Sodium Balance and the Dysnatremias

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KEYWORDS

• Sodium balance • Dysnatremias • Hypernatremia • Hyponatremia

KEY POINTS

- The serum sodium concentration is expressed as the quantity of sodium divided by the volume of water in the serum.
- Disorders of sodium concentration often reflect disorders in water homeostasis.
- Hypernatremia most commonly occurs when there is a sustained loss of water from the body, or when an animal ingests or is force-fed a sodium-rich fluid without adequate amounts of free (pure) water.
- Hyponatremia most commonly occurs when an animal loses sodium and water in diarrhea or in urine with ingestion or retention of only water, resulting in dilution of the extracellular fluid sodium concentration.
- When treating severe hypernatremia or hyponatremia, it is most prudent for the veterinarian to correct these disorders slowly to avoid potentially serious neurologic complications.

INTRODUCTION

The dysnatremias are defined as abnormalities in serum sodium concentration.[1] Depending on the magnitude and duration of the sodium abnormality and the nature of any concurrent or primary disease, hypernatremia and hyponatremia may result in no consequences, subclinical impairment of health and productivity, or severe clinical disease. Dysnatremias can be the sequelae to diseases or environmental conditions that promote fluid gain or loss from the body, as well as medical interventions that add excessive amounts of sodium or water to the extracellular fluid (ECF). Extreme, sustained dysnatremia may result in central nervous system (CNS) dysfunction and death.

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SERUM SODIUM CONCENTRATION AND OSMOLARITY

The sodium concentration of the ECF is accurately represented by the serum sodium concentration. This concentration can be viewed in the same light as a fraction is viewed in mathematics, with the numerator the sodium concentration and the denominator the volume of serum water. In most ruminant species, the normal range of serum sodium concentration is approximately 135 to 155 mEq/L.[2] In New World camelids (NWCs), the normal range of serum sodium concentration is slightly higher, at 147 to 158 mEq/L.[3]

When the ECF sodium concentration is abnormal, the normal animal restores normal serum sodium concentration (eunatremia) by increasing or decreasing the amount of the water in the body. Because regulation of sodium concentration is based on the body's management of water, dysnatremias can be thought of as disorders of water balance.[4,5] It is vital that the clinician thinks of sodium concentration not as an indicator of the amount of sodium in the ECF, but rather as the relative ratio of sodium to water.

Sodium is the predominant cation in the ECF. Sodium and its accompanying anions are the solutes that exert the greatest influence on osmolarity of the ECF.[6] Osmolarity is the concentration of particles per liter of water. Almost all cellular membranes are highly permeable to water, so a disparity of osmolarity between the intracellular fluid (ICF) and ECF results in rapid movement of water from the fluid compartment with low osmolarity to that of higher osmolarity. When an osmotic gradient exists between the ECF and ICF, the ensuing movement of water results in cellular shrinkage or swelling. Therefore, osmolarity is tightly controlled to prevent potentially detrimental changes in cellular volume.[7,8]

The osmolarity of the ECF is accurately represented by a serum sample and can be measured in the laboratory with an osmometer. In most animals, normal serum osmolality (for dilute fluids such as the ECF, osmolarity [expressed as mOsm/L] and osmolality [expressed as mOsm/kg] are approximately equal and are essentially synonymous[6]) ranges from approximately 270 to 310 mOsm/kg.[9] This result is commonly referred to as the measured osmolarity. Osmometers require frequent calibration and intensive maintenance and are not commonly available in private practices, so the calculated serum osmolarity is more commonly used. Serum osmolarity is estimated using the following equation[10]:

$$\text{Serum osmolarity} = \left(2 \times \left[Na^+\right]\right) + \frac{[\text{glucose}]}{18} + \frac{\text{BUN}}{2.8}$$

where serum $[Na^+]$ is expressed in mEq/L and serum [glucose] and blood urea nitrogen [BUN] are expressed in mg/dL and the result is referred to as the calculated osmolarity.

The difference between the measured and calculated osmolarity is termed the osmolar gap. In most healthy animals, the osmolar gap is less than 10 mOsm/L. An osmolar gap greater than this value may indicate 1 or more of the following[10]:

1. Laboratory error in osmometry or serum biochemistry
2. True states of decreased ECF water content caused by severe hyperlipemia or hyperproteinemia or
3. The presence of unmeasured, low-molecular-weight solutes in the serum, such as ethylene glycol or ethanol

Ethylene glycol intoxication has been reported in livestock.[11,12] It is characterized by hyperosmolarity, an increased osmolar gap, metabolic acidosis, azotemia, hypocalcemia, and a high case fatality rate.