Overview of Fluid and Electrolyte Maintenance

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Disclosure

• I have no relevant financial relationships to disclose.
Pharmacist Objectives

• Discuss the distribution of total body fluid, and apply this concept towards the management of a patient's fluid replacement.

• Recommend an appropriate intravenous fluid regimen based on a patient's clinical characteristics.

• Develop an effective electrolyte replacement plan based on a patient's clinical status and electrolyte abnormalities.

• Identify appropriate clinical situations for the use of hypertonic and hypotonic saline, and recommend monitoring parameters to ensure the safe use of these intravenous fluids.
Technician Objectives

- Recognize appropriate precautions to be taken while compounding intravenous electrolyte replacement products, including hypotonic and hypertonic saline.

- Delineate the differences between colloid and crystalloid fluids, and recall appropriate instances for their use.

- Identify common intravenous fluid regimens and describe appropriate dosages and concentrations for electrolyte additives.

- Identify common units and calculations involved in compounding electrolyte replacement products.
Fluid Management
Fluid Distribution

- Total body fluid (TBF)
  - Estimated as ~60% of lean body weight (LBW) in males
  - Estimated as ~50% of LBW in females

- TBF further divided
  - Intracellular (IC) space 60% of TBF
    - Enclosed by the cell membrane
  - Extracellular (EC) space 40% of TBF
    - Interstitial space 75% of EC fluid
    - Intravascular space 25% of EC fluid
      - Plasma ~3L
      - Red blood cells ~2L fluid

- Distribution in the body determines distribution of intravenous (IV) fluids
Fluid Distribution

Total Body Fluid

Intracellular
60% TBF

Extracellular

Interstitial Fluid
75% EC

Capillary Membrane

Intravascular Fluid
25%
Fluid Compartments

Figure 33-1 Distribution of body water. The extracellular space includes the vascular compartment and the interstitial spaces.
Osmotic Equilibrium

• Osmotic pressure
  • Created by concentration of ions/electrolytes in each compartment
  • Responsible for containing water in each space, keeps volume constant

• Osmolality
  • Number of particles per kilogram of water

• Osmotic Equilibrium
  • Water moves across the cell membrane from of region of low osmolality to one of higher osmolality

• Plasma osmolality
  • Normal value: 280-300 mOsm/kg
Acute Fluid Resuscitation

- Intravascular fluid depletion can occur as a result of shock
  - Associated with reduced cardiac function and organ hypoperfusion
  - Signs and symptoms usually occur when ~15% (750mL) of blood volume is lost or shifts out of intravascular space

- Signs and Symptoms of intravascular volume depletion
  - Tachycardia
  - Hypotension
  - Orthostatic changes in HR or BP
  - Increased BUN/Scr ration >10:1
  - Dry mucous membranes
  - Decreased skin turgor
  - Reduced urine output
  - Dizziness
  - Improvement after a 500- or 1000-mL fluid bolus

- Fluid resuscitation is indicated in patients exhibiting signs and symptoms
Acute Fluid Resuscitation

• Goal: restore intravascular volume and prevent organ hypoperfusion

• Crystalloids recommended as a rapid infusion
  • NS or LR typically used
  • LR preferred in surgery and trauma patients
  • LR has more physiological amount of Cl than NS

• Crystalloids vs Colloids
  • No difference has been shown in time to resuscitation or outcomes
  • Colloids: higher cost, some adverse effects

• Selective instances to consider colloids (controversial)
  • 4-6L crystalloid fluid resuscitation has failed or caused significant edema
  • Patients with albumin <2.5mg/dL who have required a large volume already
  • Albumin + diuretics for patients with clinically significant edema and low albumin
Maintenance Fluid Replacement

• Indicated in patients unable to tolerate oral fluids

• Goal: prevent dehydration and maintain normal fluid/electrolyte balance

• Administered as continuous infusions through peripheral or central lines

• Example maintenance fluid
  • $D_5W$ with 0.45% NaCl with 20-40mEq of KCl per liter
Maintenance Fluid Replacement

- Calculations to determine daily volume needed in children and adults
  - Administer 100mL/kg for the first 10kg of weight, then 50mL/kg for the next 10-20kg, plus 20mL/kg for every kilogram greater than 20kg
  OR
  - Administer 20-40ml/kg/day (adults only)

