# Lactic Acidosis

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# Objectives

- Define metabolic acid-base disorders including lactic acidosis
- Understand the causes and clinical effects of metabolic acidosis and alkalosis
- Recall the lactate metabolism in the body
- Differentiate between the types of lactic acidosis
- Understand the clinical significance of measuring anion gap
- Discuss the causes and diagnosis of lactic acidosis in conditions such as myocardial infarction

# Overview

- Introduction to metabolic acid-base disorders
  - Metabolic acidosis and alkalosis
- Lactic acidosis
  - Definition
  - Lactate metabolism in tissue
  - Mechanisms involved in lactic acidosis
  - Types and causes of lactic acidosis
  - Diagnosis and treatment

# Metabolic acid-base disorders

Changes in bicarbonate conc. in the extracellular fluid (ECF) cause acid-base disorders

- Occur due to high conc. or loss of $H^+$ ions
- Can lead to:
  - Metabolic acidosis
  - Metabolic alkalosis

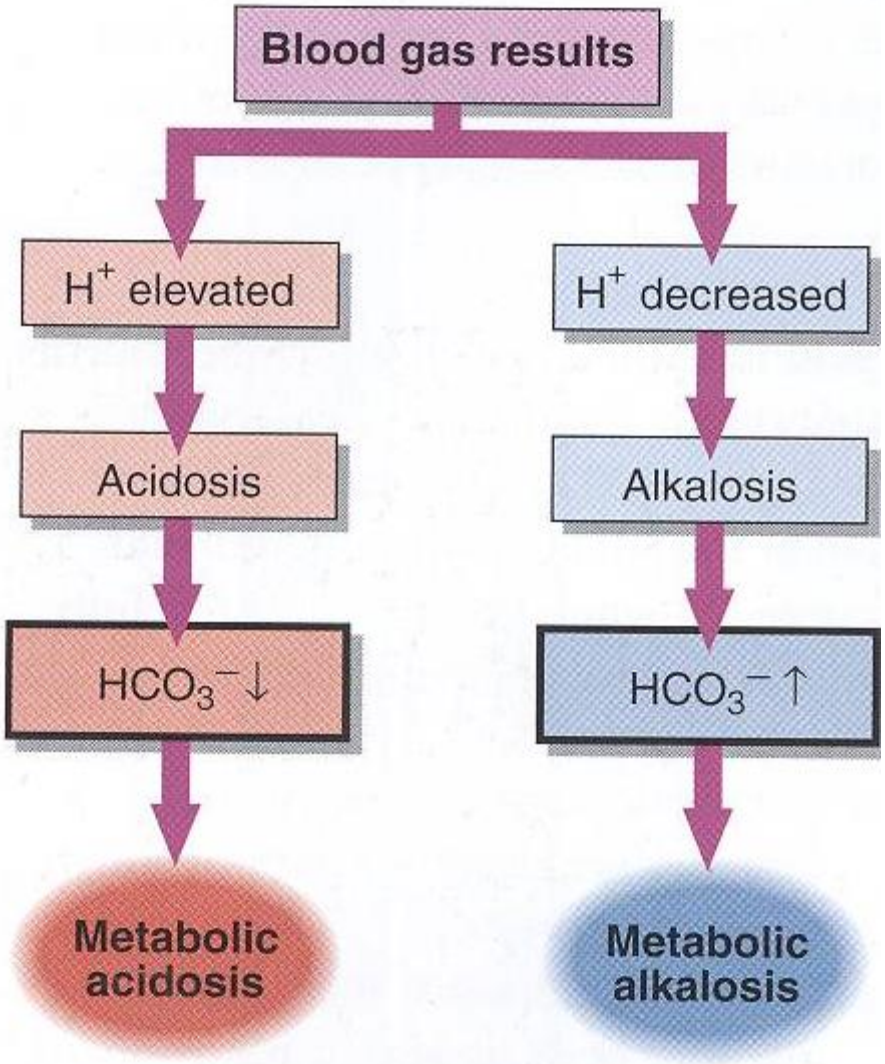
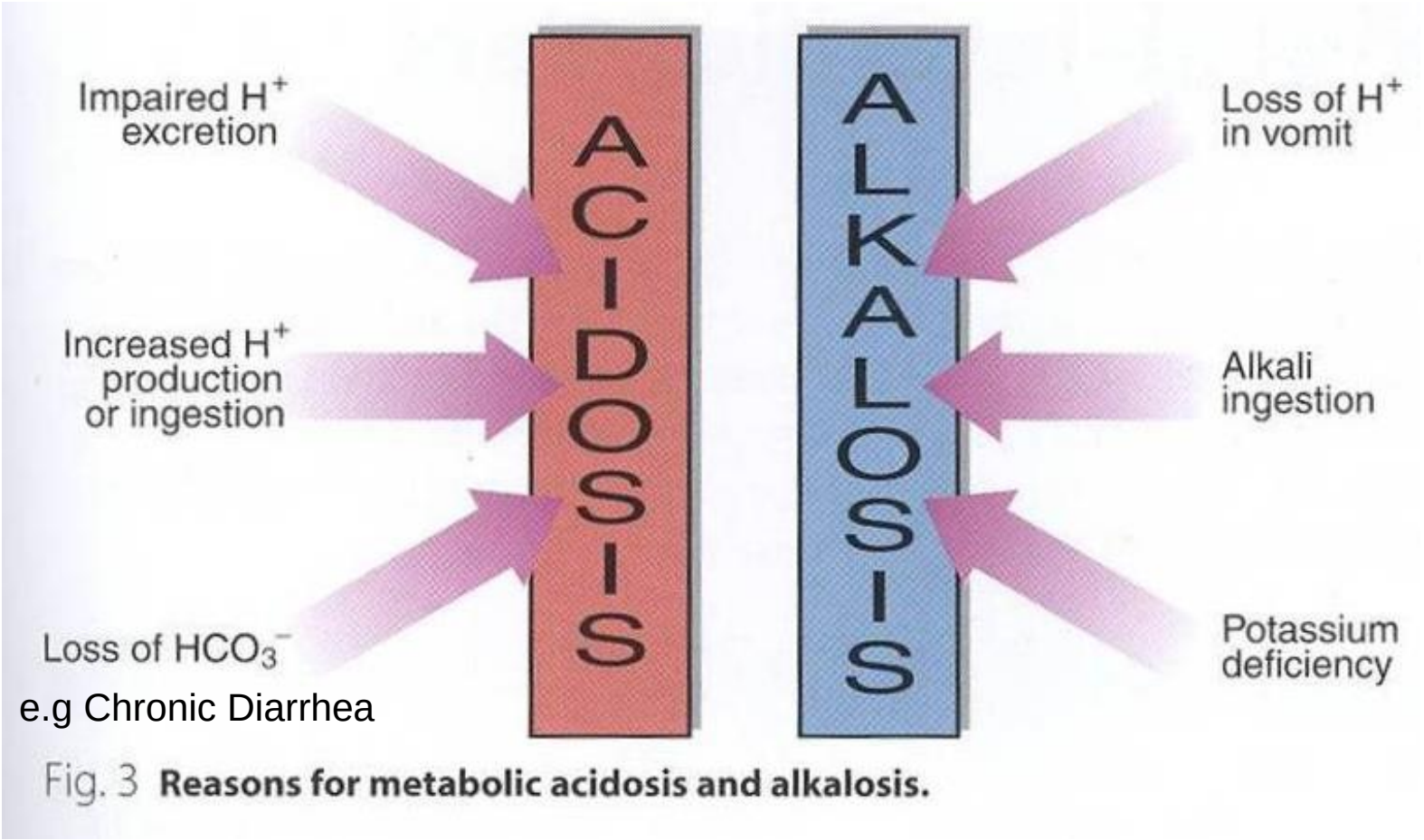



Fig. 1 **Recognizing primary metabolic acid–base disorders by inspecting the $HCO_3^-$ concentration.**




e.g Chronic Diarrhea

Fig. 3 **Reasons for metabolic acidosis and alkalosis.**

# Metabolic acidosis

Reduction in bicarbonate conc. of ECF

Causes are:

- Increased production of $H^+$ ions
- Ingestion of $H^+$ or drugs metabolized to acids
- Impaired excretion of $H^+$

# Anion gap

- It is the difference between the sum of:
  - $Na^+$ and $K^+$ (cations) and
  - the sum of $Cl^-$ and $HCO_3^-$ (anions)
- Helps in assessing acid-base problems
- Normal anion gap: 3-11 mEq/L
- High anion gap: >11 mEq/L (acidosis)
- Low anion gap: <3 mEq/L (alkalosis)

