Electrolytes: Enteral and Intravenous – Adult – Inpatient Clinical Practice Guideline

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Table 1. UW Health Guidelines for the Use of Oral, Enteral, and Intravenous Electrolytes in Adults[1-34]

Electrolyte	Concentration	Oral	Gastric (NG/OG/PEG) For patients with enteral access in small bowel, IV preferred due to adverse GI effects	Standard Adult IV dose	High-risk[A] Adult IV dose	Notes
Potassium Normal reference: 3.5-5.1 mmol/L	3.6-3.9 mmol/L	20 mEq potassium chloride caps/tabs/powder	20 mEq potassium chloride powder packets (dilute in ~100 mL per packet, see note 3)	Use oral/enteral supplementation	20 mEq (see note 4)	1. If CrCl < 30 mL/min, reduce dose by 50% 2. For oral doses >20 mEq, divide into increments of 20 mEq given every 2 hours 3. If patient is fluid restricted, dilute oral powder in 50 mL 4. Intravenous infusion rate: • Peripheral line: max 10 mEq/hour • Central line: max 20 mEq/hour
	3.1-3.5 mmol/L	40 mEq potassium chloride caps/tabs/powder (see note 2)	40 mEq potassium chloride powder packets (dilute in ~100 mL per packet, see note 3)	Consider oral/enteral repletion; 40 mEq (see note 4)	40 mEq (see note 4)	
	2.5-3.0 mmol/L	If asymptomatic: may consider combination of enteral and IV repletion with 20 mEq oral potassium chloride caps/tabs/powder and 40 mEq IV (see note 4) If symptomatic: IV repletion recommended (see IV dose columns)		60 mEq (see note 4)	60 mEq (see note 4)	
	< 2.5 mmol/L	IV repletion recommended (see IV dose columns)		80 mEq (see note 4)	80 mEq (see note 4)	
Magnesium Normal reference: 1.6-2.6 mg/dL	1.5-1.8 mg/dL	Consider no replacement, except in patients admitted on cardiac units, who have had recent cardiac surgery, or who have cardiac disorders, including arrhythmias, prolonged QTc, and digitalis toxicity, or in patients with eclampsia or pre-eclampsia In these patient populations, consider 0.05 g/kg IV (see note 8, 9, 10)				5. If CrCl < 30 mL/min, reduce dose by 50% 6. If CrCl < 30 mL/min and using magnesium sulfate solution: • Magnesium 1.5-1.8 mg/dL: Magnesium sulfate solution 2000 mg (dilute in ~50 mL) x 1 dose • Magnesium 1.1-1.4 mg/dL: Magnesium sulfate solution 2000 mg (dilute in ~50 mL) every 4 hours x 3 doses 7. See Table 2 for alternative product contents 8. For IV dosing, use actual body weight unless actual is >130% ideal body weight; in these cases, use ideal body weight 9. Maximum IV dose is 8g/day 10. Intravenous infusion rate • Infuse doses of ≤ 0.05 g/kg over 12 hours or over 24 hours for supplements >0.05 g/kg • Maximum infusion rate is 0.5 to 1 g/hr
	1.0-1.4 mg/dL	Magnesium oxide elemental tablets 500 mg BID x 2 doses	Magnesium sulfate solution 2000 mg (dilute in ~50 mL) every 4 hours x 5 doses	0.05 g/kg (see note 8, 9, 10)	0.1 g/kg (see note 8, 9, 10)	
	< 1.0 mg/dL	IV repletion recommended (see IV dose columns)		0.1 g/kg (see note 8, 9, 10)	0.15 g/kg (see note 8, 9, 10)	

Electrolyte	Concentration	Oral	Gastric (NG/OG/PEG) For patients with enteral access in small bowel, IV preferred due to adverse GI effects	Standard Adult IV dose	High-risk[A] Adult IV dose	Notes
Phosphate Normal reference: 2.3-4.7 mg/dL	2.4-3.0 mg/dL	Phosphate-potassium packet (PHOS-NAK powder**) 1 packet** every 4 hours while awake x 3 doses[B,C]	Phosphate-potassium packet (PHOS-NAK powder) **1 packet** every 4 hours while awake x 3 doses (dilute in ~75 mL)[B,C]	Consider no replacement[C] or use oral/enteral supplementation	0.16 mmol/kg (see notes 15 to 18), consider oral/enteral supplementation	11. Consider oral/enteral supplementation in any asymptomatic patient, or combination of oral/enteral and IV. 12. If CrCl <30 mL/min, reduce IV dose by 50% 13. If CrCl <30 mL/min, use of phosphorus tablet (K-PHOS Neutral) preferred due to lower potassium content: • Phosphate 2.4-3.0 mg/dL: 1 tablet every 4 hours while awake x 2 doses • Phosphate 1.6-2.3 mg/dL: 1 tablet every 4 hours while awake x 3 doses • Phosphate 1.0-1.5 mg/dL: 1 tablet every 4 hours while awake x 4 doses 14. See Table 2 for alternative product content 15. For IV dosing, use actual body weight unless actual is >130% ideal body weight; in these cases, use ideal body weight 16. Maximum IV dose is 45 mmol; recheck phosphate level 6 to 12 hours after dose to determine if further supplementation is necessary 17. Administer IV dose over 2 to 3 hours for mild or moderate hypophosphatemia and over 6 to 8 hours for severe hypophosphatemia 18. Round IV supplementation to the nearest 7.5 or 15 mmol increment
	1.6-2.3 mg/dL	Phosphate-potassium packet (PHOS-NAK powder) **2 (two) packets** every 4 hours while awake x 3 doses[B]	Phosphate-potassium packet (PHOS-NAK powder) **2 (two) packets** every 4 hours while awake x 3 doses (dilute in ~75 mL)[B]	0.16 mmol/kg (see notes 15 to 18), consider oral/enteral supplementation	0.32 mmol/kg (see notes 15 to 18), consider oral/enteral supplementation	
	1.0-1.5 mg/dL	Phosphorus TABLET (K-PHOS Neutral) **2 (two) tablets** every 4 hours while awake x 4 doses[B]	Phosphorus TABLET (K-PHOS Neutral) **2 (two) tablets** every 4 hours (crush & dilute in ~75 mL)[B]	0.32 mmol/kg (see notes 15 to 18), consider oral/enteral supplementation	15 mmol IV once over 2 hours, then 0.32 mmol/kg (see notes 15 to 18)	
	< 1.0 mg/dL	IV repletion recommended (see IV dose columns)		0.64 mmol/kg (see notes 15 to 18)	15 mmol IV once over 2 hours, then 0.64 mmol/kg (see notes 15 to 18)	
Ionized Calcium Normal reference: Serum: 4.6-5.2 mg/dL Whole blood: 4.9-5.6 mg/dL	Serum:≤4.59 mg/dL Whole blood: ≤4.89 mg/dL	Calcium carbonate chew tabs 1000 mg every 4 hours x 4 doses	Calcium carbonate suspension 1250 mg every 4 hours x 4 doses	• Consider oral/enteral replacement if asymptomatic[D] • 2 g calcium gluconate or 1 g calcium chloride (optimally infused over 2 hours)		19. Ionized (unbound) calcium concentrations are preferred over total serum calcium concentrations for hypocalcemia monitoring 20. Use oral/enteral calcium for asymptomatic hypocalcemia ONLY 21. Maximal oral calcium absorption occurs at elemental doses ≤500 mg and when given with a meal 22. For IV administration, calcium gluconate preferred due to extravasation risk with calcium chloride 23. See Table 2 for alternative product contents

