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Drug Shortage Alert
Electrolytes
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Recommendations and information provided in this Drug Shortage Alert are compiled by experts in the field. Practitioners are advised to consult with their institution's staff to ensure that response to any drug shortage is in line with internal policies and procedures.

INTRODUCTION

- Lack of availability of any IV electrolyte can have serious consequences. As such, an interdisciplinary team should systematically analyze institutional usage patterns and automatic electrolyte replacement protocols and policies. Depending on current availability, routine usage of these IV electrolytes should be evaluated, and restrictive criteria (e.g., based on indication or severity of laboratory findings) may need to be implemented to conserve existing supply for critical patients and indications. This alert is for the following electrolytes:
    - Concentrated calcium
    - Concentrated magnesium
    - Concentrated phosphate
    - Concentrated potassium
    - Concentrated sodium
- This summary provides information relevant in the event of a shortage and its impact on adult and pediatric patients by providing potential management strategies, pharmacotherapeutic considerations, and safety implications.
- The recommendations provided within this document are based on current evidence, including a review of available literature by the SCCM Drug Shortages and Medication Safety Committee and the need for conservation during this shortage.
- Additional resources regarding electrolyte shortages can be found on the American Society of Parenteral and Enteral Nutrition Product Shortages web page.

GENERAL MANAGEMENT STRATEGIES

- Consider switching to oral or enterally administered electrolyte products when oral/enteral intake is initiated (excluding patients with malabsorption syndrome or nonfunctioning gastrointestinal tract). Consult a pharmacist for product information.
- Purchase only as much electrolyte and mineral injection supply as needed. In the interest of fair allocation to all patients nationally, do not stockpile.
- Reserve IV electrolyte products for those patients receiving parenteral nutrition (PN) or those with a therapeutic medical need for IV electrolytes.

- Limit the use of electrolyte additives in IV fluids for patients with disease states and clinical conditions for which they are appropriate.
- Reconsider the use of serum electrolyte algorithms and protocols as automatic IV electrolyte replacement therapies in otherwise asymptomatic patients.
- Review the entire portfolio of electrolytes available nationally. There may be a shortage in one concentration or salt form but availability in another form.
- Determine whether a standardized, commercially available PN product with standard electrolytes might be appropriate for a portion of your PN patient population. Generally, additional components can be added to these products.
- Consider compounding PN in a single, central location (either in a centralized pharmacy or as outsourced preparation) to decrease inventory waste.
- Include PN component shortages and outages in the healthcare organization's strategies and procedures for managing medication shortages and outages.

IV CONCENTRATED CALCIUM

Calcium is essential to homeostasis and the function of multiple organ systems. This review contains guidance for calcium replacement, including when to use various calcium salts in life-threatening situations and nutritional supplementation.

Signs and symptoms of calcium deficiency are usually seen with ionized calcium ≤ 2.8 mg/dL (≤ 0.7 mmol/L) or total calcium ≤ 7.5 mg/dL (≤ 1.875 mmol/L). Symptoms include:

- Hypotension
- Bradycardia
- Hyperactive reflexes
- Bronchospasm

MANAGEMENT STRATEGIES

- Depending on your institution's supply, considerations for reserving IV calcium for the scenarios in **Table 1** is prudent.

Table 1. Potential Clinical Scenarios for Reservation of Calcium During Shortages

Drug	Clinical scenario
IV calcium gluconate	• Patients without central IV access needing calcium repletion • PN patients requiring calcium in PN ○ Calcium chloride has limited compatibility in PN and should be administered as a separate infusion.

IV calcium chloride	• Reserve for life-threatening situations, including:
	  ○ Hyperkalemia with ECG disturbances
	  ○ Cardiac resuscitation/ACLS
	  ○ Overdose of calcium channel blockers or beta-adrenergic blockers
	  ○ Massive transfusion of packed red blood cells

ACLS, advanced cardiac life support; ECG, electrocardiogram; IV, intravenous.

Table 2 describes selected indications for the above-mentioned drug shortages, specifically in the critically ill.

Table 2. Potential Management Strategies for Drug Shortage

Indication in the critically ill	Suggested strategies	Key points
Hyperkalemia and ECG disturbances	• Reserve IV calcium only if patient has ECG changes (peaked T-waves)	• No correlation exists between the degree of hyperkalemia and severity of symptoms; however, life-threatening arrhythmias are more likely in patients with rapid rise of serum potassium.
Cardiac resuscitation/ACLS	• Consider administration of IV calcium only if the cause of arrest is suspected to be hyperkalemia, CCB overdose, or hypocalcemia.	• Limit indiscriminate administration of calcium during cardiac arrest.
Overdose of CCB or beta-adrenergic blocker	• IV calcium chloride or gluconate should be reserved for this life-threatening situation.	• Calcium gluconate may be preferred in acidotic patients to avoid worsening existing acidosis.
Massive transfusion of packed red blood cells	• For each round of MTP, administer 1 gram of IV calcium chloride or 3 grams of IV calcium gluconate.	• Citrate chelation of calcium resulting in hypocalcemia may worsen coagulopathy. • Target high-normal level of calcium during MTP.
Severe, symptomatic hypocalcemia	• IV calcium chloride or gluconate should be reserved for patients who are symptomatic (tetany, acute heart failure, and arrhythmias).	• Symptoms depend on both the degree of hypocalcemia and the rate of decline in serum calcium concentrations.