# Metabolic acidosis

High anion gap occurs in:

- Renal disease
- Diabetic ketoacidosis
- Lactic acidosis
- Poisoning

# Clinical effects of acidosis

Hyperventilation is the compensatory physiological response to acidosis

- Increased $H^+$ conc. stimulates respiratory response
- Hyperventilation: deep, rapid, and gasping respiratory pattern
- Arrhythmia, cardiac arrest
- Loss of consciousness, coma, death

## Metabolic acidosis

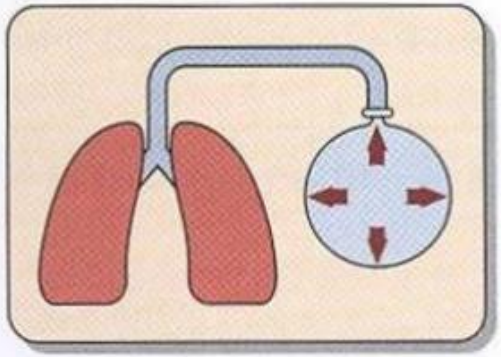
$$[H^+]\uparrow \propto \frac{PCO_2}{[HCO_3^-]\downarrow}$$

Acidosis develops

$$[H^+]\uparrow \propto \frac{PCO_2\downarrow}{[HCO_3^-]\downarrow}$$

Respiratory compensation occurs quickly

Increased ventilation



# Metabolic alkalosis

Increase in bicarbonate conc. in ECF

Causes are:

- Loss of $H^+$ ions in gastric fluid due to vomiting
- Ingestion of sodium bicarbonate
- Potassium deficiency as a result of diuretic therapy

# Clinical effects of alkalosis

- Hypoventilation (depressed breathing)
  - Increases $PCO_2$ to compensate alkalosis
  - Respiratory arrest
- Confusion, coma, death

## Metabolic alkalosis

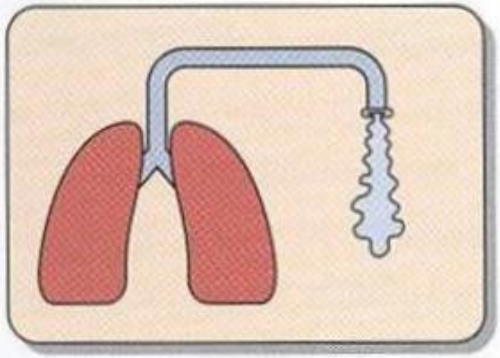
$$[H^+]\downarrow \propto \frac{PCO_2}{[HCO_3^-]\uparrow}$$

Alkalosis develops

$$[H^+]\downarrow \propto \frac{PCO_2\uparrow}{[HCO_3^-]\uparrow}$$

Respiratory compensation occurs quickly

Decreased ventilation



# Lactic acidosis

- Elevated conc. of plasma lactate is called lactic acidosis
- Occurs either due to:
  - Failure of circulatory system (hypoxia)
  - Disorders of carbohydrate metabolism