[A] High-risk: clinically malnourished, active alcoholism, recent surgery, admitted for cardiac disease, graft-versus-host disease, diabetic ketoacidosis, or undergoing diuresis

[B] Patients with hyperkalemia, impaired renal function, or that require larger doses of phosphate replacement should receive replacement using the phosphorus tablet (K-PHOS Neutral) as it contains less potassium than the phosphate-potassium packet (PHOS-NAK powder)

[C] Replete if: active alcoholism, malnourished, liver cirrhosis, critical status, hepatectomy, parenteral nutrition, or burn injury if benefit outweighs risk

[D] Symptoms of hypocalcemia: tetany, numbness in extremities, stridor, mental status changes, hypotension

Table 2. Available oral, enteral, and intravenous electrolyte products at UW Health

	Oral				Intravenous	Notes
	Product	Elemental Content				
Magnesium	Magnesium oxide elemental 250 mg tablets	250 mg			Magnesium Sulfate: • 1 g /100 mL • 2 g /50 mL • 4 g /100 mL	Magnesium sulfate 1 g = 8 mEq = 98.6 mg elemental magnesium
	Magnesium sulfate 1 gram	98 mg				
Calcium	Calcium carbonate chew tabs 500 mg	200 mg per tab			Calcium gluconate (**preferred**): • 1 g/100 mL normal saline • 2 g/100 mL normal saline	Calcium gluconate 1 g = 93 mg of elemental calcium Preferred due to lower extravasation risk
	Calcium carbonate suspension 1250 mg/5 mL	500 mg per 5 mL			Calcium Chloride: • 1 g/100 mL normal saline • 2 g/100 mL normal saline	Calcium chloride 1g = 273 mg elemental calcium
Phosphate	Phosphorus TABLET (K-PHOS Neutral)	8 mmol phosphorus	1.1 mEq potassium	13 mEq sodium	Phosphate Sodium: • 15 mM PO_4/20 mEq Na/100 mL	
	Phosphate-potassium packet (PHOS-NAK powder)	8 mmol phosphorus	7.1 mEq potassium	7.1 mEq sodium	Phosphate Potassium: • 7.5 mM PO4 /11 mEq K/100 mL • 15 mM PO4 /22 mEq K/100 mL (central line recommended)	Peripheral access may be used for IV administration in high-risk patients when benefit outweighs the risk
Potassium	Oral packet	20 mEq			Potassium Chloride • 10 mEq/100 mL • 20 mEq/100 mL (central line recommended)	Peripheral access may be used for IV administration in high-risk patients when benefit outweighs the risk
	Oral liquid (contains sorbitol)	40 mEq/15 mL (20%)				
	Oral solution	13.3 mEq/5 mL (20%)			Phosphate (Potassium) • 7.5mM PO_4 /11 mEq K/100 mL • 15 mM PO_4 /22 mEq K/100 mL (central line recommended)	
	Extended-release oral tablet	10 mEq; 20 mEq			Potassium Acetate • 10 mEq/100 mL • 20 mEq/100 mL (central line recommended)	

Introduction

Significant electrolyte depletion can result in serious complications for patients. Intravenous electrolyte replacement can produce life-threatening complications, serious arrhythmias and phlebitis; therefore supplementation must be carefully monitored.[2]

There are multiple underlying factors for electrolyte disorders in adult inpatients. Alterations in absorption, distribution, hormonal, and/or homeostatic mechanisms can all cause disturbances. Therefore, treating the underlying cause and prescribing adequate therapy is essential for repletion. In addition, the intracellular vs. extracellular electrolyte concentrations must be considered. Due to distribution variances, labs may not directly correlate with true electrolyte level. Therefore, continuous monitoring is essential to properly replete patients.[18]

Scope

Intended Users: Physicians, advanced practice providers, nurses, pharmacists

Objectives: To identify the appropriate patients requiring intravenous, oral, or enteral electrolyte replacement, to recommend appropriate treatment, and to minimize inappropriate use of electrolyte replacement.

