

Hyponatremia and Hypokalemia

Critical Care in the ED
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No financial disclosures



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Outline:

1. Hyponatremia

- Diagnosis
- Initial treatment

2. Hyperkalemia

- Diagnosis
- Initial treatment



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Hyponatremia: diagnosis

Is it “True” hyponatremia?

- Send serum OSM (normal 285-295 mmol/L)



Peixoto, A. SCCM MCCBRC. 2015; Faubel and Topf, 1999.



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Hyponatremia: diagnosis

False Hyponatremia:

If serum OSM normal (285-295 mosm/kg)

- Hyperproteinemia
- Hyperlipidemia

If serum OSM high (>295 mosm/ kg)

- Hyperglycemia
- Mannitol
- ETOH**



Faubel and Topf, 1999.



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Hyponatremia: diagnosis

True hyponatremia (hypotonic hyponatremia)

Low serum osmolality (<280 mosm/ kg)



Faubel and Topf, 1999; Topf, Joel. In Watto, M. Hyponatremia Deconstructed. The Curbsiders Podcast. 2019



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Hyponatremia: diagnosis

Is ADH present? (and is water excretion normal)



Peixoto, A. SCCM MCCBRC. 2015



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Hyponatremia: diagnosis

No ADH present (Urine mOsm/kg < 100-200)

- Increased water consumption
 - Primary polydipsia
- Decreased solute intake
 - beer potomania
 - tea and toast diet



Peixoto, A. SCCM MCCBRC. 2015; Topf, Joel. In Watto, M. Hyponatremia Deconstructed. The Curbsiders Podcast. 2019



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Hyponatremia: diagnosis

ADH present (Urine mOsm/kg > 100-200)

Is ADH excretion appropriate?



Peixoto, A. SCCM MCCBRC. 2015



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Hyponatremia: diagnosis

ADH present (Urine mOsm/kg > 100-200)

Is ADH excretion appropriate? → Check volume status

Hypovolemic: YES

- Urine Na > 20 mEq/ L
 - Renal losses (ex. diuretics)
- Urine Na < 20 mEq/ L
 - Extra renal losses (ex. vomiting)



Peixoto, A. SCCM MCCBRC. 2015; *Am Fam Physician*. 2015;91(5):299



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Hyponatremia: diagnosis

ADH present (Urine mOsm/kg > 100-200)

Is ADH excretion appropriate? → Check volume status

Hypervolemic: YES but “maladaptive”

- ex. heart failure, cirrhosis



Peixoto, A. SCCM MCCBRC. 2015



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Hyponatremia: diagnosis

ADH present (Urine mOsm/kg > 100-200)

Is ADH excretion appropriate? → Check volume status

Euvolemic: NO

- SIADH
 - CNS disease
 - Malignancy
 - Medications
 - Surgery / pain
 - Pulmonary disease
- Hypothyroidism
- Adrenal insufficiency



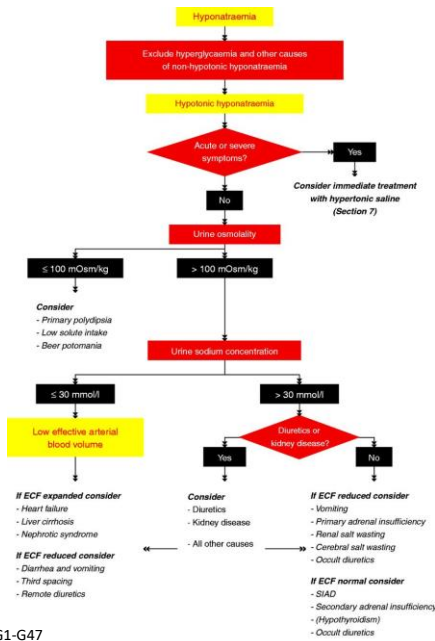
Int J Nephrol Kidney Failure 2016 2(3); Peixoto, A. SCCM MCCBRC. 2015



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Eur J Endocrinol 2014; 170 (3), G1-G47



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Hyponatremia: treatment

Pathophysiology:

Acute vs. Chronic

- **Chronic** hyponatremia: brain cells extrude organic solutes from cytoplasm, which allows equalization of serum and plasma OSM without large increase in cell water
- **Acute** hyponatremia: "Ability of brain to adapt to cellular swelling is exceeded and cerebral edema may result."



