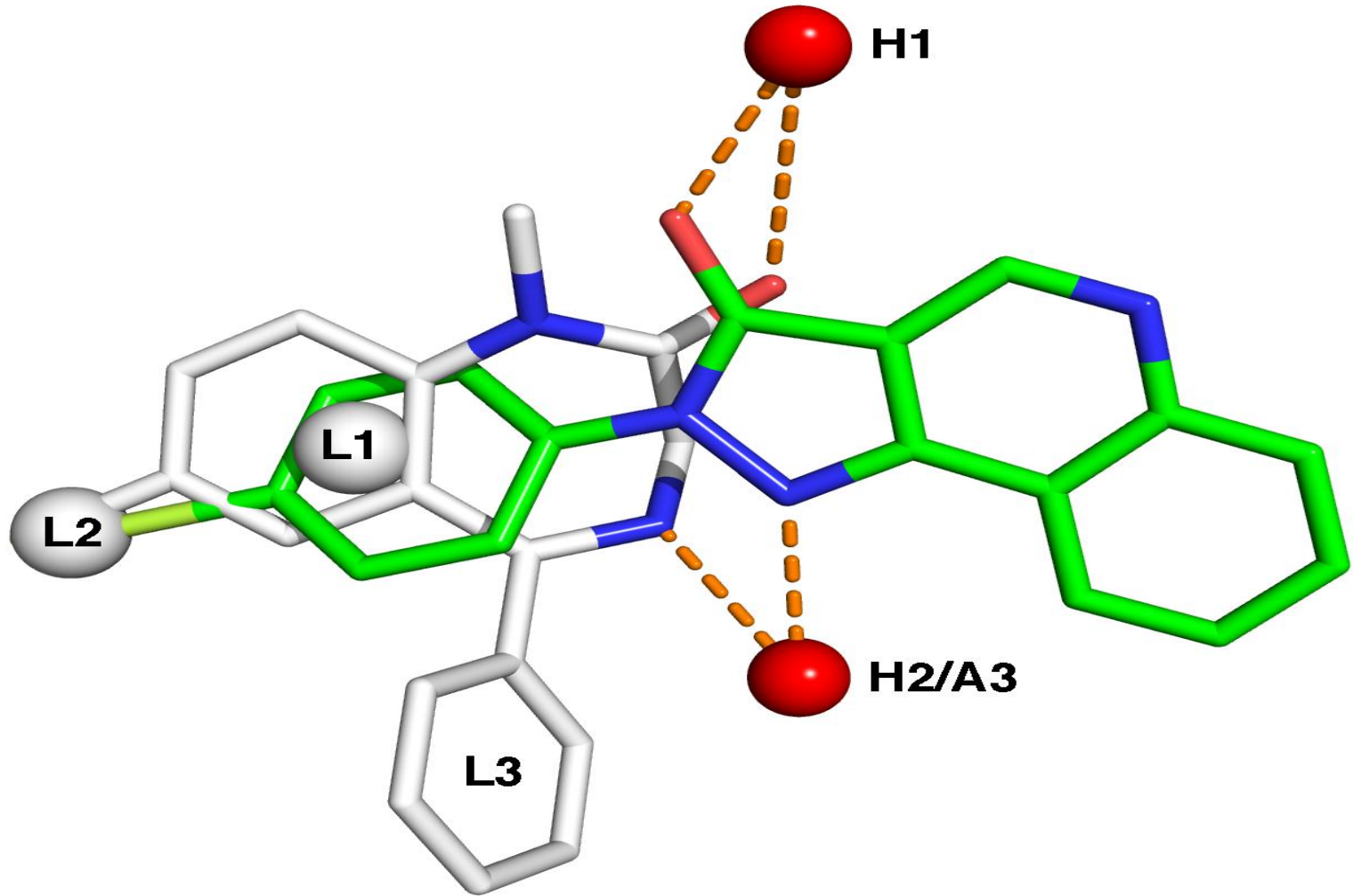


Electrolyte Replacement Therapy



Hypokalemia

Etiology:

- GIT loss (vomiting, diarrhea)
- Drugs (loop diuretics, corticosteroids, gentamycin, theophylline)
- Co-existing factor: electrolyte abnormality (hypomagnesaemia), hyper aldosteronism, insulin therapy, alkalosis).

Indications for replacement:

- Evidence of potassium loss.
- Significant deficit in body potassium.
- Acute therapy in redistributive disorders (thyrotoxicosis).

