Dibartola Ch 3: Disorders of Sodium and Water

Treatment of Hypernatremia

- Main goals are to replace lost water and electrolytes, and facilitate renal excretion of sodium
    - 1st priority: restore ECF volume
    - 2nd priority: diagnose and treat underlying disease
- Pure Water Loss: intra and extracellular compartments

$$\text{Water deficit} = \text{Wt(present)} \times \left(\frac{P_{Na}(\text{present})}{P_{Na}(\text{previous})} - 1 \right)$$

MacIntyre, Respiratory Care: Principles and Practice: Intracellular FWD

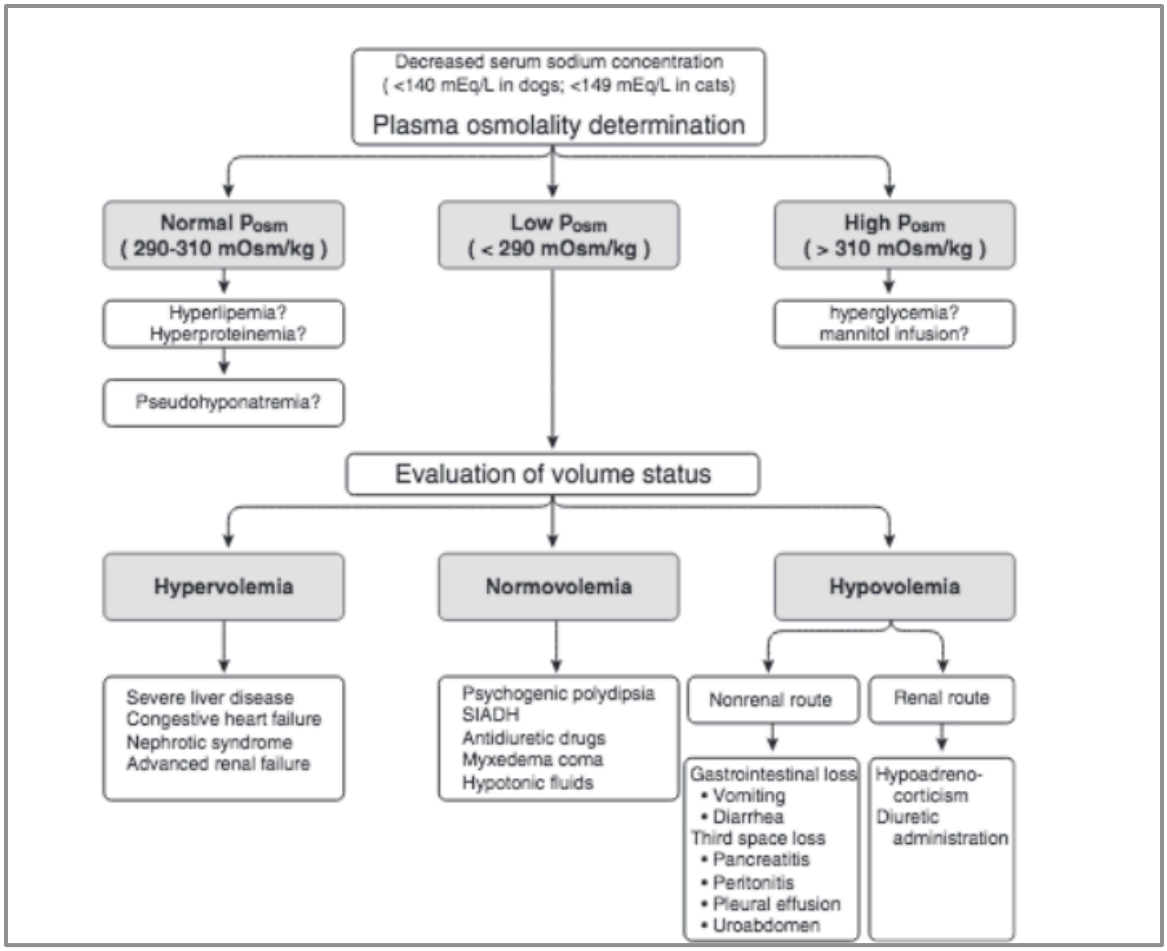
$$\text{Free water deficit} = \text{TBW} \times \left(1 - \frac{140}{\text{Serum Na}^+}\right)$$

$$\text{Free water deficit} = 0.6 \times \text{Weight (kg)} \times \left(1 - \frac{140}{\text{Serum Na}^+}\right)$$

- Pure water deficit:
    - D5W (278 mOsm/kg)
    - The glucose ultimately enters cells and is metabolized so that administration of D5W is equivalent to administration of water
    - FWD must be replaced and hypernatremia corrected slowly over 48 hours of chronic or unknown hypernatremia
        - Brain production of osmolytes or that prevent cellular dehydration
        - Excessively rapid lowering of the serum sodium concentration may result in development of cerebral edema
        - Correction of the serum sodium concentration at a rate of less than 10 to 12 mEq/L per 24 hours minimizes the risk
- Hypotonic loss
    - Cause more severe extracellular volume contraction than do losses of pure water
    - Signs of volume depletion are more likely with hypotonic losses
- Gain of Impermeant Solute
    - In patients with normal cardiac and renal function treat with D5W
        - D5W will further expand an already expanded ECF volume

- In patients who may develop pulmonary edema, use of a loop diuretic and targeting normalization over 48h is likely to be better tolerated