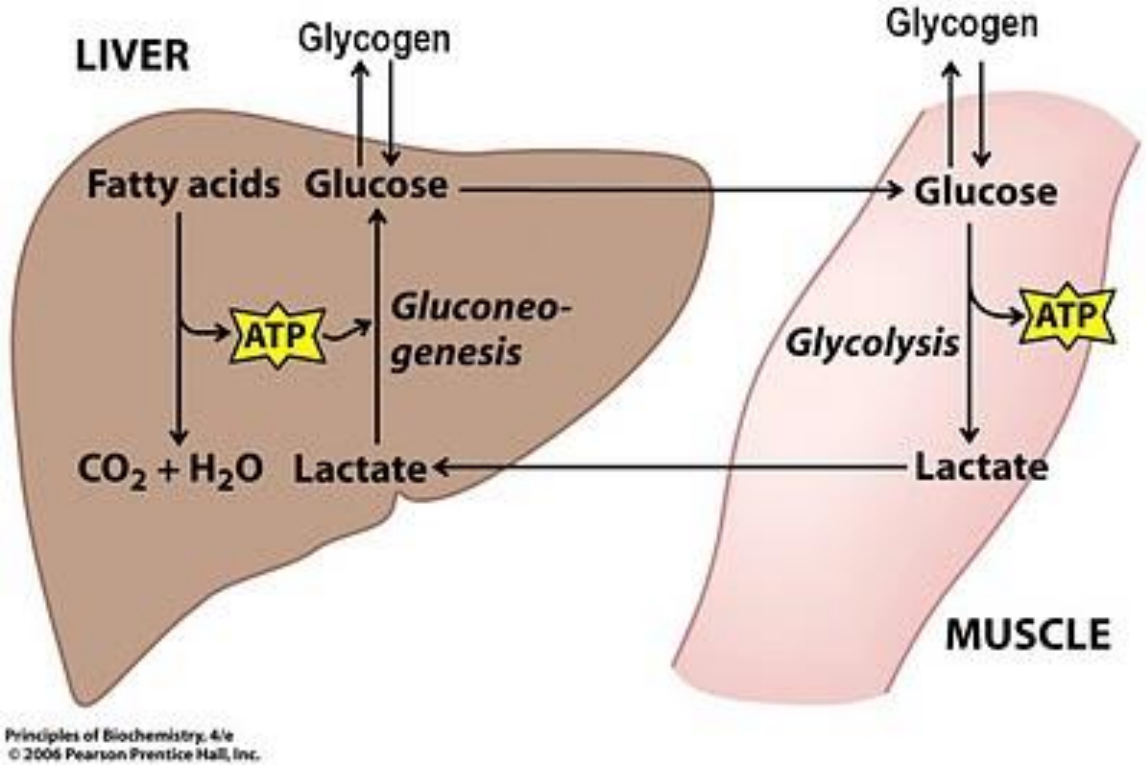
# Lactate metabolism in tissue

- The body tissues produce ~ 1500 mmoles of lactate each day
- The lactate enters blood stream and metabolized mainly by the liver (Cori cycle)
- All tissues can produce lactate under anaerobic conditions
- Pyruvate is converted to lactate by lactate dehydrogenase enzyme

**Pyruvate + NADH + $H^+$**

*Lactate dehydrogenase*

**Lactate + $NAD^+$**




# The Cori cycle

# Lactate metabolism in tissue

- The skeletal muscles produce high amounts of lactate during vigorous exercise
- Lactate is metabolized in liver (60%) and kidney (30%) to glucose
- Some lactate is metabolized to $CO_2$ and water (Krebs cycle)

# Mechanisms involved in lactic acidosis

Lactic acidosis can occur due to:

- Excessive tissue lactate production
- Impaired hepatic metabolism of lactate

# Types and causes of lactic acidosis

Type A

- Due to hypoxia in tissues (most common)
- Hypoxia causes impaired oxidative phosphorylation and decreased ATP synthesis
- To survive, the cells switch to anaerobic glycolysis for ATP synthesis
- This produces lactate as a final product
- The amount of oxygen required to recover from oxygen deficiency is called oxygen debt

# Types and causes of lactic acidosis

- Type A is due to inadequate supply of oxygen to tissues in:
  - Myocardial infarction
  - Pulmonary embolism
  - Uncontrolled hemorrhage
  - Tissue hypoperfusion (shock, cardiac arrest, acute heart failure, etc.)
  - Anaerobic muscular exercise

# Types and causes of lactic acidosis

Type B

- Due to disorders in carbohydrate metabolism
  - Congenital lactic acidosis is due to deficiency of pyruvate dehydrogenase enzyme
- Chronic hepatic disease accompanied by shock or bleeding
- Liver failure
- Drug intoxication

# Diagnosis and treatment

- Diagnosis done by measuring blood lactate levels
  - Hyperlactemia: 2 – 5 mmols/L
  - Severe lactic acidosis: > 5 mmols/L

- Treatment:
  - Correcting the underlying conditions
  - Restoring adequate tissue oxygen
  - Avoiding sodium bicarbonate

# Take home message

- Lactic acidosis can be caused by hypoxia, excessive production and impaired clearance of lactic acid
- It carries clinical significance in the diagnosis of myocardial infarction, pulmonary embolism and other metabolic conditions

# References


- Acid-Base Physiology by Kerry Brandis (www.anaesthesiamcq.com)
- Friedrich C. Luft. Lactic acidosis update for critical care clinicians., *J. Am. Soc. Nephrol*. 12: S15–S19, 2001.