Symptoms:

usually manifest when serum K <3.0

- Muscle weakness (K <2.5), cramps
- Respiratory muscle weakness
- GIT symptoms: anorexia, nausea, vomiting.
- Cardiac arrhythmias, ECG changes” prolong PR interval, prominent U waves, T wave flattening or inversion
- If prolonged hypokalemia: functional changes in the kidney and glucose intolerance

Therapy

- Calculate potassium required by this equations;

Goal K – Serum K X 100 = total mEq K required

serum Cr

10 mEq of KCL will raise the serum K by ~0.1mEq/L

❖ Goal = normal potassium level in blood is 3.6 to 5.2 millimoles per liter (mmol/L)

Formulations

Potassium Chloride: PREFERRED AGENT

- Most patients with hypokalemia and **alkalosis** are also chloride depleted.
- Raises serum potassium at a faster rate.
- Available as liquid, slow release tablet or capsule, and IV.
- Oral: 40 mEq tid-qid; IV 10- 20 mEq/hr
- **Potassium Bicarbonate/ Citrate/ Acetate:**
- can be used in patients with hypokalemia and metabolic **acidosis**.
- **Potassium Phosphate:**
- Rarely used (Fanconi syndrome with phosphate wasting)

Adverse Effects

- Hyperkalemia.
- Potassium can increase tonicity of IV fluids.
- Oral therapy- pills are large, can be difficult to swallow.
- Peripheral IV therapy:(Pain & Phlebitis)

Check serum potassium 2-4 hours later to assess response to therapy

Goal of Therapy

- Prevent life threatening complications.
- Urgency of replacement depends on severity, rate of decline and comorbid conditions

- Elderly.
- Underlying heart disease.
- Patient on digoxin or anti-arrhythmic drugs.

Example

72-year-old female admitted for weakness and dehydration due to acute gastroenteritis. She is having up to 6 BM/day. Her serum K on admission is 2.5 mEq/L and serum Cr is 2.0. ECG reveals u-waves.

1. How much potassium do you order?

$$4 - 2.5 / 2 \times 100 = 75 \text{mEq}$$

2. What formulation do you choose?

KCL; if bicarb. is low then consider potassium bicarb. or acetate

3. What route should the potassium be administered?

initial= oral and then IV; (re-assess 2-4 hours later and give more orally if needed)

4. Serum potassium remains low, what else could be contributing?

Low magnesium, ongoing diarrhea.

Hypomagnesemia

Average daily intake: 360mg

- low magnesium suspected in following cases:

- Chronic diarrhea
- Hypocalcemia
- Refractory hypokalemia
- Ventricular arrhythmias

Symptoms/Signs:

- Tetany (seizures in children/neonates)
- Hypokalemia
- Hypoparathyroidism → hypocalcemia ($<1.2\text{mg/dL}$)
- Vitamin D deficiency (due to low calcitriol)
- ECG changes
 - Ventricular arrhythmias (especially during ischemia or bypass)

Therapy

- IV if symptomatic (magnesium sulfate)
- 1.5-1.9mg/dL → 2g magnesium sulfate IV
- 1.2-1.4mg/dL → 4g
- 0.8-1.1mg/dL → 6g
- <0.8mg/dL → 8g

Oral if asymptomatic: each tablet contains 60-84mg,
give 2-4 tabs/day in mild cases

6-8 tabs for severe depletion

- Slow Mag (magnesium chloride)
- Mag tab SR (magnesium lactate)

Magnesium Oxide

- Avoid replacement in patients with reduced GFR
- Treat underlying disease (diuretics, alcohol, uncontrolled diabetes)

Goal of therapy:

- maintain plasma magnesium concentration over 1.0mg/dL acutely in symptomatic patients
- In cardiac patients, maintain Mg >1.7 (usually goal 2.0mg/dL) to avoid arrhythmias

- Serum levels are poor reflection of actual body stores (mostly intracellular) so aim for high-normal serum level

Adverse effects:

- elevation of plasma Mg can remove the stimulus for Mg retention and lead to increased excretion

- Diarrhea

Drug interactions

-Magnesium intoxication

Hypocalcemia

Clinical Manifestations:

-Acute

serum Ca <7.5mg/dL

- Neurologic: tetany (from paresthesia to seizures and bronchospasm), cramps
- Cardiac: prolonged QT, hypotension, heart failure, arrhythmia
- Papilledema
- Psychiatric manifestations