Am J Med 2013; 126, S1-S42



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Hyponatremia: treatment

Osmotic demyelinating syndrome:

Initial improvement with serum NA levels, then one to several days later patient will present with new and progressive neurological deficits

Dx: MRI will show typical changes in pons; may take up to 4 weeks to develop changes on imaging.

Table 3 Factors That Place Patients at High Risk of Developing the Osmotic Demyelination Syndrome with Correction of Chronic Hyponatremia

High Risk of Osmotic Demyelination Syndrome

- Serum sodium concentration ≤ 105 mmol/L
- Hypokalemia*
- Alcoholism*
- Malnutrition*
- Advanced liver disease*

L = liter; mmol = millimole.

*Unlike the rate of increase in serum sodium concentration, neither the precise level of the serum potassium concentration nor the degree of alcoholism, malnutrition, or liver disease that alters the brain's tolerance to an acute osmotic stress have been rigorously defined.



Am J Med 2013; 126, S1-S42



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Hyponatremia: treatment

Severity	Symptom
Moderately severe	Nausea without vomiting Confusion Headache
Severe	Vomiting Cardiorespiratory distress Abnormal and deep somnolence Seizures Coma (Glasgow Coma Scale ≤ 8)



Eur J Endocrinol 2014; 170 (3), G1-G47



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Hyponatremia: treatment

Hyponatremia with severe symptoms:

100 cc bolus of 3% saline over ten minutes

- X3 if needed
- “Goal is urgent correction of serum Na 4-6 mmol/L to prevent brain herniation and neurological damage”

OR

150 cc bolus 3% over 20 minutes with re-dosing as needed until target of 5 mmol/L is reached (1D)



Eur J Endocrinol 2014; 170 (3), G1-G47; *Am J Med* 2013; 126, S1-S42



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Hyponatremia: treatment

Hyponatremia with moderate symptoms:

- Begin prompt diagnosis
- Remove medications and other factors contributing to hyponatremia
- Cause specific treatment
- Consider single IV infusion of 150 cc 3% hypertonic over 20 minutes (2D)



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Hyponatremia: treatment

Mild to moderate symptoms: Rate of correction

- Minimum correction of 4- 8 mmol/L/d if risk for ODS low
- Minimum correction of 4-6 mmol/L/d if risk for ODS high; not to exceed 8 mmol/L/d
- Versus 10 mmol/ L in first day and 8 in second day (EJE)

Agreement in <18 mmol/L in 48 hours



Eur J Endocrinol 2014; 170 (3), G1-G47; *Am J Med* 2013; 126, S1-S42



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Hyponatremia: treatment

Severe chronic hyponatremia:

Correction rate of 4-6 mEq/L/d

Initial infusion rate can be estimated by using desired correction rate times weight in kg (ex. rate of 0.5-1.0 mmol/L/hr x weight in kg to correct serum Na level by 0.5- 1.0 mmol/L/ hr.)



Eur J Endocrinol 2014; 170 (3), G1-G47; *Am J Med* 2013; 126, S1-S42; *N Engl J Med* 2007; 356:2064-2072



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Hyponatremia: treatment

Cause specific treatment:

Hypovolemic hyponatremia: monitor electrolytes, observe rate of correction for chronic hyponatremia, may need to switch to hypotonic fluid to retard rate of correction once Na approaches goal

SIADH: fluid restriction, possible vaptan therapy

Tea and toast: increase solute intake

Primary polydipsia: fluid restriction, monitor for diuresis

Hypervolemic hyponatremia (heart failure): hypertonic saline with loop diuretics versus fluid restriction