Target Population: Adult inpatients with a clinical condition warranting oral, enteral, or intravenous electrolyte replacement therapy. This document does not pertain to parenteral nutrition (PN).

Clinical Questions Considered:

- How to provide clinically appropriate oral, enteral, and IV electrolyte supplementation (potassium, phosphate, magnesium, calcium) in adult inpatients?
- What patient populations are appropriate for oral and enteral electrolyte supplementation?
- What patient populations are appropriate for intravenous electrolyte supplementation?

Definitions

- Ideal Body Weight (>60 inches) = 50* kg + [2.3 x (height (inches) – 60)]
- Ideal Body Weight (<60 inches) = 50* kg + [- 2.3 x (60 – height (inches))]
    - *Use 45.5 kg for females

Recommendations

1. Potassium (K^+)

Potassium is mainly found in the intracellular space (98%) versus extracellular space (2%). Some physiologic functions of this cation include: cellular metabolism, protein synthesis and regulation of action potentials across cell membranes. Entry of potassium into cells is dependent on the sodium-potassium ATPase pump. This pump is regulated by many factors including insulin, glucagon, catecholamines, and acid-base balance.[18,35]

Mild to-moderate hypokalemia can increase the likelihood of cardiac arrhythmias in patients with cardiac ischemia, heart failure, or left ventricular hypertrophy.[1,3] Hypokalemia can have profound effects on the excitability of electrical tissues in cardiac, skeletal, and smooth muscle which in some patients can lead to cardiac arrhythmias, muscular paralysis, or respiratory failure.[3,35]

1.1. Dosing recommendations for patients with normal renal function (>30 mL/min) are listed in Table 1. *(UW Health GRADE High quality evidence, strong recommendation)*

1.2. Current literature does not support supplementing normal electrolyte levels in adult patients who are not classified as high risk. *(UW Health GRADE Low quality evidence, strong recommendation)*

1.3. **Oral and Enteral Potassium Replacement, Administration, and Monitoring**

- 1.3.1. If creatinine clearance is <30 mL/min, administer approximately 50% of normally recommended doses. Use caution in patients with anuria and patients with ESRD receiving dialysis.[4] (*UW Health GRADE Moderate quality evidence, strong recommendation*)
- 1.3.2. Oral doses greater than 20 mEq should be given in divided doses every two to twelve hours to increase tolerability and decrease gastrointestinal discomfort.[36,37] (*UW Health GRADE Moderate quality evidence, strong recommendation)*
- 1.3.3. Higher doses may be required for patients with ongoing or chronic causes of potassium loss.[1-4] (*UW Health GRADE Moderate quality evidence, strong recommendation*)
- 1.3.4. Very low serum potassium concentrations can reflect a large total body deficit of both intracellular and extracellular potassium so higher doses may be required.[1] (*UW Health GRADE Low quality evidence, strong recommendation*)
- 1.3.5. Higher serum potassium concentrations are targeted in patients with cardiac disease.[2] (*UW Health GRADE Moderate quality evidence, strong recommendation*)
- 1.3.6. Potassium requirements can be much greater in patients on loop or thiazide diuretic therapy (e.g., furosemide, bumetanide, hydrochlorothiazide, chlorothiazide).[38] (*UW Health GRADE Moderate quality evidence, strong recommendation*)
- 1.3.7. Maintain appropriate magnesium serum concentrations with potassium supplementation since magnesium is an important cofactor for potassium uptake.[2] (*UW Health GRADE Moderate quality evidence, strong recommendation*)
- 1.3.8. Potassium replacement utilizing potassium elixirs should be avoided, and should instead be achieved by utilizing potassium powder packets or tablets swallowed whole or dissolved in approximately 100 mL of water per tablet or packet prior to oral administration, especially when delivered to the small bowel due to the risk of hyperosmolar-induced diarrhea and/or abdominal pain.[36,37] (*UW Health GRADE Moderate quality evidence, strong recommendation*)
  - 1.3.8.1. Patients on fluid restrictions should receive dissolved potassium supplementation in approximately 50 mL of water per tablet or packet.[36,37] (*UW Health GRADE Moderate quality evidence, strong recommendation*)
- 1.3.9. The appropriate route of administration should be chosen based on availability and tolerability: (*UW Health GRADE Low quality evidence, strong recommendation*)
  - Oral - Use capsules or tablet formulation. Consider powder packet if patient is unable to swallow tablets.
  - Gastric (Nasogastric tube, Orogastric tube, or Percutaneous Endoscopic Gastric tube) - Use powder packet.

- Small Bowel (Nasoduodenal tube, Nasojejunal tube, or jejunostomy tube) – IV or diluted oral powder recommended.

