Metabolic Acidosis: A Quick Reference

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- Metabolic acidoses are characterized by a decrease in $\text{HCO}_3^-$ and base excess, a decrease in pH, and a compensatory decrease in $\text{PCO}_2$.
  - Metabolic acidosis can be identified by a decrease in $\text{HCO}_3^-$ or base excess.
  - Base excess is the amount of acid needed to return blood pH to normal. The more negative the base excess, the more severe is the metabolic acidosis.
  - There is a compensatory hyperventilation that decreases $\text{PCO}_2$ and minimizes the change in pH.
  - In dogs, for each 1-mEq/L decrease in $\text{HCO}_3^-$, $\text{PCO}_2$ decreases by 0.7 mm Hg.
  - Cats do not seem to decrease ventilation in the face of metabolic acidosis; thus, their $\text{PCO}_2$ does not change.
- Metabolic acidosis can result from decreases in the strong ion difference (SID, or the difference between all strong cations and strong anions in blood) or an increase in nonvolatile weak acids.

ANALYSIS
- Indications: Measurement of base excess and $\text{HCO}_3^-$ is useful in severely ill pets (eg, severe dehydration, vomiting, diarrhea, oliguria, anuria) or in animals that have a condition known to be associated with metabolic acidosis or a low total carbon dioxide (total $\text{CO}_2$) concentration. Total $\text{CO}_2$ is almost synonymous with $\text{HCO}_3^-$ in samples handled anaerobically. A blood gas analysis is necessary to determine if the low total $\text{CO}_2$ is attributable to a metabolic acidosis or a compensation for respiratory alkalosis.
- Typical reference range: Normal $\text{HCO}_3^-$ concentration is approximately 19 to 23 mEq/L in dogs and 17 to 21 mEq/L in cats. Normal base excess is approximately 0 to −5 in dogs and cats. These values may vary among laboratories and analyzers.
Box 1: Principal causes of metabolic acidosis

*Strong ion difference acidosis*

Dilution acidosis (recognized by $\uparrow [\text{Na}^+]$)
- With hypervolemia (gain of hypotonic fluid)
  - Severe liver disease
  - Congestive heart failure
- With normovolemia (gain of water)
  - Psychogenic polydipsia
  - Hypotonic fluid infusion
- With hypovolemia (loss of hypertonic fluid)
  - Hypoadrenocorticism
  - Diuretic administration

*Hyperchloremic acidosis*

- Diarrhea$^a$
- Fluid therapy$^a$ (eg, 0.9% sodium chloride [NaCl], 7.2% NaCl, potassium chloride [KCl]–supplemented fluids)
- Total parenteral nutrition
- Renal failure
- Hypoadrenocorticism

*Organic acidosis*

- Uremic acidosis$^a$
- Diabetic ketoacidosis$^a$
- Lactic acidosis$^a$
- Toxicities
  - Ethylene glycol
  - Salicylate

*Nonvolatile ion buffer acidosis*

*Hyperphosphatemic acidosis*

- Phosphate-containing enemas
- Intravenous phosphate
- Renal failure$^a$
- Urethral obstruction
- Uroabdomen

$^a$Most important causes in small animal practice.
• Danger values: pH less than 7.1 indicates life-threatening acidosis, which may impair myocardial contractility. HCO₃⁻ concentrations less than 8 mEq/L are usually associated with severe acidosis.

• Artifacts: HCO₃⁻ concentration is calculated in blood gas machines based on pH and PCO₂. Thus, artifacts that interfere with PCO₂ or pH affect the estimation of HCO₃⁻ (see Quick References on respiratory alkalosis and respiratory acidosis elsewhere in this issue for further details).

• Drug effects: Acetazolamide and NH₄Cl may cause metabolic acidosis.

**METABOLIC ACIDOSIS**

• Causes: Metabolic acidosis can result from the following (Box 1):
  - Decrease in the SID (or the difference between all strong cations and strong anions in blood)
  - Dilutional acidosis (increase in free water)
  - Hyperchloremic acidosis (increase in chloride concentration)
  - Organic acidosis (increase in strong anions other than chloride)
  - Increase in nonvolatile weak acids
  - Hyperphosphatemic acidosis
  - Metabolic acidoses also can be divided based on changes in the anion gap in hyperchloremic acidosis and high anion gap acidosis.
    - The most common causes of hyperchloremic acidosis are fluid therapy and diarrhea.
    - The most common causes of high anion gap acidosis are renal failure, diabetic ketoacidosis, and lactic acidosis.
  - Hyperphosphatemia is an often overlooked cause of high anion gap acidosis.

**Fig. 1.** Algorithm for evaluation of patients that have acid-base disorders.
Signs: Clinical signs in dogs and cats with metabolic acidosis are more likely to be caused by the underlying disease. Compensatory tachypnea can be observed in some patients. Severe metabolic acidosis can lead to depression.

Stepwise approach: Algorithms for the differential diagnosis of metabolic acidosis are presented in Figs. 1 and 2.

Further Readings