Eur J Endocrinol 2014; 170 (3), G1-G47; *Am J Med* 2013; 126, S1-S42



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Hyponatremia: treatment

Pitfalls:

- “Normal saline never hurt anybody”
 - “The degree to which normal saline raises serum Na varies with the cause of the hyponatremia”
 - Situations to avoid normal saline:
 - SIADH
 - Hypervolemic hyponatremia (cirrhosis, ex)
 - Severe hyponatremia
- Watch for rapidly reversible causes of hyponatremia
 - Water diuresis that can lead to rapid overcorrection
 - Ex. True volume depletion, adrenal insufficiency, SIADH (stimulus removed)



Eur J Endocrinol 2014; 170 (3), G1-G47; *Am J Med* 2013; 126, S1-S42



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Hyponatremia: Summary

- **Initiate diagnostic work up early in ER**
 - Detailed history and physical
 - Serum electrolytes, UA, Serum OSM, urine OSM and urine electrolytes
 - If consistent with SIADH, look for cause
 - Thyroid function
 - Cortisol level
- **Decide if emergent treatment required in ER** (ex. if severely symptomatic)
 - 150 cc bolus 3% hypertonic saline with goal increase in serum Na 5 mmol/L
- **In chronic hyponatremia:**
 - Use cause specific therapies
 - Avoid overcorrection
 - use caution with normal saline
- **Monitor for rapid reversal of condition leading to large volume urine output**



Am J Med 2013 126, S1-S42



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Hyperkalemia: diagnosis

Pseudohypokalemia is common:

- Hemolysis
- Leukocytosis
- Thrombocytosis
- Traumatic venipuncture

Mechanisms of hyper K:

- Increased intake
- Transcellular shifts
- Impaired excretion



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Hyperkalemia: diagnosis

-Symptoms are sparse

- Cardiac arrest was a presenting symptom in 43% of 1803 patients hospitalized at a tertiary care center with serum $K^+ \geq 6.5$

-ECG is insensitive for diagnosis of hyperkalemia

- “<50% of patients who had dangerous arrhythmias or death had EKG changes”
- Severe hyperkalemia with normal ECG



Clin J Am Soc Nephrol. 2008 Mar;3(2):324-30; An et al, *Crit Care* 2012; Topf, Joel. In Watto, M. Hyperkalemia Masterclass. The Curbsiders Podcast. 2019



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Hyperkalemia: diagnosis

What qualifies as requiring emergent therapy?

1. Clinical signs of hyperkalemia: cardiac conduction abnormalities, muscle weakness/ paralysis
2. Severe hyperkalemia (serum potassium >6.5 mEq/L)
3. Moderate hyperkalemia (serum potassium >5.5 mEq/L) with ongoing potassium absorption



Treatment and prevention of hyperkalemia in adults. *UpToDate*, Waltham, MA, 2017



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Hyperkalemia: treatment

3 treatment stages:

1. 10 minutes: cellular membrane stabilization
2. 30 min: Intracellular K⁺ shift
3. 120 min: K⁺ excretion/ removal



Pharmacol Res. 113 (2016) 585-591



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Hyperkalemia: treatment

Stabilize cardiac membrane:

- Calcium: > 6.0 with ECG changes or
- >6.5 with with/ without ECG changes
- 10 mL of 10% calcium gluconate or calcium chloride administered as bolus
 - Onset immediate, duration of effect 30-60 minutes



Pharmacol Res. 113 (2016) 585-591; NHS Guidelines Oct 2018



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Hyperkalemia: treatment

Intracellular shift:

- Regular insulin with glucose/ dextrose alone or
 - Onset of action 15 min, peak 30-60 and last for 4-6 hours
 - q1 hour Accuchecks for up to 6 hours following administration
- Combination of nebulized B2 agonist (albuterol 10-20 mg) used as single dose to shift K intracellularly
 - Effects of inhaled B agonists observed within 30 mins and duration is approximately 2 hours



Pharmacol Res. 113 (2016) 585-591; Topf, Joel. In Watto, M. Hyperkalemia Masterclass. The Curbsiders Podcast. 2019