1.3.10. In cases of severe hypokalemia, serum potassium levels may be evaluated every two to six hours to ascertain response to therapy.[4,39] (*UW Health GRADE Moderate quality evidence, weak/conditional recommendation*)

1.4. **Intravenous Potassium Replacement, Administration, and** Monitoring

1.4.1. Very low potassium concentrations can reflect a large total body deficit of both intracellular and extracellular potassium so higher doses may be required.[1] *(UW Health GRADE Low quality evidence, strong recommendation)*

1.4.2. Decrease supplemental potassium doses by 50% in patients with a creatinine clearances <30 mL/min.[3,4,11,40,41] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

1.4.3. Modest bolus doses of potassium given over 1 hour, 10-20 mEq for potassium levels 2.5-3.4 mmol/L should be considered a starting point in anephric or hemodialysis-dependent patients.[3,4,11,40,41] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

1.4.4. Potassium concentrations greater than 3.5 mmol/L are targeted in patients with cardiac disease.[2,41] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

1.4.4.1. In a prospective, observational, case-control, multi-center study, serum potassium levels <3.5 mmol/L was a predictor for serious perioperative (odds ratio [OR] 2.2, 95% confidence interval [CI] 1.2-4.0) intraoperative (OR 2.0; 95% CI 1.0-3.6), and postoperative arrhythmias (OR 1.7; 95% CI, 1.0-2.7). In total, 2402 patients were included in the two-year study period and were undergoing elective coronary artery bypass graft surgery. Some limitations of this study were small sample size (10000 needed to show statistical significance between hypokalemia and death), as well as not accounting for other electrolyte therapies (including magnesium). Authors concluded that potassium repletion for those undergoing a cardiac procedure was a low-risk, low-cost, and beneficial option. Therefore, UW Health Guidelines supports targeting levels > 3.5 mmol/L for patients with cardiac disease.

1.4.5. Potassium requirements can be much greater in patients on loop or thiazide diuretic therapy (e.g., furosemide, bumetanide, hydrochlorothiazide, chlorothiazide).[9] *(UW Health GRADE Low quality evidence, strong recommendation)*

1.4.6. Maintain normal magnesium concentrations with potassium supplementation since magnesium is an important cofactor for potassium uptake.[2] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

1.4.7. Never administer potassium IV push.[3] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

1.4.8. Administer parenteral potassium either slowly by adding it to maintenance fluids or over a shorter period via intermittent infusion depending on the degree of hypokalemia.[4] *(UW Health GRADE Low quality evidence, weak/conditional recommendation)*

1.4.9. An infusion pump is required for all one liter continuous infusions bags containing potassium 40 mEq or more.[4] *(UW Health GRADE Low quality evidence, strong recommendation)*

1.4.10. Infusion rates faster than 10 mEq/hour require a smart infusion pump.[3] *(UW Health GRADE Low quality evidence, strong recommendation)*

1.4.11. The amount of potassium in any liter of fluid for either peripheral or central administration should not exceed 88 mEq (except in parenteral nutrition formulations).[2,3] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

1.4.12. Peripheral Administration

1.4.12.1. Rate of peripheral administration should rarely exceed 10 mEq/hour. In extreme circumstances, potassium may be peripherally administered at 20 mEq/hour.[3] *(UW Health GRADE Moderate quality evidence, weak/conditional recommendation)*

1.4.12.2. The addition of lidocaine to potassium chloride infusions to decrease pain from peripheral vein irritation is not recommended due to limited evidence of safety or

efficacy. [42-45] *(UW Health GRADE Moderate quality evidence, weak/conditional recommendation)*

1.4.12.2.1. Potential adverse drug events with the use of lidocaine include, but are not limited to: numbness and tingling in the fingers and toes, unusual sensations around the mouth, metallic taste, tinnitus, lightheadedness, and/or dizziness.[42-44]

1.4.12.2.2. The addition of lidocaine to potassium chloride may also mask pain reducing the ability to detect an extravasation event.

1.4.12.3. To minimize irritation associated with potassium chloride, it is recommended to administer via Y-site with intravenous maintenance fluids whenever feasible. *(UW Health GRADE Low quality evidence, strong recommendation)*

1.4.13. Central Administration

1.4.13.1. Administer IV supplemental bolus potassium via the central route at concentrations less than 0.2 mEq/mL to minimize concentrated potassium boluses into the heart.[3] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

1.4.13.1.1. Administering potassium boluses at higher concentrations may lead to serious, life-threatening arrhythmias.[2,3] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

1.4.13.2. The maximum central line infusion rate should not exceed 20 mEq/hour unless the patient is experiencing a life-threatening condition due to hypokalemia. Faster infusions can result in cardiac arrhythmias and death.[3] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

1.4.14. Infusion rates ≥20 mEq/hour require telemetry.[3] *(UW Health GRADE Low quality evidence, strong recommendation)*

1.4.15. Potassium levels are required following supplementation, especially if correcting severe hypokalemia (serum potassium ≤2.5 mmol/L) or in patients with multiple medical problems.[2] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

1.4.16. In cases of severe hypokalemia, potassium levels are recommended every two to six hours initially to ascertain response to therapy.[4,39] *(UW Health GRADE Low quality evidence, weak/conditional recommendation)*

2. Phosphate (PO_4^{3-})

Phosphate is the primary anion within the intracellular space. Functions of this electrolyte include: nerve and muscle conduction, ATP production, glucose utilization, and glycolysis. Since critically ill patients are often hypermetabolic, phosphate requirements and therefore supplementation can be higher than adult patients admitted to general care.[18,46]

Clinical manifestations of moderate-to-severe hypophosphatemia affect many organ systems and include rhabdomyolysis, glucose intolerance, respiratory distress, and arrhythmias.[47] Hypophosphatemia is a common electrolyte abnormality in patients who are malnourished, have an alcohol dependency, or are receiving nutrition support.[14]

2.1. Dosing recommendations for patients with normal renal function (>30 mL/min) are listed in Table 1 *(UW Health GRADE Moderate quality evidence, strong recommendation)*

