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Metabolic Acidosis: A Quick Reference

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- Metabolic acidoses are characterized by a decrease in HCO_3^- and base excess, a decrease in pH, and a compensatory decrease in P_{CO_2}.
  - Metabolic acidosis can be identified by a decrease in 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 P_{CO_2} and minimizes the change in pH.
    - In dogs, for each 1-mEq/L decrease in HCO_3^-, P_{CO_2} decreases by 0.7 mm Hg.
    - Cats do not seem to decrease ventilation in the face of metabolic acidosis; thus, their P_{CO_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 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 CO_2) concentration. Total CO_2 is almost synonymous with HCO_3^- in samples handled anaerobically. A blood gas analysis is necessary to determine if the low total CO_2 is attributable to a metabolic acidosis or a compensation for respiratory alkalosis.
- Typical reference range: Normal 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.

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Box 1: Principal causes of metabolic acidosis

Strong ion difference acidosis

Dilution acidosis (recognized by ⇑ [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. HCO_3^- concentrations less than 8 mEq/L are usually associated with severe acidosis.
- Artifacts: HCO_3^- concentration is calculated in blood gas machines based on pH and P_{CO_2}. Thus, artifacts that interfere with P_{CO_2} or pH affect the estimation of HCO_3^- (see Quick References on respiratory alkalosis and respiratory acidosis elsewhere in this issue for further details).
- Drug effects: Acetazolamide and NH_4Cl 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.

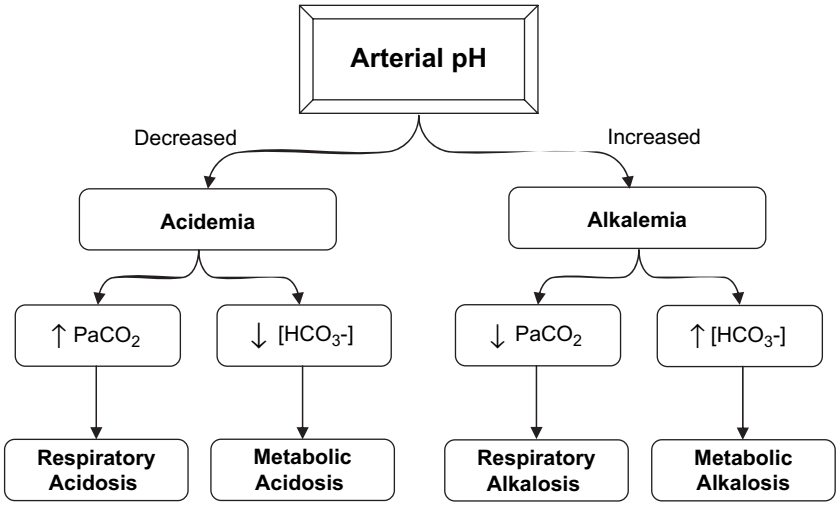

Fig. 1. Algorithm for evaluation of patients that have acid-base disorders.

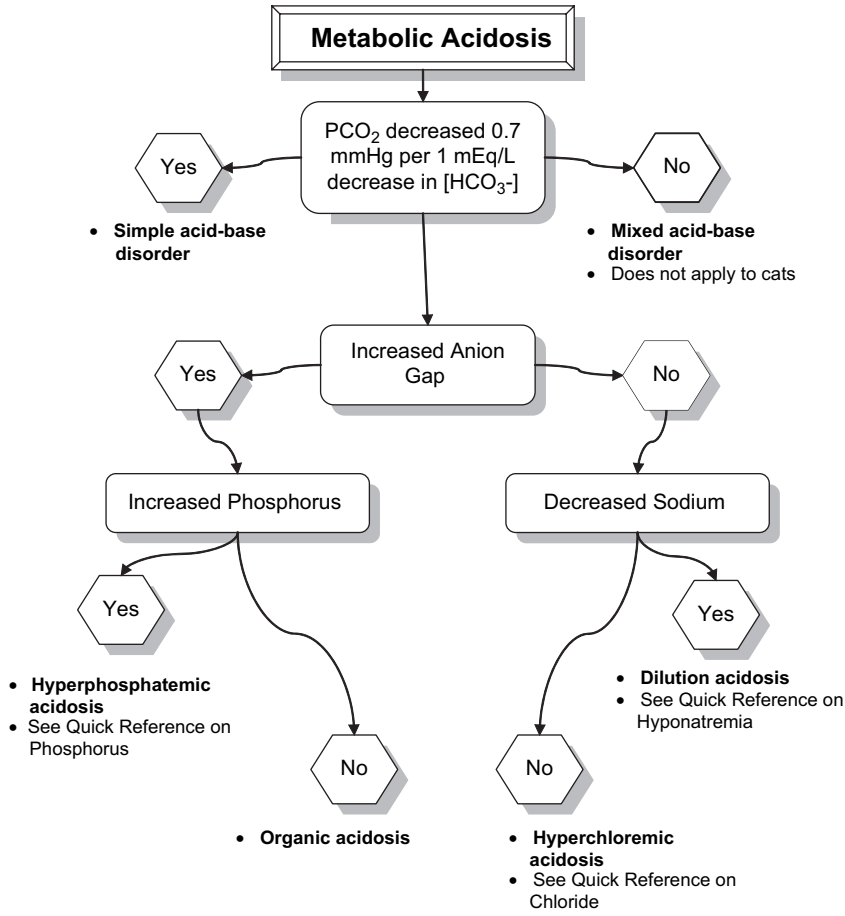

Fig. 2. Algorithm for evaluation of patients that have metabolic acidosis.

- 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

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