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Hyperkalemia: diagnosis

Bicarbonate: “sodium bicarbonate should not be first line strategy to treat hyperkalemia in life-threatening situations”



Pharmacol Res. 113 (2016) 585-591



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Hyperkalemia: treatment

Potassium removal/ excretion

- Consider loop diuretics
- Potassium binding agents
 - Sodium polystyrene sulfonate
 - Should not be given in post op patients, those with bowel obstruction or ileus, those with underlying bowel disease
 - Patiromer
- Hemodialysis in patients with severe renal dysfunction



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Hyperkalemia: Summary

- Prompt recognition of hyperkalemic emergency
- Acute treatment decisions should not be based on ECG alone
- Mainstays of emergency therapy are IV calcium, IV insulin and promotion of renal excretion of potassium
- Potassium binders as second agent if delay for HD
- Early call to nephrology if severe renal dysfunction



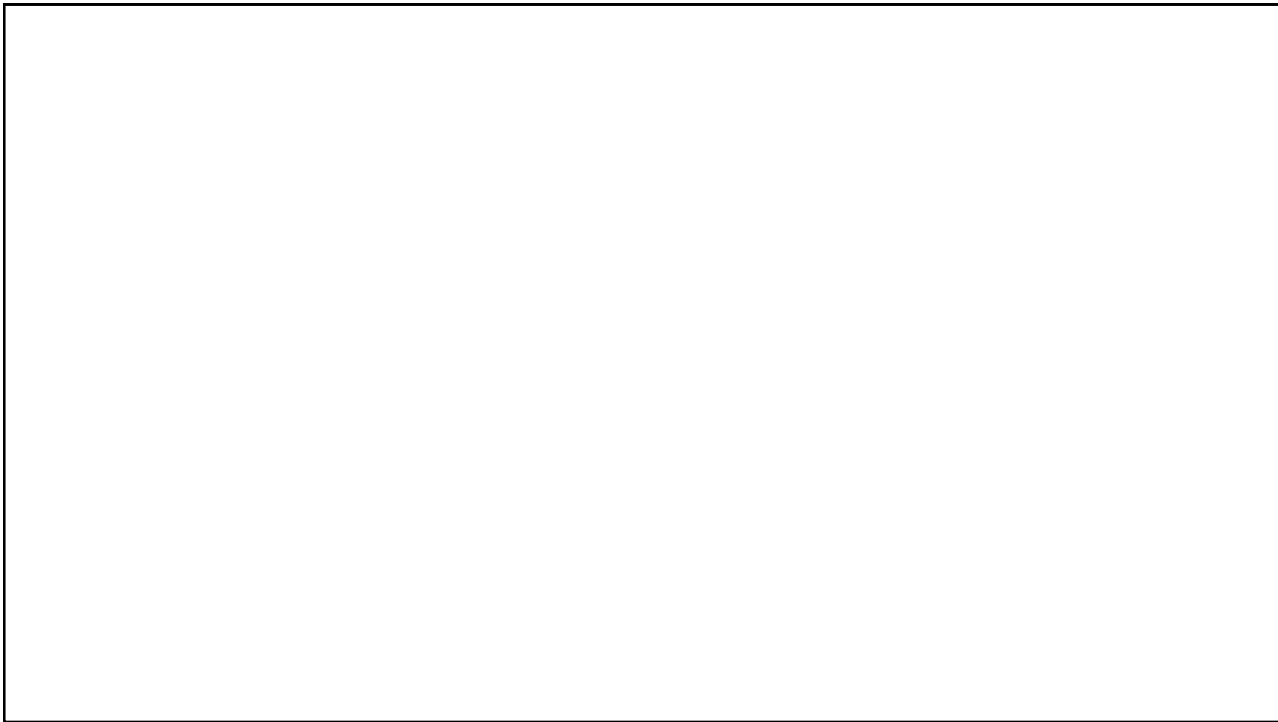
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