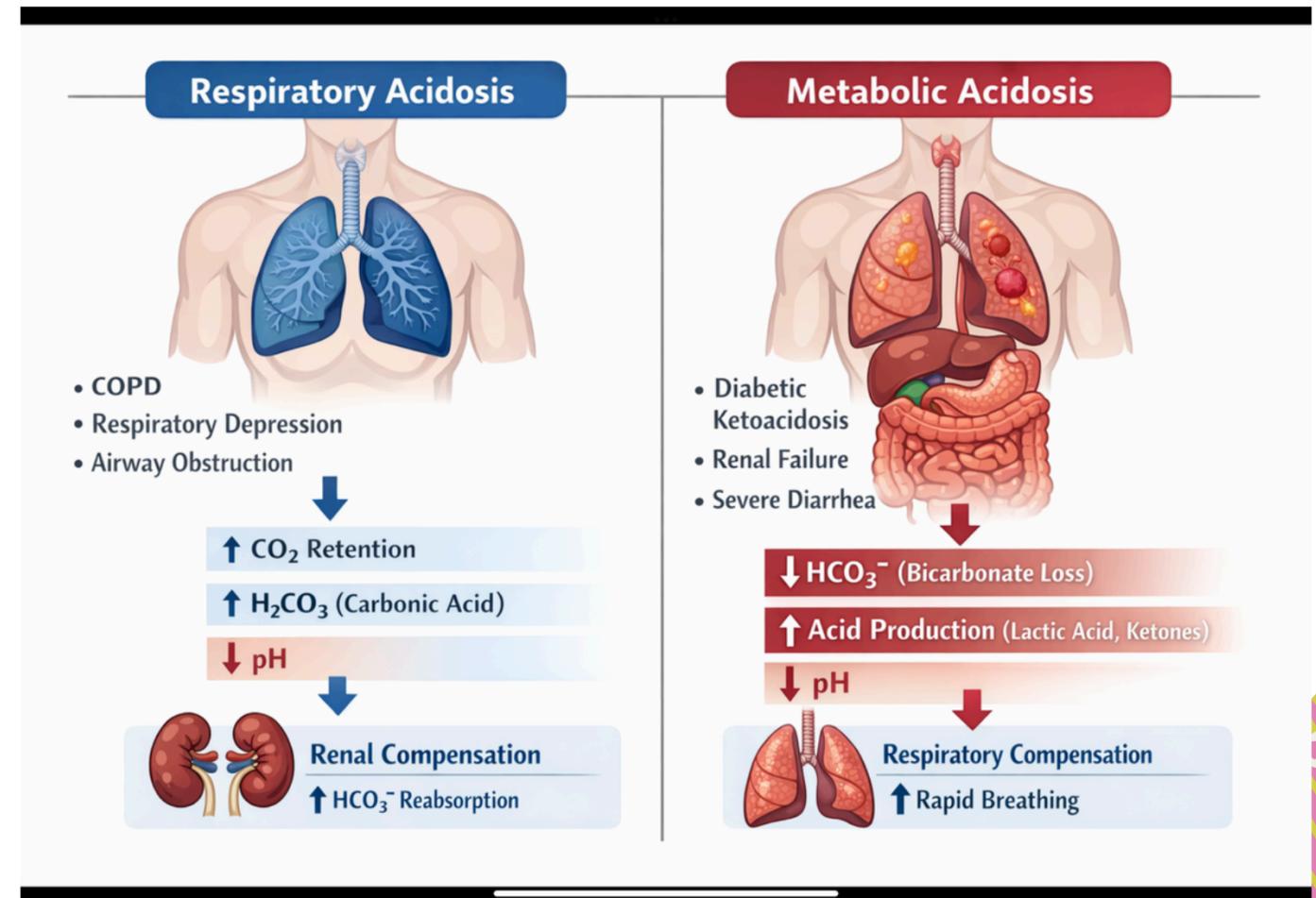
Metabolic Alkalosis

Cause: increased bicarbonate or acid loss.

Examples:

- prolonged vomiting
- gastric suction
- diuretic therapy
- pyloric stenosis in infants

Leads to neuromuscular irritability and weakness.



Fluid & Sodium Balance

Total body water \approx 60% of body weight.

Sodium = main extracellular cation.

Hyponatremia \rightarrow cellular swelling (brain edema risk).

Hypernatremia \rightarrow cellular dehydration.

Regulated by:

- ADH
- Aldosterone
- Renin–Angiotensin system

Clinical Importance

Blood pH must remain tightly controlled.

- **Bicarbonate buffer is the main regulator.**
- **Lungs control CO_2 (respiratory).**
- **Kidneys control H^+ and HCO_3^- (metabolic).**
- **Fluid and electrolyte balance is critical in IV therapy and ICU care.**
- **Early diagnosis of acid–base disorders saves lives.**



thank you