- Chronic

- EPS, dementia, cataracts, dry skin

Therapy

- Symptomatic or acute serum Ca <7.5 mg/dL:
- IV Calcium gluconate 1-2g(amp) over 10-20min (temporary rise for 2-3 hrs, must be followed by slower infusion 50mL/hr if Ca remains low)
- Asymptomatic and serum Ca >7.5 mg/dL or chronic

Oral therapy: calcium carbonate or citrate 1-2g/day (500mg bid-qid)

Etiology:

- decrease in vitamin D
- Decrease in PTH
- Hypomagnesemia
- Drugs (corticosteroids, rifampin, calcitonin, chloroquine)

Therapy

- Correct for albumin calcium or check ionized calcium

Add Vitamin D in following cases:

- Hypo parathyroidism: Vitamin D (Calcitriol 0.25-0.5mcg bid)
- Vitamin D deficiency: 50,000IU/week for 6-8 weeks then 800-1000IU daily
- Ergocalciferol (D3)
- Cholecalciferol (D2)

Goals of therapy:

- Treat and prevent manifestations of hypocalcemia
- In hypoparathyroidism: to raise serum Ca to low-normal range (8.0-8.5mg/dL)

Adverse Effects:

- Rapid infusion- bradycardia, hypotension
- Extravasation- tissue necrosis
- Hypercalcemia
- Hypercalciuria
- Constipation
- Hypophosphatemia

Example: 35 y/o male with hypo parathyroidism , presents with serum Ca of 6.2, albumin ionized Ca 0.77. Has some mild muscle cramps, otherwise asymptomatic.

1. How do you initially treat his hypocalcemia?

- IV Calcium Gluconate 1g IV over 10-20min

2. Repeat serum Ca is 6.6, how do you proceed with treatment?

-start Calcium gluconate 1mg/mL in 5% DW 50mL/hr infusion

3. After initial treatment, what maintenance regimen should you initiate?

-Calcitriol (0.5mcg bid)

-Calcium carbonate (tid)

Hypophosphatemia

Due to:

- Redistribution
- Decreased intestinal absorption
- Increased urinary excretion

Common situations:

- Chronic alcoholism
- Respiratory alkalosis (hyperventilation)
- Chronic ingestion of antacids (containing aluminum or Mg)
- Hyperparathyroidism (primary or secondary)
- Vitamin D deficiency
- Fanconi syndrome (associated with multiple myeloma in adults)

Signs/Symptoms:

$<2.0\text{mg/dL}$,

severe usually when serum $\text{PO}_4 <1.0\text{mg/dL}$

Acute:

Metabolic encephalopathy- irritability, paresthesia → confusion, seizure, coma

Respiratory failure due to weakened diaphragm

Reduction in cardiac output leading to heart failure

Coagulopathy with thrombocytopenia

Chronic:

Hypercalciuria

Increased bone resorption: Osteomalacia, Ricketts

Treatment

- Usually aimed at treating the underlying cause (resolution of diarrhea, Vit D therapy, antacid, etc.)
- If treatment is needed, oral therapy is preferred
- Asymptomatic, serum PO₄ =2.0mg/dL or symptomatic with serum PO₄ 1.0-1.9mg/dL
- Available as tablet and powder/packets (sodium phosphate, potassium phosphate) 250-500mg tid - qid over 24 hours

- Decrease dose by one-half in patients with reduced GFR
- Increase dose in severely obese patients
- Recheck after 12 hours to determine if additional/continued supplementation is required

IV therapy if symptomatic and serum PO₄ <1.0mg/dL

- sodium phosphate is preferred
- Weight based
- PO₄ >1.3mg/dL: 0.08-0.24meq/kg over 6 hours
- PO₄ <1.3mg/dL: 0.25 -0.5meq /kg over 8-12 hours

- Increased dosage for critically ill patients in ICU
- Frequent monitoring- recheck levels every 6 hours
- Switch to oral when patient able or serum PO₄ >1.5mg/dL
- Goal of therapy: increase serum PO₄ to 2.0mg/dL
- **Side effects of therapy:**
 - Oral: Diarrhea, nausea, hyperkalemia
 - IV: Hyperphosphatemia→ hypocalcemia, arrhythmia
- Maintenance therapy is not usually required