A Quick Reference on Anion Gap and Strong Ion Gap

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KEYWORDS

• Anion gap • Strong ion gap • Metabolic acidosis • Unmeasured anions • Acid-base • Small animals

KEY POINTS

- Disturbances of acid-base balance have been widely reported in the veterinary literature.
- An appropriate approach to these disorders is essential to ensure proper management of emergent or critically ill patients, in terms of morbidity and mortality.
- Metabolic acidosis and complex mixed disorders are frequent imbalances in those patients.
- The anion gap (AG) and strong ion gap (SIG) concepts can be used to help in the identification of unmeasured anions and unmeasured strong anions, respectively, in the pathogenesis of such disorders.
- In the clinical setting, some concomitant conditions of the patient, such as hypoalbuminemia and hyperphosphatemia, may interfere in the interpretation of results; thus, AG and SIG adjusted calculations for albumin and phosphate must be obtained using appropriate formulas before reaching any conclusions.

INTRODUCTION

Acid-base disturbances and electrolytes have diagnostic, therapeutic, and prognostic implications and impact morbidity and mortality. Thus, a proper assessment, monitoring, and guided treatment of these disorders is important for an effective management of those patients. Different approaches to acid-base analysis have been developed, such as the traditional and the quantitative approaches. The traditional approach is based on the Henderson-Hasselbalch equation and uses pH, partial pressure of carbon dioxide, bicarbonate (HCO_3^-), base excess, and anion gap (AG); whereas the quantitative approach or simplified strong ion model uses pH, P_{CO_2}, strong ion difference (SID), total concentration of weak acids (A_{tot}), and strong ion gap (SIG).

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In the diagnostic approach for acid-base imbalances, the AG and SIG can be used to help identify unmeasured anions mainly to differentiate causes of metabolic acidosis and clarify the pathogenesis of some mixed acid-base disorders in the ill patient. However, some considerations must be taken into account in the clinical setting because some drugs and/or clinical conditions of the patient associated to the underlying disease process may interfere with their interpretation. If adjusted AG and SIG calculations are used in the clinical setting, the traditional method could perform at least as well as the quantitative approach in uncovering a hidden metabolic acid-base disorder.

ANION GAP

The AG concept represents the difference between all the measured major cations (positively charged ions) and anions (negatively charged ions) present in plasma. The major cations of extracellular fluid are sodium, potassium, calcium, and magnesium; whereas, the major anions are chloride, bicarbonate, plasma proteins (mainly albumin), organic acid anions (including lactate), phosphate, and sulfate. Because of the law of electroneutrality, the concentration of cations in a solution, such as plasma, must be equal to the concentration of anions; so in reality there is no AG (Fig. 1).

In the clinical setting, a greater proportion of cations can be measured directly in comparison with anions. The difference between the two, the AG, is in fact a measure of the quantity of unmeasured anions in plasma and can be calculated as follows:

$$Na^{+} + K^{+} + Ca^{2+} + Mg^{2+} = Cl^{-} + HCO_3^{-} + Alb^{-} + \text{Organic anions}^{-} + PO_4^{-} + SO_4^{-}$$

or

$$Na^{+} + K^{+} + \text{Unmeasured Cations } (UC^{+}) = Cl^{-} + HCO_3^{-} + \text{Unmeasured Anions } (UA^{-})$$

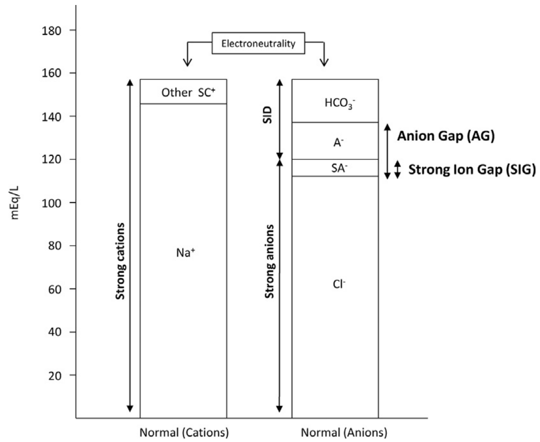

Fig. 1. Schematic illustration of plasma cations and anions in normal acid-base status, showing the respective components of the AG and SIG. Strong cations in plasma include sodium (Na^{+}) and others (K^{+}, Ca^{2+}, and Mg^{2+}). Strong anions in plasma include Cl^{-} and others (SA^{-}), such as lactate, ketones, or sulfates. A^{-} represents net negative charge of weak acids or nonvolatile plasma buffers (mainly albumin and phosphates).