2.1.1. Order intravenous phosphate (sodium) or phosphate (potassium) boluses in millimole (mmol) amounts of phosphate rounded to the nearest 7.5 mmol or 15 mmol increments. *(UW Health GRADE Low quality evidence, strong recommendation)*

2.2. Supplementation of phosphate concentrations 2.5 to 3.0 mg/dL may be beneficial for patients at high risk for developing hypophosphatemia (e.g. critical care, active alcohol abuse, malnourished patients). Supplement with one phosphate-potassium packet or tablet every 4 hours while awake for 3 doses. (*UW Health GRADE Low quality evidence, strong recommendation*)

2.3. **Oral and Enteral Replacement, Administration, and Monitoring**

2.3.1. If creatinine clearance is <30 mL/min, administer approximately 50% of normally recommended doses. See potassium dosing information. Use caution in patients with anuria and patients with ESRD receiving dialysis.[3,4] (*UW Health GRADE Moderate quality evidence, strong recommendation*)

2.3.2. Patients with hyperkalemia, impaired renal function, or patients that require large doses of phosphate replacement should receive replacement using the phosphorus tablet (K-PHOS Neutral) as it contains less potassium than the phosphate-potassium packet (PHOS-NAK powder). (*UW Health GRADE Moderate quality evidence, strong recommendation*)

2.3.3. Phosphate is poorly absorbed via the gastrointestinal tract. If oral/enteral phosphate repletion does not increase serum phosphate, consider using intravenous repletion.[18] (*UW Health GRADE Low quality evidence, strong recommendation*)

2.3.4. Oral/enteral phosphate supplementation can cause diarrhea. If this becomes problematic, consider phosphate administration via the intravenous route.[18] *(UW Health GRADE Low quality evidence, strong recommendation)*

2.3.5. Phosphate tablets or powder packets should be diluted in approximately 75 mL of water prior to enteral tube administration (Nasogastric tube, Jejunostomy tube, Orogastric tube, or Percutaneous Endoscopic Gastric tube).[36,37] (*UW Health GRADE Moderate quality evidence, strong recommendation*)

2.4. **Intravenous Replacement, Administration, and Monitoring**

2.4.1. If creatinine clearance is <30 mL/min, administer 50% of the above dose. See potassium dosing information. Use caution in patients with anuria and patients with ESRD receiving dialysis.[3,4] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

2.4.2. Use actual body weight unless patient's actual weight is >130% ideal body weight (IBW), in which case use ideal body weight for dose calculations.[14,47] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

2.4.3. The maximum intravenous dose of phosphate is 45 mmol based on weight-based dosing in Table 1. Recommend to re-check levels as listed in 2.4.6.[24] (UW Health GRADE Moderate quality evidence, strong recommendation)

2.4.4. Administer total calculated dose over two to three hours for mild or moderate hypophosphatemia and over four to six hours for severe hypophosphatemia.[14] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

2.4.5. For severe hypophosphatemia (phosphate concentrations less than 1 mg/dL), the first dose of phosphate can be administered at a more aggressive rate of 7.5 mmol of phosphate/hour.[47] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

2.4.6. Since response to phosphate supplementation is not predictable, re-check levels six to twelve hours post-supplementation.[28,46,48] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

3. Magnesium (Mg^{2+})

In comparison to potassium, magnesium is the second most abundant intracellular cation. Magnesium serves as a cofactor for biochemical and adenosine triphosphatase reactions.[49,50] Magnesium homeostasis can be affected by multiple factors which include: renal function, gastrointestinal function, and medication therapy (e.g. diuretics).[18]

Moderate to severe hypomagnesemia can result in numerous complications such as cardiac arrhythmias, muscle weakness, and metabolic disturbances, including hypokalemia and hypocalcemia.[16]

3.1. Symptomatic hypomagnesaemia should be promptly treated as a medication emergency with intravenous magnesium supplementation.[16,18] (*UW Health GRADE Moderate quality evidence, strong recommendation*)

3.2. Dosing recommendations for patients with normal renal function (CrCl >30 mL/min) are listed in Table 1. (*UW Health GRADE Moderate quality evidence, strong recommendation*)

3.3. Current literature does not support supplementing normal electrolyte levels in adult patients who are not classified as high risk, as defined in 3.5.9. *(UW Health GRADE Low quality evidence, strong recommendation)*

3.4. **Oral Magnesium Replacement, Administration, and Monitoring**

- 3.4.1. In patients with creatinine clearance <30 mL/min, administer approximately 50% of normally recommended doses.[3,4] (*UW Health GRADE Moderate quality evidence, strong recommendation*)
- 3.4.2. Take into consideration that serum concentrations may not accurately reflect total body stores since magnesium is primarily an intracellular ion.[16] (*UW Health GRADE High quality evidence, strong recommendation*)
- 3.4.3. Oral preparations are considered first-line for minor and asymptomatic hypomagnesemia.[31,32] (*UW Health GRADE Moderate quality evidence, strong recommendation*)
- 3.4.4. The majority of oral magnesium-containing preparations can cause diarrhea, which is most frequently associated with single doses greater than 250 mg of elemental magnesium. If diarrhea is problematic, consider intravenous magnesium sulfate.[31,32] (*UW Health GRADE High quality evidence, strong recommendation*)
- 3.4.5. Magnesium sulfate solution doses of 2000 mg should be diluted in approximately 50 mL of liquid prior to enteral administration to increase tolerability.[36,37] (*UW Health GRADE Moderate quality evidence, strong recommendation*)
- 3.4.6. Reassess magnesium concentration 36 to 48 hours after the final dose to allow for tissue distribution.[16] (*UW Health GRADE Moderate quality evidence, strong recommendation*)