- Approach to the Patient with Hyponatremia
  - Determine osmolality



  - Normal Osmolality
    - Pseudohyponatremia
    - Treatment is directed at underlying disorder, and not 'correction' of the [Na]
  - Increased Plasma Osmolality
    - When an impermeant solute is added to ECF, water moves from ICF to ECF
    - Osmolality of both compartments increases
    - When the added solute is not Na, the serum [Na] is reduced by the translocation of water
      - But plasma osmolality is higher than normal
    - Most common with DM

        - 100mg/dL increase in [glucose] = 1.6-2.4 mEq/L decrease in [Na]
- Decreased Plasma Osmolality
    - The total body sodium content and ECF volume of patients with hyponatremia and hypoosmolality may be normal, decreased, or increased, and hyponatremia may be classified according to the volume status of the patient as hypovolemic, normovolemic, and hypervolemic
    - Hypovolemic Hyponatremia
        - For hypovolemia patients to develop hyponatremia, the total body deficit of sodium must exceed that of water
        - Fluid loss by renal (diuretic and hypoadrenocorticism) or nonrenal (GI and 3rd spacing) routes
    - Hypervolemic Hyponatremia
        - May occur despite the presence of increased total body sodium and expansion of the ECF in patients with ascites or edema
        - Occurs via impaired excretion of ingested water leading to a dilutional effect on the serum sodium concentration
        - Observed in three clinical conditions:
            - Congestive heart failure (baroreceptor mediated vasopressin release)
            - Severe liver disease (decreased oncotic pressure, eventual RAAS activation)
            - Nephrotic syndrome (decreased oncotic pressure, RAAS activation, primary renal abn?)
    - Normovolemic Hyponatremia
    - Psychogenic polydipsia, SIADH, administration of hypotonic fluids or drugs with antidiuretic effects, and myxedema coma of severe hypothyroidism
    - SIADH
        - Vasopressin release in the absence of normal osmotic or nonosmotic stimuli
        - 1. Hyponatremia with plasma hypoosmolality
        - 2. Inappropriately high urine osmolality in the presence of plasma hypoosmolality
        - 3. Normal renal, adrenal, and thyroid function
        - 4. Presence of natriuresis despite hyponatremia and plasma hypoosmolality as a result of mild volume expansion (urine sodium concentration usually
        - 5. No evidence of hypovolemia (which could result in nonosmotic stimulation of vasopressin release)
        - 6. No evidence of ascites or edema (which could result in hypervolemic hyponatremia)
        - 7. Correction of hyponatremia by fluid restriction

        - Myxedema coma
            - Decreased distal delivery of tubular fluid and nonosmotic stimulaion of vasopressin release
    - Clinical Signs of Hyponatremia
        - Related to rapidity of onset rather than actual concentration
        - Early signs: mild lethargy, nausea, slight weight gain (but can be marked weight gain in more severe cases), vomiting, coma. With severe, acute cases: weakness, incoordination, and seizures may also result
    - Treatment of Hyponatremia
        - 1. Diagnose and manage the underlying disease
        - 2. (if necessary) increase serum [Na] and plasma osmolality
        - Symptomatic dogs with chronic hyponatremia should be treated conservatively at correction rates of less than 10 to 12 mEq/L/day (0.5 mEq/L/hr)
        - Conventional crystalloid solutions
        - Arginine vasopressin (AVP) receptor antagonists (vaptans) block either V2 receptors or both V2 and V1A receptors
        - Increase free water excretion by the kidneys and effectively normalize serum sodium concentration in patients with non-osmotic release of AVP causing euvolemic (SIADH) or hypervolemic (CHF, liver failure) hyponatremia

$$\begin{aligned} \mathrm{TBS(present)} &= \mathrm{TBS(previous)} \\ \mathrm{TBW(present)} \times P_{\mathrm{osm}}\mathrm{(present)} &= \mathrm{TBW(previous)} \\ &\quad \times P_{\mathrm{osm}}\mathrm{(previous)} \end{aligned}$$

If we assume that body water (TBW) is 60% of body weight measured in kilograms (Wt) and that $2.1 \times P_{\mathrm{Na}}$ is an estimate of P_{osm}:

$$\begin{aligned} &2.1 \times \mathrm{P_{Na}(present)} \times 0.6 \times \mathrm{Wt(present)} \\ &= 2.1 \times \mathrm{P_{Na}(previous)} \times 0.6\,\mathrm{Wt(previous)} \end{aligned}$$

This equation reduces to:

$$\begin{aligned} &\mathrm{P_{Na}(present)} \times \mathrm{Wt(present)} = \\ &\mathrm{P_{Na}(previous)} \times \mathrm{Wt(previous)} \end{aligned}$$

$$\mathrm{Wt(previous)} = \frac{\mathrm{P_{Na}(present)} \times \mathrm{Wt(present)}}{\mathrm{P_{Na}(previous)}}$$

The water deficit is the difference between the previous and present body weights:

$$\begin{aligned} &\mathrm{Wt(previous)} - \mathrm{Wt(present)} = \\ &\frac{\mathrm{P_{Na}(present)} \times \mathrm{Wt(present)}}{\mathrm{P_{Na}(previous)}} - \mathrm{Wt(present)} \end{aligned}$$

or

$$\mathrm{Wt(present)} \times \left(\frac{\mathrm{P_{Na}(present)}}{\mathrm{P_{Na}(previous)}} - 1 \right)$$

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