

Electrolytes

Tony Mills

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1. Hyponatremia

- a. Causes:
 - i. Decreased GFR: Kidney can only manipulate what is filtered into the tubule
 - ii. Poor Kidney Function: Inability to concentrate urine
 - iii. ADH: Increased hypothalamic secretion or decreased response.
 1. SIADH, Diabetes insipidus
 - iv. Diuretics: especially thiazides
 - v. Free water intake: hard to do with good kidneys
 - vi. Pseudohyponatremia: Very rare
 1. Hypertriglyceridemia (1000's)
 2. Hyperproteinemia (multiple myeloma)
- b. Hypertonic Hyponatremia
 - i. Severe hyperglycemia / mannitol tx
 1. Sodium drops 1.6 for every 100 glucose over 100
 - ii. Glucose pulls fluid from cellular space, diluting Na
- c. Hypotonic Hyponatremia
 - i. Impaired renal water excretion and Free water intake
- d. Asymptomatic
 - i. Asymptomatic hyponatremia should be corrected gradually
 - ii. Water restriction: will temporarily stop worsening of hyponatremia. Not appropriate for most long term therapies.
 - iii. Edematous states: Treat the Na overload with diuretics. Only use water restriction if hyponatremia is present
 - iv. Dehydration: Treat with 0.9% saline
 - v. SIADH: Water restriction, consider vasopressin
 1. Stop underlying problem
- e. Symptomatic
 - i. **Symptomatic hyponatremia is a medical emergency and needs to be treated immediately**
 - ii. **Rapidity of onset is more important than actual Sodium concentration**
 - iii. Water restriction: will stop condition from worsening....temporizing measure only
 - iv. **Severe CNS symptoms:**
 1. **Hypertonic saline to raise the Na level 6-8meq/L at a rate of ~ 1 mEq/L per hour**
 2. If symptoms improve, hypertonic saline should be stopped
 3. 50-100mL/Hr of 3% saline is a good starting point until calculations can be made.
 4. **This is not to correct the hyponatremia, it is to alleviate cerebral edema.**

2. Hypernatremia

- a. Causes
 - i. Extra-renal water losses: Insensible losses, diarrhea, Sweat
 - ii. Renal water losses: Osmotic losses, Diabetes Insipidus
 - iii. Iatrogenic: administering hypertonic saline
 - iv. Inadequate water intake
- b. Symptoms
 - i. CNS
 1. Anorexia, restlessness, nausea, and vomiting occur early
 2. altered mental status, lethargy or irritability, and, eventually, stupor or coma
 - ii. Musculoskeletal
 1. witching, hyperreflexia, ataxia, or tremor
- c. Treatment
 - i. Severe dehydration should be corrected with 0.9% saline
 - ii. Subsequent replacement with hypotonic fluid
 1. 0.5-1 mEq/hr over 36-72 hours
 - iii. Replace deficit plus maintenance

3. Hypokalemia

a. Causes

- i. Spurious
 1. Insulin immediately preceding sample
 2. Sample sits too long: WBC's take up K
- ii. Redistribution
 1. Alkalosis, Beta-adrenergics, Theophylline Toxicity, Factor replacement for severe megaloblastic anemias
- iii. Extra-Renal
 1. Diarrhea / laxative abuse, Sweat, Fasting / inadequate intake
- iv. Renal
 1. With Metabolic Acidosis
 2. DKA
 3. Carbonic anhydrase inhibitor therapy
 4. Ureterosigmoidostomy
 5. With Metabolic Alkalosis
 6. Magnesium depletion
 7. Antibiotics: Penicillin, Gentamicin
 8. Leukemias

b. Treatment

- i. Oral replacement: Preferred method
- ii. IV replacement
 1. Risk of severe Hyperkalemia
 2. Irritates veins
 3. Limit concentration to 30 mEq/L and rate to 10 mEq/Hr
 - a. May ↑ in Emergent setting with Central lines and close monitoring

4. Hyperkalemia

a. Causes

- i. Pseudohyperkalemia:
 1. marked thrombocytosis (platelets > 1,000,000) or Severe Leukocytosis (WBC > 200,000)
 2. Mononucleosis
 3. Hemolysis during blood draws
- ii. Redistribution:
 1. Acidosis, Hypertonic states, Massive Digitalis overdose, Autosomal Dominant hyperkalemic periodic paralysis
- iii. Impaired Excretion
 1. Aldosterone deficiency, Renal failure
- iv. Drugs

b. Symptoms

- i. Neuromuscular:
 1. weakness, ascending paralysis, respiratory failure
- ii. EKG changes:
 1. peaked T waves, flattened p waves, prolonged PR interval, idioventricular rhythm, widened QRS with deep S waves, Sine wave pattern

c. Treatment

- i. Stop potassium administration
- ii. Obtain EKG
- iii. Send Stat repeat potassium (draw without tourniquet)
- iv. **If EKG changes:**
 1. **Calcium 10 ml of 10% solution (1 gm) IV over 5-10 minutes to stabilize the heart**
 2. **Insulin 10 units with Glucose to drive K+ into cells**
 3. **Fluids to dilute the K+**
 4. **Bicarb 1 ampule (50 mEq) IV over 5-10 minutes if Acidotic to redistribute**
 5. Hemodialysis
 6. Kayexalate 15-30 gms in sorbitol orally

