Magnesium Disorders: Student Handout

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Magnesium Disorders: A Student Guide

Learning Objectives

- Recognize magnesium's critical role as enzyme cofactor
- Understand why hypomagnesemia is often missed
- Recognize magnesium-potassium-calcium interactions
- Manage hypomagnesemia effectively
- Know when hypermagnesemia is dangerous

Quick Facts About Magnesium

- **Normal range:** 1.8-2.4 mg/dL (0.75-1.0 mmol/L)
- **99% intracellular** (only 1% in blood—why serum levels don't reflect total body stores)
- **Total body:** ~25 grams, 60% in bone
- **Cofactor for 300+ enzymes** ☐ essential for energy metabolism
- **Controls Na-K-ATPase pump** ☐ regulates heart rhythm, muscle contraction
- **Regulates calcium channels** ☐ critical for cardiac and neuromuscular function

The Forgotten Electrolyte

Why students miss it: - Normal serum level doesn't exclude deficiency (intracellular stores depleted first) - Many causes (diuretics, PPIs, diarrhea, medications) - Symptoms overlap with potassium, calcium, and other disorders - ~2-15% of hospitalized patients; up to 65% of ICU patients have it

Key concept: Check magnesium whenever you see hypokalemia or hypocalcemia—odds are it's there.

Hypomagnesemia: The Most Common Form

Common Causes

Medication-induced (Very Common) - **Diuretics:** Loop (furosemide) > thiazide - Problem: 60% of filtered Mg reabsorbed in thick ascending limb - Loop diuretics block this—major losses - **Proton pump inhibitors:** Chronic use (months-years) impairs intestinal absorption - **Aminoglycosides, cisplatin, amphotericin B:** Nephrotoxic, increase renal losses - **Calcineurin inhibitors:** Cyclosporine, tacrolimus in transplant patients

GI losses (Most physiologic) - **Diarrhea:** #1 overall cause (secretory diarrhea worse than osmotic) - **IBD, short bowel, pancreatitis** - **Post-bariatric surgery:** Reduced absorptive surface

Renal losses: - **Hyperaldosteronism:** Increases distal tubule losses - **Diabetes:** Osmotic diuresis from glycosuria - **Inherited:** Gitelman syndrome, Bartter syndrome

Alcohol abuse (Multiple mechanisms) - Poor intake + malabsorption + increased renal losses - Alcohol damages intestinal epithelium

Clinical Presentation

Mild: - Fatigue, weakness - Irritability, poor concentration

Moderate: - Muscle cramps (especially legs) - Tremor, vertigo - Personality changes

Severe: - Tetany, seizures - Cardiac arrhythmias (especially with hypokalemia) - Altered mental status

Cardiac manifestations: - Arrhythmias (torsades de pointes) - Enhanced digoxin toxicity - Hypertension - Coronary vasospasm

Diagnosis: The Challenge

Problem: Serum magnesium doesn't reflect total body stores - 30% of body magnesium can be lost before serum level drops

Clinical approach: 1. **Suspect it** based on risk factors (diuretics, diarrhea, PPI use) 2. **Check serum Mg^{2+}** (imperfect but only bedside test) 3. **Check concurrent electrolytes:** K^+, Ca^{2+}, phosphate 4. **Consider 24-hour urine magnesium** if unclear (values <120 mg/day suggest deficiency) 5. **Fractional excretion of Mg:** FEMg >2% suggests renal wasting; <2% suggests extrarenal losses

Management

Oral replacement (mild-moderate): - Magnesium citrate, glycinate, or lactate: 400-800 mg daily - **Avoid magnesium oxide** (poor absorption, causes diarrhea) - Divided doses improve absorption - Side effect: loose stools (actually desired if diarrheal losses)

IV replacement (severe or GI intolerance): - Magnesium sulfate 1-2 grams (4-8 mmol) IV over 1-2 hours - Can repeat to total 6-10 grams per day - Slower safer: 6 grams infused over 24 hours

Critical principle: Always replace magnesium when correcting potassium - Hypomagnesemia prevents renal potassium retention - Your K^+ won't stay up without adequate Mg^{2+}

Special Case: PPIs and Hypomagnesemia

Mechanism: - Reduces gastric acidity ☐ less ionized magnesium - Directly inhibits intestinal Mg^{2+} transporters (TRPM6, TRPM7) - Duration-dependent: months to years of use

Clinical pearl: - Suspect if: long-term PPI user + hypokalemia refractory to K+ replacement + hypomagnesemia - Solution: Discontinue PPI if possible, switch to H2 blocker (ranitidine, famotidine) - Or: Aggressive Mg2+ supplementation alongside K+

Hypermagnesemia: Rare but Dangerous

When It Occurs

- **CKD stage 4-5:** Only cause in otherwise healthy person
- **Massive intake:** Epsom salt ingestion, IV magnesium overdose
- **Medications:** Magnesium-containing laxatives in renal failure

Clinical Features (By Severity)

Level	Manifestation
4.8-6.0	Asymptomatic or mild sedation
6.0-10.8	Absent deep tendon reflexes, weakness, confusion
10.8-15.6	Respiratory depression, complete heart block
>15.6	Cardiac arrest, coma

