# Disorders of Sodium and Water Homeostasis

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**KEYWORDS**

• Sodium • Dysnatremia • Hypernatremia • Hyponatremia • Water • Osmolality • Osmolarity • Dog

**KEY POINTS**

- Disturbances in sodium homeostasis are linked to concentration of sodium in water; therefore, sodium balance is linked to water balance.
- Hyponatremia is usually secondary to an excess of free water, and hypernatremia is usually secondary to a loss of free water.
- Chronic sodium changes should be treated slowly (no more than 0.5–1.0 mEq/L/h changes).
- For shock resuscitation of patients with a dysnatremia, a fluid containing the SAME amount of sodium (within 10 points of the patients' serum sodium) should be used; then, slow changes of sodium can be started.

Sodium (Na) and water disorders traditionally have been viewed as difficult concepts by veterinarians. However, these concepts are easily and predictably explained with a basic understanding of physiology. The objectives of this article are to facilitate understanding of the changes in serum Na concentration associated with the loss or gain of fluids of different tonicity as well as to explain formulation of a fluid therapy plan that takes into account changes in serum Na concentration.

## WATER BALANCE MADE EASY

Imagine 2 compartments separated by a semipermeable membrane. Each compartment has the same osmolality (number of solute particles per kilogram of solvent). If solute (without water) is added to compartment number 1 without changing the volume of the compartment, the concentration of osmoles in that compartment will increase transiently. The increase in osmolality in compartment number 1 will result in

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movement of water (by osmosis) from compartment number 2 to compartment number 1 until the osmolality of the two compartments is equalized. The final osmolality will be the same in both compartments and higher than the initial osmolality.[1]

The same concept will apply if the volume of water or number of Na ions in body fluids is changed: water will flow from one compartment to the other in order to maintain the same osmolality in both compartments. Thus, there are only 4 ways to change serum Na concentration: adding free water (or hypotonic fluid), removing free water (or hypotonic fluid), adding Na, or removing Na.

Hyponatremia is the most common Na disturbance in small animal patients.[2] In a large study investigating hyponatremia in 16,691 dogs and 4211 cats, hyponatremia was identified in 25.5% of dogs and 49.4% of cats.[2] In that study, there was a significant association of hyponatremia with nonsurvival in both dogs and cats; the severity of hyponatremia was linearly associated with a higher case fatality rate in both species. As mentioned before, hyponatremia can result either from excess of free water (eg, water drinking, intravenous fluid therapy, or antidiuretic hormone [ADH] secretion) or from loss of Na (in excess of water), which is rare, because Na usually is followed by water, although some clinical examples do exist (eg, salt-losing nephropathy, cerebral salt wasting syndrome).[3] Hyponatremia usually means that an excessive amount of water is present in body fluids, and the generalization *hyponatremia means too much water* applies in most situations. Treatment of hyponatremia mainly requires understanding and resolution of the primary process.

Conversely, the generalization *hypernatremia means not enough water* also is true most of the time. Hypernatremia may arise either from loss of free water (eg, evaporation from the skin or respiratory tract) or hypotonic fluid or by the addition of Na (eg, intravenous fluid therapy with 0.9% saline or hypertonic saline). Treatment of hyponatremia is mainly based on slow volume replacement to avoid detrimental transcellular shifts of water, as is discussed later.

## SODIUM AND WATER DISTURBANCES: A LITTLE PHYSIOLOGY GOES A LONG WAY

The Darrow-Yannet[4,5] diagram (**Fig. 1**) illustrates the partition of total body water (TBW) into compartments. Although some variation exists based on species, age, or gender, it is estimated that[6]

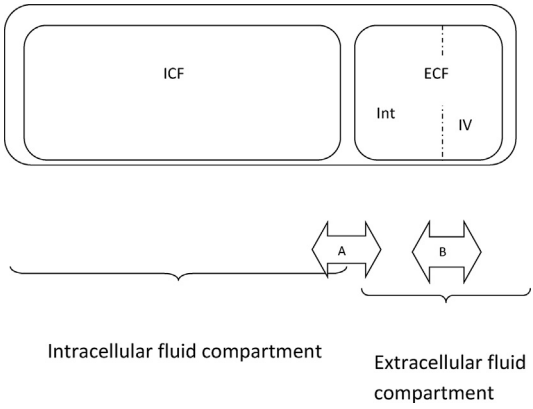


**Fig. 1.** Partition of total body water within body compartments. (A) Movement of water from ICF and ECF. (B) Movement of water within the ECF. See text for details. ECF, extracellular fluid compartment; ICF, intracellular fluid compartment; Int, intersitial compartment; IV, intravascular compartment.