



Clinical Acidosis: Understanding the Disturbance of Acid–Base Balance

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Clinical acidosis is a significant metabolic disorder encountered in both human and veterinary medicine. In veterinary clinical practice, especially in critical care, acidosis is frequently associated with shock, renal disease, diarrhea, respiratory disorders, and metabolic emergencies such as diabetic ketoacidosis. Because cellular functions depend on a tightly regulated blood pH, even minor deviations can impair enzyme activity, oxygen delivery, and organ performance. Early recognition and correction are therefore essential to prevent life-threatening consequences.

Normal Acid–Base Physiology

In most domestic animals, normal blood pH ranges from 7.35 to 7.45. The body maintains this narrow range through three primary mechanisms:

1. Buffer systems – The bicarbonate–carbonic acid buffer is the most important extracellular system. Proteins and phosphates also contribute.
2. Respiratory regulation – The lungs regulate carbon dioxide (CO₂), which combines with water to form carbonic acid. Increased ventilation removes CO₂ and raises pH.
3. Renal regulation – The kidneys excrete hydrogen ions (H⁺) and reabsorb or generate bicarbonate (HCO₃⁻).

Acidosis occurs when blood pH falls below normal due to increased acid accumulation or decreased bicarbonate concentration. Clinically, it is categorized into metabolic acidosis and respiratory acidosis.

Metabolic Acidosis

Metabolic acidosis results from a primary decrease in bicarbonate concentration or excessive acid production. It is one of the most common acid–base disorders in veterinary medicine.

Causes

- Severe diarrhea (loss of bicarbonate)
- Renal failure (impaired acid excretion)
- Diabetic ketoacidosis (ketone body accumulation)
- Lactic acidosis due to shock or hypoxia
- Toxicosis (e.g., ethylene glycol)
- Ruminal acidosis in cattle after grain overload

In small animals, metabolic acidosis is often seen in acute kidney injury, septicemia, or prolonged dehydration. In large animals, high-concentrate feeding without proper adaptation predisposes cattle to ruminal acidosis, where lactic acid accumulation leads to systemic acid–base imbalance.

Respiratory Acidosis

Respiratory acidosis develops when alveolar ventilation is inadequate, leading to retention of CO₂. Since CO₂ forms carbonic acid in blood, its accumulation lowers pH.

Causes

- Pneumonia
- Chronic bronchitis
- Airway obstruction
- Thoracic trauma
- Anesthetic overdose
- Neuromuscular disorders affecting respiration

Unlike metabolic acidosis, respiratory acidosis is primarily a ventilation problem. The kidneys attempt to compensate by increasing bicarbonate retention, but this process takes time.

Pathophysiological Effects

Acidosis influences nearly every organ system:

- Cardiovascular system: Decreased myocardial contractility, hypotension, and arrhythmias.
 - Central nervous system: Depression, lethargy, confusion, and in severe cases, coma.
 - Respiratory system: In metabolic acidosis, compensatory hyperventilation (deep, rapid breathing) occurs to eliminate CO₂.
 - Electrolyte imbalance: Hyperkalemia is common due to hydrogen–potassium ion exchange.
- Persistent severe acidosis impairs oxygen delivery to tissues and can lead to multi-organ dysfunction.

Clinical Signs

Clinical presentation depends on severity and cause but may include:

- Tachypnea or dyspnea
- Weakness and lethargy
- Anorexia
- Dehydration
- Vomiting (in small animals)
- Diarrhea (especially in calves)
- Ataxia
- Cardiac arrhythmias

In ruminants, ruminal atony, depression, and laminitis may accompany metabolic acidosis. In dogs and cats, signs such as altered mentation and shock may predominate.

Diagnosis

Accurate diagnosis requires integration of history, clinical findings, and laboratory data.

1. Blood Gas Analysis

This is the gold standard test. It measures:

- pH
- Partial pressure of CO₂ (PaCO₂)
- Bicarbonate concentration
- Base excess

2. Serum Biochemistry

Electrolytes (Na⁺, K⁺, Cl⁻), renal parameters, glucose, and lactate levels help identify underlying causes.

3. Anion Gap Calculation

Anion gap helps differentiate causes of metabolic acidosis:

$$\text{Anion Gap} = \text{Na}^+ - (\text{Cl}^- + \text{HCO}_3^-)$$

An increased anion gap suggests accumulation of organic acids such as lactate or ketones.

Treatment Principles

Management depends on correcting the underlying disorder and stabilizing the patient.

1. Fluid Therapy

Isotonic crystalloids restore circulation and improve renal perfusion. Balanced electrolyte solutions are commonly used.

2. Treat the Primary Cause

- Insulin in diabetic ketoacidosis
- Antibiotics in sepsis
- Correction of dehydration
- Removal of toxins
- Dietary adjustment in ruminal acidosis

3. Sodium Bicarbonate Therapy

Reserved for severe metabolic acidosis (pH < 7.1).

Bicarbonate deficit can be calculated:

Deficit (mEq) = Body weight (kg) × 0.3 × Base deficit

It must be administered cautiously to avoid overcorrection.

4. Oxygen and Ventilatory Support

Essential in respiratory acidosis or hypoxic patients. Mechanical ventilation may be required in severe cases.

Complications and Prognosis

Untreated acidosis can lead to:

- Circulatory shock
- Cardiac arrest
- Organ failure
- Death

The prognosis depends on the severity of acidosis, the underlying cause, and the speed of intervention. Early recognition and prompt correction generally result in favorable outcomes.

Prevention

Preventive measures include:

- Balanced nutrition in ruminants
- Gradual feed transitions
- Early treatment of diarrhea and dehydration
- Monitoring renal function in chronic kidney disease
- Careful anesthetic monitoring

In critical care practice, routine acid–base monitoring significantly improves survival rates.

Conclusion

Clinical acidosis is a serious but manageable metabolic disturbance. Whether metabolic or respiratory in origin, understanding its pathophysiology allows for accurate diagnosis and effective treatment. Prompt correction of the underlying cause, appropriate fluid therapy, and careful monitoring remain the cornerstones of successful management. For veterinarians, especially those involved in internal medicine and critical care, mastery of acid–base disorders is essential for improving patient outcomes and ensuring effective clinical decision-making.

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