3.5. **Intravenous Magnesium Replacement, Administration, and Monitoring**

- 3.5.1. In patients with creatinine clearance <30 mL/min, administer approximately 50% of normally recommended doses.[50] *(UW Health GRADE Moderate quality evidence, strong recommendation)*
- 3.5.2. Use actual body weight for calculations unless patient's actual weight is >130% of ideal body weight. In these patients, use ideal body weight for dose calculations.[50] *(UW Health GRADE Moderate quality evidence, strong recommendation)*
- 3.5.3. Take into consideration that blood concentrations may not accurately reflect total body stores since magnesium is primarily an intracellular ion.[16] *(UW Health GRADE Moderate quality evidence, strong recommendation)*
- 3.5.4. For treatment of hypomagnesemia without symptoms the optimal rate of administration is over 12 hours for supplements of ≤0.05 g/kg or 24 hours for supplements >0.05 g/kg. If medically necessary supplemental doses can be administered over four to six hours.[16,50] *(UW Health GRADE Moderate quality evidence, strong recommendation)*
- 3.5.5. For a severely low magnesium concentration (<1 mg/dL) and/or symptomatic patient (tetany or seizures), administer a bolus (1 to 2 g) over 10 minutes, then administer the remaining calculated dose as separate infusion(s) over 12 to 24 hours.[16,50] *(UW Health GRADE Moderate quality evidence, strong recommendation)*
- 3.5.6. If medically necessary, the infusion rate can be increased to a maximum of 0.5 (preferred) to 1 g/hr. Infusing magnesium over a shorter time period is less effective as faster rates may result in much of the dose being excreted.[49,51] *(UW Health GRADE Moderate quality evidence, strong recommendation)*
- 3.5.7. Administer the total magnesium dose as multiple of 1 or 2 g doses.[16,49] *(UW Health GRADE moderate quality evidence, strong recommendation)*
- 3.5.8. Consider a maximum daily dose of 8 g of magnesium.[52,53] *(UW Health GRADE Low quality evidence, strong recommendation)*
- 3.5.9. Consider not repleting magnesium levels of ≥1.5 mg/dL except in patients admitted on cardiac units, in patients with recent cardiac surgery, in patients with cardiac disorders (including arrhythmias, prolonged QTc, digitalis toxicity) or in patients with eclampsia or pre-eclampsia.[51,52,54-57] *(UW Health GRADE Moderate quality evidence, strong recommendation)*
- 3.5.10. Administration: Life-threatening Emergencies

3.5.10.1. When ventricular fibrillation/pulseless ventricular tachycardia cardiac arrest is associated with torsades de pointes, administer IV bolus magnesium 1 to 2 g over one to two minutes (central line preferred).[58] *(UW Health GRADE Low quality evidence, weak/conditional recommendation)*

3.5.10.2. For the treatment of polymorphic ventricular tachycardia with a prolonged QT interval, administer IV magnesium 1 to 2 g over 15 minutes.[58] *(UW Health GRADE Low quality evidence, weak/conditional recommendation)*

3.5.10.3. For the treatment of adult status asthmaticus administer single 2 g dose over 20 minutes.[59] *(UW Health GRADE Low quality evidence, strong recommendation)*

3.5.11. Reassess magnesium concentration 36 to 48 hours after the final dose to allow for tissue distribution.[16] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

3.5.12. Even if level is checked during next lab draw, a follow-up lab should be ordered (36 to 48 hours) post-infusion to allow for complete magnesium distribution and avoid "falsely" high concentrations. *(UW Health GRADE Very low quality evidence, strong recommendation)*

4. Calcium (Ca^{2+})

Calcium is primarily found within the bones (99%) versus serum (1%). Within the serum, calcium (~40%) is primarily bound to albumin or other proteins and is not active. Therefore, in patients with low albumin levels, total calcium levels do not reflect active calcium.[19]

Ionized, unbound calcium is the active form of calcium within the blood. Direct measurement of ionized calcium is preferred since its levels are not affected by albumin.[18]

Untreated hypocalcemia can lead to serious neurologic and cardiovascular complications.[20,38] In addition to supplementing calcium, it is also important to identify and correct any underlying causes of hypocalcemia (e.g., hypomagnesemia, decreased vitamin D concentrations, hypoparathyroidism, hyperphosphatemia). [20,38,60,61]

4.1. Dosing recommendations for patients with normal renal function (>30 mL/min) are listed in Table 1. *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.2. Indications for IV calcium supplementation for hypocalcemia: [20,38,60,61]*(UW Health GRADE Moderate quality evidence, strong recommendation)*

- Patient is symptomatic (muscle tetany, paresthesias)
- Clinically relevant ionized calcium concentration (whole blood Ca ≤4.89 mg/dL or serum blood Ca ≤4.59 mg/dL)
- Calcium channel blocker overdose
- Massive blood transfusion (≥5 units of packed red blood cells)
- Patient is receiving inotropic/vasopressor support
- Cardiac protection when treating hyperkalemia
- Prevention of worsening hypocalcemia

4.3. **Oral Calcium Replacement, Administration, and Monitoring**

4.3.1. Oral calcium supplementation may be safely used in patients with impaired renal function, hyperphosphatemia, and underlying cardiac dysrhythmias including patients receiving CVVH. Serum calcium levels should be closely monitored in these patients due to their underlying conditions.[19,38,60] (*UW Health GRADE Moderate quality evidence, strong recommendation*)

4.3.2. Ionized (unbound) calcium concentrations, which measure the unbound, active form of calcium, are preferred over total serum calcium concentrations for monitoring.[19] (*UW Health GRADE Moderate quality evidence, strong recommendation*)

