YOUR GUIDE TO
Common Electrolyte Disturbances

An Algorithmic Approach to Navigating the Evaluation and Management of 6 Electrolyte Imbalances
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Navigating Care for Common Electrolyte Disturbances

No matter the cause, electrolyte disturbances are frequently encountered in the small animal veterinary clinic. Canine and feline patients can experience a wide range of imbalances, ranging from hypochloremia to hypernatremia. Though common, navigating these conditions can be complex. This book is a collection of algorithms, written by Drs. Audrey Cook and Justin Heinz, to aid in the evaluation and management of 6 of the most common electrolyte disturbances. Use this book to guide your care decisions for these imbalances, and if needed, access an in-depth review of each condition via the link in its introduction. — The Editors of TVP
Hypochloremia

Subnormal serum [Cl] are often noted in patients with changes in total body water content and are therefore associated with proportional decreases in serum sodium values. Specific evaluation of chloride status is unnecessary, and reasons for a change in serum [Na] should be investigated instead. Read More About This Condition.

Evaluation of the Hypochloremic Patient

Calculate corrected chloride = Normal [Na] / Patient [Na] × Patient [Cl]

Is this within the reference range?

- No
  - History of diuretic use or sodium bicarbonate administration?
    - Yes
      - Adjust as appropriate and reassess
    - No
      - Evidence of respiratory compromise?
        - Yes
          - Provide oxygen therapy; pursue thoracic and/or airway diagnostics
        - No
          - History of vomiting?
            - Yes
              - Gastrointestinal obstruction highly likely; pursue appropriate diagnostics
            - No

[Cl] = chloride concentration; [Na] = sodium concentration
Chlorine is the most abundant extracellular fluid anion, and serum [Cl] are closely linked to sodium status. Processes that increase [Na] are expected to drive [Cl] in the same direction; a disconnect between the two therefore has diagnostic and therapeutic implications. Read More About This Condition.

**Hyperchloremia**

Chloride is the most abundant extracellular fluid anion, and serum [Cl] are closely linked to sodium status. Processes that increase [Na] are expected to drive [Cl] in the same direction; a disconnect between the two therefore has diagnostic and therapeutic implications.

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**Evaluation of the Hyperchloremic Patient**

(Reported [Cl] > Upper End of Reference Range)

1. **Determine corrected [Cl]**
   
   \[ \text{Corrected [Cl]} = \frac{\text{Normal [Na]} \times \text{Patient [Cl]}}{\text{Patient [Na]}} \]

2. **Increased**
   
   - **History of halide administration?**
     - Yes: Spurious hyperchloremia
     - No: Lipemic sample?

3. **Lipemic sample?**
   
   - Yes: Remasure using ion-selective method
   - No: Address as appropriate and measure.

4. **Metabolic acidosis**
   
   - Acidic or neutral
     - Yes: Consider end-stage renal disease
     - No: Glucosuria?
   
   - Alkalotic
     - Yes: Consider RTA type II
     - No: Fanconi syndrome

5. **pH decreased**
   
   - History of diarrhea?
   - Medication use?
   - Fluid therapy?

6. **pH increased**
   
   - History of diarrhea?
   - Medication use?
   - Fluid therapy?

Read More About This Condition.
Does the patient need immediate fluid resuscitation?

No

Yes

Consider alternative dilution solutions for medication, if available (not 0.9% NaCl)

Use a balanced, buffered replacement fluid (not 0.9% NaCl)

Patient with metabolic acidosis:

Chronic

Acute

Begin oral NaHCO₃

Administer a buffered replacement fluid

Venous pH > 7.1

Venous pH < 7.1

Calculate \( \text{HCO}_3^- \) deficit

\[
\text{HCO}_3^- \text{ deficit} = \text{Weight (kg)} \times (\text{Desired} [\text{HCO}_3^-] - \text{Patient} [\text{HCO}_3^-]) \times 0.3
\]

Administer 1/3 IV over 30 minutes; reassess

\( \text{HCO}_3^- = \text{bicarbonate}; \text{NaCl} = \text{sodium chloride}; \text{NaHCO}_3 = \text{sodium bicarbonate} \)
Hypokalemia

Changes in [K] within the extracellular fluid are a poor reflection of total body potassium content. In most instances, hypokalemia reflects potassium loss (via the kidneys or gastrointestinal tract) or the translocation of potassium into the intracellular compartment. Read More About This Condition.