- Adjust fluids according to individual patient’s input, output, insensible losses
Commonly Used IV Fluids

Crystalloids

- Crystalloids
  - Normal saline, Lactated Ringer’s, Normosol-R
  - Contain water, sodium, chloride, and additional electrolytes
  - Hypertonic and hypotonic crystalloid options

- Normal Saline (0.9% sodium chloride)
  - Advantages
    - Low risk for adverse reactions
  - Disadvantages
    - Freely distributes across vascular barrier
    - Risks of hypernatremia and hyperchloremic metabolic acidosis

- Additional Considerations
  - Duration 1-4 hours
  - Isotonic
Commonly Used IV Fluids
Crystalloids

- **Lactated Ringers (or Ringers Lactate)**
  - **Advantages**
    - Low risk for adverse reactions
  - **Disadvantages**
    - Freely distribute across the vascular barrier
    - Risk of respiratory acidosis due to CO\textsubscript{2} accumulation
    - Risk for hyperkalemia (4mEq/L of potassium)
    - Impaired metabolism of lactate to bicarbonate in patients with severe liver disease

- **Additional Considerations**
  - Duration of action 1-4 hours
  - Considered equally effective as NS
  - Not recommended in hemorrhagic shock or brain trauma
  - Traditionally preferred in surgical patients
  - Contains sodium chloride, sodium lactate, potassium chloride, calcium chloride
Commonly Used IV Fluids
Crystalloids

• 5% Dextrose in Water (D₅W)
  • “Free water”: metabolized to water and carbon dioxide
  • Water crosses any membrane in the body
    • 60% into the IC space and 40% to the EC space

• Hypotonic
  • Isotonic in bag but becomes hypotonic when metabolized to free water

• Additional Considerations
  • Not preferred for fluid resuscitation
  • 50 grams of dextrose per liter
  • Not recommended in patients with neurologic injury or elevated intracranial pressure
Commonly Used IV Fluids
Colloids

• Colloids
  • PRBCs, albumin, dextran, hetastarch
  • Too large to cross capillary membrane
  • Provide significant volume increase because they remain in intravascular space

• Controversial use
  • Albumin showed no mortality benefit over NS (SAFE trial)
  • Hydroxyethyl starch no longer recommended due to adverse effects
  • Expensive compared to crystalloids
  • Higher risk of adverse and allergic reactions
Commonly Used IV Fluids

Colloids

- Albumin (5% and 25% formulations)
  - Advantages
    - Colloids provide greater volume expansion than equal volumes of crystalloids
  - Disadvantages
    - Potential for allergic reactions
    - Potential for transmission of infection
    - Hyperoncotic albumin may cause kidney damage
    - Expensive

- Additional Considerations
  - Natural colloid (blood product)
  - Duration of action 12-24 hours
  - 5% albumin is iso-oncotic, 25% albumin is hyperoncotic
Commonly Used IV Fluids

Colloids

- Dextran
  - Advantages
    - Provides greater volume expansion than equal volumes of crystalloids
  - Disadvantages
    - High risk for adverse reactions
    - Potential for allergic reactions or anaphylactoid reactions
    - Impairs hemostasis
    - May cause kidney damage

- Additional Considerations
  - Artificial colloid
  - Duration of action 1-2 hours
  - Use for fluid resuscitation has fallen out to favor due to risk of adverse reactions
Commonly Used IV Fluids

Colloids

- **Hydroxyethyl starch (HES)**
  - **Advantages**
    - Provides greater volume expansion than equal volumes of crystalloids
    - May modulate inflammation
  - **Disadvantages**
    - Potential for anaphylactoid reactions
    - May accumulate in tissues and cause prolonged itching
    - May impair platelet function and/or cause kidney damage
    - Expensive

- **Additional Considerations**
  - Synthetic colloid
  - Duration of action up to 36 hours
  - Hyperoncotic (6%)
  - Larger molecular weight than albumin
  - Not recommended in patients with severe sepsis (increased mortality, bleeding)
## Composition of Commonly Used Intravenous Replacement Solutions