4.3.3. "Corrected" total serum calcium concentrations for serum albumin <4 mg/dL ("corrected" total calcium = measured serum calcium + (4 – measured serum albumin)*(0.8)) often overestimate total serum calcium concentrations and should not be used to estimate the severity of hypocalcemia.[20,60] (*UW Health GRADE Moderate quality evidence, strong recommendation*)

4.3.4. In order to maximize absorption, oral calcium carbonate should be administered in doses of 500 mg or fewer and with food.[62,63] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.3.5. Monitor ionized calcium concentration in patients that are hypoalbuminemic. Approximately 40% of calcium is bound to protein (primarily albumin) and hypoalbuminemia can cause low total calcium concentrations, while ionized calcium concentrations remain within normal limits.[20] (*UW Health GRADE Moderate quality evidence, strong recommendation*)

4.3.6. Monitor ionized calcium concentration in patients with increases in extracellular fluid concentrations of phosphate, citrate, or bicarbonate. These changes increase the proportion of bound calcium and decrease ionized calcium. Similarly, alkalosis increases bound calcium and decreases concentrations of ionized calcium.[19,57,62-64] (*UW Health GRADE Moderate quality evidence, strong recommendation*)

4.4. **Intravenous Calcium Replacement, Administration, and Monitoring**

4.4.1. Intravenous calcium may be safely used in patients with impaired renal function (including patients receiving CVVH), hyperphosphatemia, and underlying cardiac dysrhythmias. Blood calcium levels should be closely monitored in these patients due to their underlying conditions.[60,61] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.4.2. During cardiac resuscitation efforts (including severe hypocalcemia, hyperkalemia, and/or calcium channel blocker and beta blocker overdose), ACLS guidelines recommend calcium chloride as the preferred agent due to the higher concentration of elemental calcium and faster calcium repletion.[60,61] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.4.3. Due to less venous irritation and less risk of metabolic acidosis, calcium gluconate is the preferred intravenous salt for replacement.[61] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.4.3.1. Since calcium gluconate is the preferred intravenous agent, calcium chloride should only be used if a shortage of calcium gluconate arises.

4.4.3.2. Due to the risk for extravasation with IV calcium chloride administration, central line administration is preferred; however peripheral lines may be used when benefit outweighs the risk. *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.4.4. In patients with severe, symptomatic hypocalcemia, a 1 to 2 g bolus of intravenous calcium gluconate may be given over 10 to 20 minutes followed by a longer infusion over 2 to 4 hours.[61] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.4.5. Administration over a shorter period of time (fewer than 10 minutes), can increase the risk of cardiac toxicities.[61] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.4.6. Due to the risk of serious arrhythmias or cardiovascular collapse in digitalized patients, administration of intravenous calcium should be given slowly over several hours and monitored with telemetry.[38,61] *(UW Health GRADE Moderate quality evidence, weak/conditional recommendation)*

4.4.7. Administering intravenous calcium concurrently with a calcium channel blocker can inhibit the pharmacologic effect of the blocker.[60,61] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.4.8. Ionized (unbound) calcium concentrations, which measure the unbound, active form of calcium, are preferred over total calcium concentrations for monitoring.[61] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.4.9. Check ionized calcium concentrations at least 10 hours after the completion of a calcium infusion to assess efficacy of therapy.[60] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.4.10. Since approximately 40% of calcium is bound to protein (primarily albumin), hypoalbuminemia can cause total calcium to appear lower than it actually is.[20] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.4.10.1. Ionized (unbound) calcium concentrations, which measure the unbound, active form of calcium, are preferred over total serum calcium concentrations for monitoring.[19] (*UW Health GRADE Moderate quality evidence, strong recommendation*)

4.4.10.1.1. Monitor ionized calcium levels in patients with increases in extracellular fluid concentrations of phosphate, citrate, or bicarbonate. These changes increase the proportion of bound calcium and decrease ionized calcium. Similarly, alkalosis increases bound calcium and decreases concentrations of ionized calcium.[61] *(UW Health GRADE Moderate quality evidence, strong recommendation)*

4.4.10.2. "Corrected" total serum calcium concentrations for serum albumin < 4 mg/dL ("corrected" total calcium = measured serum calcium + (4 – measured serum albumin)*(0.8)) often overestimate total serum calcium concentrations and should not be used to estimate the severity of hypocalcemia.[20,60] (*UW Health GRADE Moderate quality evidence, strong recommendation*)

5. Sliding Scale Electrolytes

5.1 Due to staffing, timing of lab draws, and diverse patient populations, sliding scale electrolyte supplementation is not safe in all patients *(UW Health GRADE Low quality evidence, strong recommendation)*

5.2 Both intravenous and oral sliding scale electrolyte replacement are only acceptable in ICU and IMC status patients on B4/3, B4/5, B6N3, B6S3, D4/5, D6/5, F4/4, F4M5, and F8/4. Additionally, general care status patients on cardiology units (B4/5, D4/5, F4M5, F4/5) may receive sliding scale electrolytes. *(UW Health GRADE Very low quality evidence, strong recommendation)*

5.3 Electrolyte replacement may not be applicable for patients on renal replacement therapy. *(UW Health GRADE Very low quality evidence, strong recommendation)*

Disclaimer

Clinical practice guidelines assist clinicians by providing a framework for the evaluation and treatment of patients. This guideline outlines the preferred approach for most patients. It is not intended to replace a clinician's judgment or to establish a protocol for all patients. It is understood that some patients will not fit the clinical condition contemplated by a guideline and that a guideline will rarely establish the only appropriate approach to a problem.