Evaluation of the Hypokalemic Patient (Defined as [K] < 3.5 mmol/L)

- History of diuretic, β-agonist, insulin?
  - Yes: Likely iatrogenic; address and adjust plan
  - No: Recent fluid therapy?
    - Yes: Determine volume status
    - No:
      - Hypovolemia: Vomiting and/or diarrhea?
        - Yes: GI loss
        - No: Acute kidney injury; diabetes mellitus
      - Euvolemia: Polyuria?
        - Yes: Hyperaldosteronism
        - No: Chronic kidney disease
      - Hypervolemia: Renal tubular acidosis
        - Hereditary
        - Toxicity

[K] = potassium concentration; GI = gastrointestinal
Management of the Hypokalemic Patient
(Defined as $[K] < 3.5$ mmol/L)

- **Serum $[K]$**
  - $< 2.5$ mmol/L
    - Does the patient need ventilatory support?
      - **Yes**
        - Intubate and manage as appropriate
        - Provide concurrent oral potassium at 0.5 mEq/kg q6-12h
        - Recheck serum $[K]$ in 4-6 hours
      - **No**
        - Begin KCl infusion at 0.5 mEq/kg/hr (see full text at link for information regarding higher dose rates)
  - $2.5-3$ mmol/L
    - Does the patient need fluid therapy?
      - **Yes**
        - Supplement fluids to $\approx 30$ mEq K/L
        - Recheck serum $[K]$ in 12-24 hours
      - **No**
        - Recheck serum $[K]$ in 5-7 days
      - **Yes**
        - Start oral potassium at 0.5 mEq/kg q12h
        - Recheck serum $[K]$ in 5-7 days
  - $> 3$ mmol/L
    - Does the patient need fluid therapy?
      - **Yes**
        - Supplement fluids to $\approx 30$ mEq K/L
        - Recheck serum $[K]$ in 12-24 hours
      - **No**
        - Recheck serum $[K]$ in 5-7 days

$[K] = $ potassium concentration; KCl = potassium chloride
Hyperkalemia is defined as a plasma or serum $[K]$ in excess of the established reference range. The causes of hyperkalemia are generally classified as increased potassium input, decreased potassium excretion, and translocation from intracellular to extracellular compartments. Read More About This Condition.

Evaluation of the Hyperkalemic Patient

Is hyperkalemia consistent with the patient’s history and physical examination?

- Yes
  - Consider thrombocytosis, EDTA contamination, hemolysis; verify $[K]$.

- No
  - True hyperkalemia
    - Is the patient on fluids, ACEI, ARB, or diuretic?
      - Yes
        - Spurious hyperkalemia
      - No
        - Consider iatrogenic
          - Is the patient azotemic?
            - Yes
              - Consider uroabdomen
            - No
              - Is the bladder large?
                - Yes
                  - Consider urethral obstruction
                - No
                  - Consider insulin deficiency
                    - Is the patient hyperglycemic?
                      - Yes
                        - Does the patient have ascites?
                          - Yes
                            - Consider unobstructed
                          - No
                            - Consider AKI: aldosterone deficiency (hypoadrenocorticism or hyporeninemic hypoaldosteronism)
                      - No
                        - Does the patient have ascites?
                          - Yes
                            - [K] attributable to third spacing
                          - No
                            - Consider parasitism, myopathy

ACEI = angiotensin-converting enzyme inhibitor; AKI = acute kidney injury; ARB = angiotensin receptor blocker; EDTA = ethylenediaminetetraacetic acid; $[K]$ = potassium concentration.
Management of the Hyperkalemic Patient

[K] <6 mmol/L
- No immediate action required; investigate cause

[K] 6–7 mmol/L
- Evaluate heart rate and ECG

[K] >7 mmol/L
- Evidence of cardiac compromise or volume overload?
  - Yes
    - Terbutaline 0.01 mg/kg IV or IM
    - Calcium gluconate 10% 0.5 mL/kg IV over 20 minutes
    - Dextrose 50% 1 mL/kg IV (dilute 1:4 if given directly IV)
    - Regular insulin 0.5 U/kg IV plus dextrose 50% at 4 mL/kg IV
    - Sodium bicarbonate 1–2 mEq/kg IV over 15 minutes (dilute 1:4 if given directly IV)
  - No
    - Administer replacement fluid bolus 20 mL/kg
    - Add 50 mL of dextrose 50% to ongoing fluid therapy (to create a 2.5% solution)

ECG = electrocardiogram; [K] = potassium concentration
Hyponatremia is defined as a plasma or serum [Na] below the reference range and usually reflects the loss of sodium in excess of water or, less commonly, the addition of water in excess of sodium. Mild, acute hyponatremia is of little concern, but elevated serum [Na] merits attention if the clinical history suggests chronicity. Read More About This Condition.