<table>
<thead>
<tr>
<th>Solution</th>
<th>Dextrose</th>
<th>Na (mEq/L)</th>
<th>Cl (mEq/L)</th>
<th>Tonicity</th>
<th>Distribution (% ECF)</th>
<th>Distribution (% ICF)</th>
<th>Free water/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>D$_5$W</td>
<td>5g/100mL</td>
<td>0</td>
<td>0</td>
<td>Hypotonic</td>
<td>40</td>
<td>60</td>
<td>1000mL</td>
</tr>
<tr>
<td>0.45% NaCl</td>
<td>0</td>
<td>77</td>
<td>77</td>
<td>Hypotonic</td>
<td>73</td>
<td>37</td>
<td>500mL</td>
</tr>
<tr>
<td>0.9% NaCl</td>
<td>0</td>
<td>154</td>
<td>154</td>
<td>Isotonic</td>
<td>100</td>
<td>0</td>
<td>0mL</td>
</tr>
<tr>
<td>3% NaCl</td>
<td>0</td>
<td>513</td>
<td>513</td>
<td>Hypertonic</td>
<td>100</td>
<td>0</td>
<td>-2331mL</td>
</tr>
<tr>
<td>LR</td>
<td>0</td>
<td>130</td>
<td>109</td>
<td>Hypotonic</td>
<td>100</td>
<td>0</td>
<td>0mL</td>
</tr>
</tbody>
</table>
# IV Fluid Distribution

<table>
<thead>
<tr>
<th>Intravenous Fluid</th>
<th>Infused Volume (mL)</th>
<th>Equivalent Intravascular Volume Expansion (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>1000</td>
<td>250</td>
</tr>
<tr>
<td>LR</td>
<td>1000</td>
<td>250</td>
</tr>
<tr>
<td>Normosol-R</td>
<td>1000</td>
<td>250</td>
</tr>
<tr>
<td>D5W</td>
<td>1000</td>
<td>100</td>
</tr>
<tr>
<td>Albumin 5%</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Albumin 25%</td>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td>Hetastarch 6%</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>
Electrolyte Replacement
# Electrolyte Composition

<table>
<thead>
<tr>
<th>Total Body Fluid</th>
<th>Intracellular Compartment</th>
<th>Extracellular Compartment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Potassium</td>
<td>• Sodium</td>
</tr>
<tr>
<td></td>
<td>• Magnesium</td>
<td>• Chloride</td>
</tr>
<tr>
<td></td>
<td>• Phosphate</td>
<td>• Bicarbonate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Calcium</td>
</tr>
</tbody>
</table>
Disorders of Sodium

• Normal range 135 – 145 mEq/L

• Role in the body
  • Sodium in the ECF determines the tonicity of the ECF
  • Directly affects the distribution of water between EC and IC compartments
  • Sodium concentration is the ratio of Na:H₂O (not absolute amount of either)
  • Sodium level does not indicate whether abnormality is due to increase in the total amount of Na, H₂O, or both
Hyponatremia

• Sodium concentration <135 mEq/L
• Most common electrolyte abnormality
• Significant morbidity and mortality
• Signs and symptoms
  • Clinically do not appear until sodium <125 mEq/L
  • Acute: cerebral edema, seizures, increased mortality risk
  • Chronic: N/V, confusion, personality changes, neurologic dysfunction, gait disturbances, seizures

<table>
<thead>
<tr>
<th>Serum sodium (mEq/L)</th>
<th>Clinical manifestations</th>
</tr>
</thead>
<tbody>
<tr>
<td>120-125</td>
<td>Nausea, malaise</td>
</tr>
<tr>
<td>115-120</td>
<td>HA, lethargy, obtundation, unsteadiness, confusion</td>
</tr>
<tr>
<td>&lt;115</td>
<td>Delirium, seizure, coma, respiratory arrest, death</td>
</tr>
</tbody>
</table>
## Types of Hyponatremia