Methodology

Development Process

Each guideline is reviewed and updated a minimum of every 3 years. All guidelines are developed using the guiding principles, standard processes, and styling outlined in the UW Health Clinical Practice Guideline Resource Guide. This includes expectations for workgroup composition and recruitment strategies, disclosure and management of conflict of interest for participating workgroup members, literature review techniques, evidence grading resources, required approval bodies, and suggestions for communication and implementation.

Methods Used to Collect the Evidence:

The following criteria were used by the guideline author(s) and workgroup members to conduct electronic database searches in the collection of evidence for review.

Literature Sources:

- PubMed
- Cochrane Review
- International Pharmaceutical Abstracts

Time Period: Through 2017

Search Terms:

- “Intravenous electrolyte administration”
- “Intravenous electrolyte replacement”
- “Potassium repletion”
- “Magnesium intravenous supplementation”
- “Calcium intravenous repletion”
- “Intravenous phosphate replacement”
- “Intravenous electrolyte supplementation for high risk patients”
- “Electrolyte repletion cardiac”
- “Electrolyte repletion burn”
- “Electrolyte repletion”
- “Supplementation hepatectomy”
- “Oral or enteral electrolyte administration”
- “Oral or enteral electrolyte replacement”

Methods to Select the Evidence:

In addition to electronic database searches, literature searches were extended to reviews and studies conducted in humans and published in English. Reference lists of relevant studies were also reviewed.

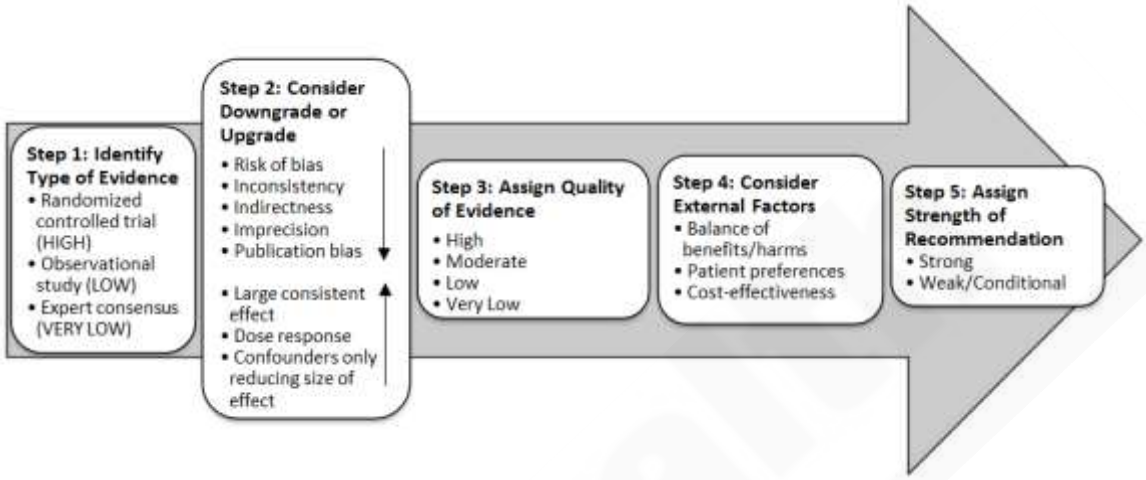
Methods Used to Formulate the Recommendations:

The workgroup members agreed to adopt recommendations developed by external organizations and/or created recommendations internally via a consensus process using discussion of the literature and expert experience/opinion. If issues or controversies arose where consensus could not be reached, the topic was escalated appropriately per the guiding principles outlined in the UW Health Clinical Practice Guideline Resource Guide.

Methods Used to Assess the Quality of the Evidence/Strength of the Recommendations:
Recommendations developed by external organizations maintained the evidence grade assigned within the original source document and were adopted for use at UW Health.

Internally developed recommendations, or those adopted from external sources without an assigned evidence grade, were evaluated by the guideline workgroup using an algorithm adapted from the Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology (see **Figure 1**).

Figure 1. GRADE Methodology adapted by UW Health



Rating Scheme for the Strength of the Evidence/Recommendations:

GRADE Ranking of Evidence

High	We are confident that the effect in the study reflects the actual effect.
Moderate	We are quite confident that the effect in the study is close to the true effect, but it is also possible it is substantially different.
Low	The true effect may differ significantly from the estimate.
Very Low	The true effect is likely to be substantially different from the estimated effect.

GRADE Ratings for Recommendations For or Against Practice

Strong	The net benefit of the treatment is clear, patient values and circumstances are unlikely to affect the decision.
Weak/conditional	Recommendation may be conditional upon patient values and preferences, the resources available, or the setting in which the intervention will be implemented.

Recognition of Potential Health Care Disparities: None identified

Collateral Tools & Resources

The following collateral tools and resources support staff execution and performance of the evidence-based guideline recommendations in everyday clinical practice.

Metrics

- Assess appropriateness of oral, enteral, and IV supplementation based on patient lab results and appropriate documentation

Associated Guidelines

- UW Health – Intravenous Administration of Formulary Medications – Adult – Inpatient/Ambulatory
- UW Health Management Extravasation of Non-Chemotherapeutic Agents – Adult/Pediatric – Inpatient/Ambulatory

Order Sets & Smart Sets

- IP – Cardiac Surgery – Electrolyte Supplementation – Adult – Supplemental [3534]
- IP – Electrolyte Supplementation – Adult – ICU/IMC Supplemental [3439]

Protocols

- Nutrition Support Care – Adult/Pediatric/Neonatal – Inpatient/Ambulatory [6]

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