Key sign: Loss of deep tendon reflexes (disappear at 7-10 mg/dL)

Management

Acute symptomatic: - **IV calcium:** 1-2 grams calcium chloride/gluconate (functional antagonism) - **Saline + loop diuretics:** Enhances excretion in intact kidneys - **Dialysis:** Only definitive treatment in renal failure

Supportive: - Monitor cardiac rhythm - Support respiration if needed - Restrict magnesium intake

The Magnesium-Potassium-Calcium Triangle

Critical relationships:

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Hypomagnesemia
    ↓
Impairs Na–K–ATPase pump
    ↓
Increased K+ excretion → HYPOKALEMIA (refractory to K+ replacement)
    ↓
Suppresses PTH → HYPOCALCEMIA
    ↓
Solution: Replace Mg2+ FIRST, then K+ and Ca2+ follow
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Clinical wisdom: If hypokalemia/hypocalcemia not responding to replacement ☐ check magnesium!

Diuretics and Magnesium Wasting

Loop Diuretics (Worst Offenders)

- Block NKCC2 transporter in thick ascending limb
- 60% of filtered Mg reabsorbed here
- Furosemide >80 mg daily = high risk
- Solution: Consider K-sparing agent (amiloride, spironolactone) to reduce Mg losses

Thiazide Diuretics

- Block NCCT transporter in distal convoluted tubule
- Gitelman syndrome phenocopy: hypomagnesemia + hypokalemia + hypocalciuria
- Chlorthalidone worse than HCTZ (longer half-life)

Prevention Strategy

- Baseline Mg^{2+} before starting diuretic
- Monitor at 1-2 weeks, then every 3-6 months
- Prophylactic supplementation for high-risk patients
- Consider K-sparing diuretic addition

Practice Questions

Q1: A 68-year-old on furosemide 80mg daily + HCTZ presents with K^+ 3.2 and Mg^{2+} 1.4 (both low). You give potassium 40 mEq daily, but K^+ stays at 3.4 after one week. What's happening?

Answer

Magnesium depletion prevents renal K^+ retention. His kidneys can't hold onto K^+ without adequate Mg^{2+}. Give magnesium 400-600mg daily first. K^+ will then improve. This is a classic example of why you must always check and replace Mg^{2+} when correcting K^+.

Q2: A 58-year-old on omeprazole for GERD develops arrhythmias. Labs: K^+ 2.9, Mg^{2+} 1.3, Ca^{2+} 7.8. All are low! What's the unifying diagnosis?

Answer

PPI-induced hypomagnesemia! PPIs impair intestinal Mg^{2+} absorption. Hypomagnesemia then prevents PTH release and causes PTH resistance (hypocalcemia) + increases K^+ losses (hypokalemia). Solution: Discontinue PPI, switch to H2 blocker (famotidine), and aggressively replace Mg^{2+} (will allow K^+ and Ca^{2+} to normalize).

Q3: A hospitalized patient receives 50 mEq IV K^+ and 3 grams IV Mg^{2+} for severe hypokalemia/hypomagnesemia. Next day, deep tendon reflexes are absent and he's weak. Mg^{2+} now 3.1 (high!). What went wrong?

Answer

Overcorrection of magnesium! Check kidney function—may be declining. The dose was appropriate for normal renal function, but if GFR dropping, accumulation occurs. Hypermagnesemia now is the problem. Hold Mg^{2+} supplementation, hydrate if kidneys working, or dialyze if renal failure. This is why you monitor both ways.

Key Takeaways

- **Suspect hypomagnesemia** in: diuretic users, PPI users, diarrhea, hypokalemia, hypocalcemia
- **Serum Mg^{2+} doesn't equal total stores** ☐ clinical suspicion + treatment often justified
- **Hypomagnesemia prevents K^+ and Ca^{2+} correction** ☐ fix Mg^{2+} first
- **PPIs cause hypomagnesemia** ☐ months to years of use
- **Diuretics (especially loop) cause major losses** ☐ monitor and supplement
- **Replace K^+, Mg^{2+}, and Ca^{2+} simultaneously** in deficiency states
- **Hypermagnesemia only in renal failure** (or huge intake) ☐ rare but deadly
- **Loss of reflexes** = key sign of hypermagnesemia (happens at 7-10 mg/dL)
- **Avoid Mg-containing laxatives in CKD** ☐ risk of hypermagnesemia

Clinical Pearl

"When electrolytes don't make sense, check magnesium" — Often the forgotten culprit underlying refractory hypokalemia or hypocalcemia.

Study tip: Remember magnesium's role in 300+ enzymes = central player in metabolism. When things aren't working metabolically, consider Mg^{2+}!

See Also

Related Student Handouts

- Hypokalemia Management
- Calcium and Phosphorus Disorders
- CKD Complications

Clinical Content (01-Clinical-Medicine/Nephrology)

- Electrolyte Disorders Hub
- Essential Renal Laboratory Tests

Butler-COM Resources

- Butler COM - Nephrology Deep Dive

Clinical Resources

- Clinical Review: Magnesium Disorders Review — Comprehensive clinical review with PubMed references