<table>
<thead>
<tr>
<th></th>
<th>Hypovolemic Hypotonic Hyponatremia</th>
<th>Euvolemic Hypotonic Hyponatremia</th>
<th>Hypervolemic Hypotonic Hyponatremia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Deficit of both Na and fluid, but total Na is decreased more than TBW</td>
<td>Normal total body Na with excess fluid volume (dilutional)</td>
<td>Caused by excess Na and fluid, but fluid excess predominates</td>
</tr>
<tr>
<td><strong>Example</strong></td>
<td>Fluid loss, third spacing, renal loss</td>
<td>SIADH, medications</td>
<td>HF, cirrhosis, nephrotic syndrome</td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td>Fluid resuscitation</td>
<td>Treat cause Fluid restriction Vasopressin receptor antagonists</td>
<td>Na and water restriction Treat underlying cause Vasopressin receptor antagonists</td>
</tr>
</tbody>
</table>
Principles of Hyponatremia Correction

• AVOID overly rapid increases in serum sodium (>10-12 mEq/L in 24 hours)

• Treat underlying cause

• Chronicity of hyponatremia impacts the rate at which correction should be undertaken

• Transient or permanent brain dysfunction may result from overly rapid correction of hyponatremia
  • Osmotic demyelination syndrome
3% Sodium Chloride Infusion

• High alert medication

• Administration
  • Symptomatic hyponatremia: infusion rate 1-2ml/kg/hour
  • Central IV access (osmolarity >900mOsm/L)
  • If peripheral IV must be used (emergency), monitor for phlebitis
  • Monitor serum sodium changes every 1-4 hours depending on symptom severity

• Complications
  • Osmotic demyelination syndrome
  • Hypokalemia
  • Hyperchloremic acidosis
  • Hypernatremia
  • Heart failure
  • Coagulopathy
  • Hypotension
Hypernatremia

• Sodium level >145mEq/dL
• Hypertonic state resulting in cellular dehydration
• Commonly observed in patients without thirst response
• High mortality rates if serum sodium >160mEq/dL (~60-75%)

• Signs and symptoms
  • Thirst, dry mucous membranes, decreased skin turgor, acute weight loss, weakness, lethargy, restlessness, irritability, confusion, hallucinations, ICH, coma, seizures, death
## Types of Hypernatremia

<table>
<thead>
<tr>
<th></th>
<th>Hypovolemic Hypernatremia</th>
<th>Euvolemic Hypernatremia</th>
<th>Hypervolemic Hypernatremia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Water loss exceeds sodium loss</td>
<td>Water loss only</td>
<td>Sodium gain exceeds water gain</td>
</tr>
<tr>
<td><strong>Example</strong></td>
<td>Insensible losses exceed intake</td>
<td>DI</td>
<td>Sodium overload, mineralicorticoid excess</td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td>0.9%NS until VS stable, then free water</td>
<td>Free water replacement, vasopressin</td>
<td>Free water replacement with loop diuretic, HD</td>
</tr>
</tbody>
</table>
Hypernatremia

- Treatment
  - Depends on cause: too little water or too much sodium

- Rapid correction is NOT indicated
  - Results in cerebral edema, seizures, neurologic damage, death
  - Do not exceed a change of greater than 10mEq/day

- Hypovolemic Hypernatremia
  - NS administered to correct ECF volume
  - Then hypotonic solution to correct $H_2O$ deficit

- Euvolemic hypernatremia
  - Hypotonic solution
  - Treatment for DI if indicated

- Hypervolemic hypernatremia
  - Goal: to remove sodium from the body
  - Diuretics (loops) and hypotonic solution ($D_5W$)
Disorders of Potassium

• Normal range: 3.5 – 5 mEq/L

• Intracellular ion
  • Most abundant cation in the body
  • 98% in intracellular compartment, 2% in extracellular space

• Role in the body
  • Cellular synthesis and metabolism, action potential across cell membrane, neuromuscular activity, cardiac conduction
Hypokalemia

• Potassium level < 3.5 mEq/L
  • Mild: 3 – 3.5 mEq/L
  • Moderate: 2.5 – 3 mEq/dL
  • Severe: < 2.5 mEq/L

• Causes
  • GI loss
  • Medications
  • Metabolic acidosis
  • Hypomagnesemia

• Signs and Symptoms
  • Mild: asymptomatic
  • Moderate to severe: muscle weakness, cramping, ileus, EKG changes, cardiac arrhythmias
Hypokalemia Treatment