Evaluation of the Hyponatremic Patient (Defined as [Na] <130 mmol/L)

Hyponatremia

GI = gastrointestinal; [Na] = sodium concentration

Serum protein or lipid concentrations

Normal

High

Verify [Na] with direct ion-selective electrode

Serum glucose concentrations

Normal

High

Correct for hyperglycemia, if present: (see full text at link for details)

True hyponatremia

Normal corrected [Na]

No specific action needed

Iatrogenic

Sodium loss

Water excess

Sodium loss

Urinary loss

Third spacing

GI loss

Inappropriate antidiuresis

Inappropriate fluid therapy

Heart failure

Liver dysfunction

Diuretic administration

Acute kidney injury

Hypoadrenocorticism

Water intoxication

Nephrotic syndrome

Liver dysfunction

GI = gastrointestinal; [Na] = sodium concentration
Management of the Hyponatremic Patient (Defined as [Na] <130 mmol/L)

Assess duration of hyponatremia (based on history, neurologic status, etc.)

- Acute (i.e., ≤24 hr)
  - Does the history suggest/support acute water intoxication?
    - No
      - No specific action needed; treat as appropriate
    - Yes
      - Using D5W, create a fluid with [Na] within 10 mmol/L of patient’s measured serum [Na]
      - 2 mL/kg 3% NaCl IV over 10–60 min; repeat until [Na] is 4–6 mmol/L higher or patient is neurologically improved

- Chronic (i.e., >24 hr)
  - Does the patient need immediate fluid resuscitation (i.e., is the patient showing signs of hypovolemic shock)?
    - No
      - Stabilize; reassess patient [Na]
    - Yes
      - Calculate Na deficit = (Target [Na] − Patient [Na]) × TBW
      - Determine time to replace deficit = (Target [Na] − Patient [Na]) × 2.4

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D5W = 5% dextrose in water solution; K = potassium; Na = sodium; [Na] = sodium concentration; NaCl = sodium chloride; TBW = total body water
Hypernatremia

Hypernatremia is defined as a plasma or serum [Na] above the reference range and reflects the loss of water in excess of sodium, or the addition of sodium in excess of water. [Na] is regulated by antidiuretic hormone, thirst, and aldosterone. A patient with hypernatremia therefore must be unable or unwilling to consume adequate amounts of water or unable to retain adequate water. Read More About This Condition.

Evaluation of the Hypernatremic Patient (Defined as [Na] >160 mmol/L)

Serum protein concentrations

Normal or increased

Low

Verify [Na] with direct ion selective electrode

True hypernatremia

Spurious hypernatremia

Determine neurologic status

Abnormal

Apparent normal

 Obtundation due to shock

Central hypodipsia

Acute salt toxicity

Salt ingestion

Pool/ocean water

Play-Doh

Follow algorithm for “undervolumed” patient

Undervolumed

Hypotonic fluid loss

Adipsia/hypodipsia

Diuretic administration

Polyuric conditions

Gastrointestinal loss

Iatrogenic

Hyperaldosteronism

Determine volume status

Apparently euvolemic

Volume loaded

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Management of the Hypernatremic Patient 
(Defined as [Na] >160 mmol/L)

Does the patient need immediate fluid resuscitation?

Yes

Using hypertonic saline, create a fluid with [Na] within 10 mmol/L of patient’s measured serum [Na]

Administer as appropriate

Expected change in [Na] with 1 liter of fluids = (Fluid [Na + K] – Patient [Na])/(TBW + 1)

Stabilize; reassess patient [Na]

No

Calculate FWD = (Patient [Na] – Target [Na])/Target [Na] × TBW

Acute (i.e., ≤24 hr)

Target change in [Na] = 1 mmol/hr

Time to replace FWD (hr) = Patient [Na] – Target [Na]

Determining concurrent replacement and maintenance fluid needs

Create/select fluid with appropriate [Na]

Recheck patient [Na] every 4-6 hr, adjust as needed

Chronic (i.e., >24 hr)

Target change in [Na] = 0.5 mmol/hr

Time to replace FWD (hr) = (Patient [Na] – Target [Na]) × 2

FWD = free water deficit; [K] = potassium concentration; [Na] = sodium concentration; TBW = total body water

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