5. Hypocalcemia

a. Causes

- i. Cellular metabolic dysfunction:
- ii. Shock, Sepsis, Trauma....
- iii. Pancreatitis
 1. Used with fat to make soaps
- iv. Post-op
 1. Parathyroidectomy
 2. Transient ischemia associated with extensive bilateral neck surgery
- v. Renal Failure
- vi. Phosphatemia

b. Symptoms

- i. Usually not seen until $<1.6\text{mEq/L}$
- ii. Paresthesias
 1. Perioral or fingertips
- iii. Hyperactive DTRs
- iv. Seizures
- v. **Chvostek:**
 1. **twitch at corner of mouth when tapping of facial nerve**
 2. **Present in 10% of normal population**
 3. **Eyelid muscle contraction said to be diagnostic**
- vi. **Trousseau**
 1. **Carpal spasm with blood pressure cuff**
 2. **Pressure greater than systolic x 3 minutes**
 3. **IP joints extended, MCP joint flexed, wrist flexed, forearm pronated**
- vii. EKG
 1. Prolonged QT, T-wave normal, ST segment prolonged

c. Treatment

- i. Not required in asymptomatic patients if not severe or prolonged (>14 days)
- ii. **Correct Mg levels first**
- iii. Calcium supplements +/- Vitamin D
- iv. Milk is a poor source of calcium
 1. Contains phosphates
 2. Children need the phosphates
- v. IV CaCl_2 for severe ($<1.3\text{mEq/L}$) or symptomatic patients
 1. 10ml of 10% over 10-20 minutes
 2. Causes vasoconstriction
 3. May cause Digitalis toxicity

6. Hypercalcemia

a. Symptoms

- i. Stones: Renal calculi
- ii. Bones: Osteolysis
- iii. Moans: psychiatric disorders
- iv. Groans: Peptic Ulcer disease, Pancreatitis and constipation
- v. EKG:
 1. Depressed ST segments, widened T waves, shortened ST segments and QT intervals
 2. Bradyarrhythmias, Bundle branch patterns \rightarrow 2nd degree block \rightarrow complete block

b. Treatment

- i. Volume repletion with NS
- ii. Furosemide 40-100 mg IV Q2-4 hrs
 1. May worsen volume depletion, hypokalemia and hypomagnesemia

7. Hypomagnesemia

a. Causes

- i. Malnourished people: Alcoholics and Elderly
- ii. Cirrhosis
- iii. Pancreatitis
- iv. GI Losses
- v. IV alimentation w/o Mg supplements
- vi. Renal Losses
 - 1. DKA, Loop Diuretics, Hypophosphatemia, Aminoglycosides, Nephrotoxic chemotherapy

b. Symptoms

- i. Neuromuscular Irritability
 - 1. Chvostek, Trousseau, Tetany, Convulsions
- ii. EKG changes
 - 1. Prolonged PR and QT, Widened QRS, Depression of ST, Inversion of T waves

c. Treatment

- i. Watch for other Electrolytes abnormalities: hypokalemia, hypocalcemia, and hypophosphatemia
- ii. Replacement
 - 1. First 2.0 gms IV may be given in over 1-2 hrs
 - 2. 8-12 gms may be given IV or IM on first day
 - 3. 4-6 gms per day thereafter

8. Hypermagnesemia

a. Causes

- i. Renal insufficiency/failure
- ii. Mg containing laxatives, antacids or enemas
- iii. Rhabdomyolysis
- iv. Perinatal setting
 - 1. Following Tx for pre-eclampsia
 - 2. Mom or Baby

b. Symptoms

<u>Level</u>	<u>Symptom</u>
2-3	Nausea
3-4	Somnolence
4-8	Loss of DTRs
8-12	Respiratory Depression
12-15	Hypotension, heartblock, cardiac arrest

c. Treatment

- i. Dilution with IV fluids
- ii. Furosemide 40-80mg IV
- iii. CaCl 5ml 10% IV over 5 min
- iv. Dialysis