- Potassium level 3.5 – 4 mEq/L
  - Increase dietary intake of potassium rich foods

- Potassium level 3 – 3.5 mEq/L
  - PO potassium supplementation in patients with cardiac conditions or on digoxin

- Potassium level <3 mEq/L
  - IV infusion recommended

- Correct hypomagnesemia first
  - Low magnesium impairs the function of the Na-K-ATPase pump
  - Impairment results in increased renal excretion of potassium
# Hypokalemia Treatment

<table>
<thead>
<tr>
<th>Plasma K⁺ (mEq/L)</th>
<th>Treatment</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-3.5</td>
<td>Oral KCl 60-80 mEq/day if no signs or symptoms</td>
<td>Doses &gt;60mEq should be divided to avoid GI effects Recheck K⁺ daily</td>
</tr>
<tr>
<td>2.5-3</td>
<td>Oral KCl 120 mEq/day or IV 60-80 mEq administered at 10-20mEq/hour if signs or symptoms</td>
<td>Monitor K⁺ (i.e. 2 hours post-infusion)</td>
</tr>
<tr>
<td>2-2.5</td>
<td>IV KCl at 10-20mEq/hour</td>
<td>Consider continuous ECG monitoring</td>
</tr>
<tr>
<td>&lt;2</td>
<td>IV KCl at 20-40mEq/hour</td>
<td>Consider continuous ECG monitoring</td>
</tr>
</tbody>
</table>
# Potassium IV Administration

<table>
<thead>
<tr>
<th></th>
<th>General Med-Surg Areas</th>
<th>ICU/Telemetry Beds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>Not to exceed 10mEq/hour</td>
<td>Recommended: 10mEq/hour Max rate: 20mEq/hour</td>
</tr>
<tr>
<td>Concentration</td>
<td>Not to exceed 10mEq/50mL</td>
<td>20mEq/50mL (central line)</td>
</tr>
<tr>
<td>Notes</td>
<td></td>
<td>Rates &gt;10mEq/hour must be monitored</td>
</tr>
</tbody>
</table>

KCl: Never to be administered IV Push!
Hyperkalemia

- Potassium level >5.5 mEq/L
  - Mild: potassium level 5.5 – 6 mEq/L
  - Moderate: potassium level 6.1 – 6.9 mEq/L
  - Severe: potassium level > 7 mEq/L

- Causes
  - Renal failure, acidosis, red cell hemolysis, overcorrection, medications, salt substitutes, traumatic injury (MVC), adrenal insufficiency

- Signs and Symptoms
  - EKG changes
    - Peaked T waves, depressed ST segment, disappearance of P wave, widened QRS complex
  - Additional
    - Muscle weakness, paresthesias, GI hypermotility, paralysis
Hyperkalemia Treatment

• Treatment Goals
  • Reverse cardiac effects immediately
  • Redistribute potassium from extracellular space into the cell
  • Eliminate potassium from the body
  • Additionally: treat underlying cause and stop excess intake or medications

• Treatment
  • Calcium gluconate
  • Insulin and glucose
  • B₂-agonists
  • Sodium bicarbonate
  • Sodium polystyrene sulfonate
  • Loop diuretics
  • Dialysis
Disorders of Magnesium

- Normal Range: 1.5 – 2.2 mEq/L
- Role in the body
  - Intracellular ion predominantly
  - Found in bone and muscle
Hypomagnesemia

- Magnesium level <1.4 mEq/L

- Causes
  - Reduced intake, reduced absorption, increased loss, drug-induced
  - Often due to other electrolyte abnormalities

- Signs and Symptoms
  - Neuromuscular: tremor, hyperactive reflexes, seizures
  - Cardiac: arrhythmias (ventricular fibrillation, Torsades de Pointes)
Hypomagnesemia Treatment

• PO, IV infusion, or IM

• PO
  • Magnesium containing antacids or laxatives
  • Magnesium oxide
  • SE: diarrhea

• IV infusion
  • Magnesium sulfate
  • Dose depends on the depletion 8-12 g (1 gram = 4 mEq)
  • Standard infusion rate: 1-2 grams/hour
Hypermagnesemia

• Magnesium level: > 2.2 mEq/L

• Causes
  • Renal failure (acute vs chronic), elderly, adrenal insufficiency, hypothyroidism, lithium

• Signs and Symptoms
  • Asymptomatic < 4 mEq/L
  • Weakness, N/V, hypotension, respiratory depression, muscle paralysis, coma, cardiac arrhythmias
Hypermagnesemia Treatment

• Reduce magnesium intake

• Enhance magnesium excretion
  • Loop diuretics

• Antagonize physiologic effects of magnesium
  • IV calcium – antagonizes neurological and cardiovascular effects of magnesium
Disorders of Phosphorous

- Normal range: 2.5 – 4.5 mg/dL
- Role in the body
  - Intracellular ion
  - Cell membrane function, DNA/RNA/proteins, part of energy molecule (ATP), RBC function, bone mineral
Hypophosphatemia

- Phosphate < 2.6 mg/dL
- Causes
  - Decreased GI absorption, increased urinary excretion, redistribution
- Signs and Symptoms
  - Neurological: irritability, neuropathy, seizures, coma
  - Musculoskeletal: weakness, atrophy, rickets, osteomalacia
  - Cardiopulmonary: CHF, respiratory failure
  - Hematologic: hemolysis, anemia
Hypophosphatemia Treatment

- Mild to moderate hypophosphatemia
  - Usually asymptomatic
  - PO phosphorous replacement

- Severe hypophosphatemia
  - IV phosphorus 15-30mmol (0.5 – 0.75 mmol/kg of IBW)
  - Max IV rate 7.5 mmol/hour
  - Monitor q6hours for up to 72 hours
Hyperphosphatemia

• Phosphate > 4.5 mg/dL

• Causes
  • Chronic kidney disease or hypoparathyroidism

• Signs and Symptoms
  • Generally asymptomatic
  • Hypocalcemia, ECG changes, and paresthesias can occur

• Treatment
  • Limit intake of phosphorous
  • Phosphate binding agents
  • Dialysis
  • Replace calcium if patient is also hypocalcemic
Disorders of Calcium

• Normal range: 8.5 – 10.5 mEq/dL (ionized calcium 1.1 – 1.3 mmol/L)

• Distribution
  • Extracellular fluid contains <1% of calcium, 99% of total body stores is in skeletal bone
    • Half of calcium in EC fluid is bound to albumin and other plasma proteins
    • Ionized calcium (unbound) is the active form
  • Ionized calcium is regulated by parathyroid hormone, phosphorous, vitamin D and calcitoin

• Role in the body
  • Bone mineral, blood coagulation, membrane excitability, muscle contraction, neuron activation
Hypocalcemia

- Total serum calcium level <8.5 mg/dL
- Ionized calcium level <1.1 mmol/L

- Causes
  - Post-operative hypoparathyroidism, vitamin D deficiency, renal failure, malnutrition, medications, hyperphosphatemia

- Signs and Symptoms
  - Neuromuscular: paresthesias, muscle cramps, tetany, laryngeal spasm
  - Cardiovascular: prolonged QT interval, arrhythmias, bradycardia, hypotension
  - Dermatologic: hair loss, brittle nails, eczema
  - CNS: depression, anxiety, memory loss, confusion, hallucinations, seizures
Hypocalcemia Treatment

- Acute hypocalcemia
  - IV calcium (calcium chloride or calcium gluconate)
  - 200-300mg of elemental calcium
  - Monitor calcium q4-6 hours during IV therapy
  - Treat underlying disorder

- Chronic hypocalcemia
  - Oral calcium supplementation
  - Oral vitamin D supplementation
Hypercalcemia

- Serum calcium > 10.5 mg/dL
- Ionized calcium > 1.3 mmol/L
- Causes
  - Usually due to malignancy, hyperparathyroidism
- Signs and Symptoms
  - Muscle weakness, anorexia, N/V, constipation, ventricular arrhythmias, lethargy, depression, psychosis, coma
- Treatment
  - Beyond the scope of this discussion
  - ECG changes: volume expansion, loop diuretics, HD
  - Treat underlying disorder
References


References