ACLS, advanced cardiac life support; CCB, calcium channel blocker; ECG, electrocardiogram; IV, intravenous; MTP, massive transfusion protocol

PHARMACOTHERAPEUTIC CONSIDERATIONS

- The use of IV calcium and management strategies in the setting of drug shortages is indication dependent.
- Check for hypomagnesemia and correct if present.
- Obtain ionized calcium concentration from patients who have hypoalbuminemia and hypocalcemia. If ionized calcium concentration is unavailable, consider calculating corrected calcium.
    - Corrected calcium = total calcium + 0.8 × (4 – measured serum albumin).
- Patients who require continuous renal replacement therapy (CRRT) may or may not require anticoagulation therapy to prevent clotting in the hemofilter to maximize CRRT circuit life. If anticoagulation is required, consider using heparin over citrate (trisodium citrate or

anticoagulant citrate dextrose formula A) to prevent the need for massive calcium repletion.

- In patients who are asymptomatic and can take oral medications, consider oral replacement of calcium (**Tables 3** and **4**).

Table 3. Parenteral Calcium Dosing Recommendations

Indication	Ionized calcium	Dose	Monitoring
Severe symptomatic hypocalcemia	Ionized calcium, ≤ 4 mg/dL (≤1 mmol/L)	• Calcium gluconate, 2-3 g* IV × 1 dose over 10 min or • Calcium chloride, 1 g** IV × 1 dose over 10 min	• Repeat every 60 min until clinical manifestations resolve. • Avoid administration of sodium bicarbonate or phosphate during calcium administration.
Mild to moderate hypocalcemia	Ionized calcium, 4–5 mg/dL (1-1.2 mmol/L)	• Calcium gluconate, 1-2 g* IV over 2 hours	• Repeat ionized calcium 6-10 hours after IV calcium administration.

*Calcium gluconate, 1 gram = 93 mg elemental calcium.
**Calcium chloride, 1 gram = 273 mg elemental calcium.

Table 4. Calcium-Containing Enteral and Parenteral Products

Product	Route	mEq	Elemental calcium (mg)	Packaging
Calcium acetate	Oral	8.5	169	667 mg/5 mL; 667 mg tabs or capsules
Calcium carbonate	Oral	20	400	260-1,500 mg tabs
Calcium chloride	Parenteral	13.6	273	1 gram/10 mL
Calcium citrate	Oral	10.5	211	150-1040 mg tabs; 760 mg/3.5 g granules
Calcium gluconate	Parenteral/oral	4.6	93	1 gram/10 mL IV; 500-1000 mg tab
Calcium glubionate	Oral	3.2	64	1.8 g/5mL
Calcium lactate	Oral	4.2	84	100-648 mg tabs

SAFETY IMPLICATIONS

- Calcium chloride is 2 to 3 times more potent than calcium gluconate.
- Calcium gluconate is preferred in general for nonemergent situations when oral or enteral route is not feasible because it is associated with decreased risk of phlebitis and is less likely to cause tissue necrosis if extravasated. This risk is decreased if calcium is administered in large veins or through a central venous catheter.
- Administer calcium chloride, 100 mg/mL, no faster than 0.5 mL to 1 mL/min (i.e., 1 gram over 10 minutes) outside of emergencies, where it may be pushed over 2 to 5 minutes. Rapid administration may cause bradycardia; heat waves; local burning sensation; metallic, calcium, or chalky taste; moderate drop in blood pressure; peripheral vasodilation; or a sense of oppression.

- If calcium gluconate is removed from PN, monitor serum calcium and albumin concentrations or, preferably, serum ionized calcium concentrations.
    - If calcium replacement is required, administer calcium gluconate as a separate infusion from PN.

IV CONCENTRATED MAGNESIUM

Magnesium is an electrolyte that is essential for many systems in the body, particularly nerve signal transmission and muscle contraction. It activates several enzymes and is important in the conversion of blood sugar into energy.

Magnesium sulfate is used in the treatment of seizures in preeclampsia, asthmatic attacks, cardiac arrhythmias, and as a tocolytic to slow contractions in preterm labor. Additionally, magnesium sulfate may be given by injection to correct a deficiency in patients unable to take an oral supplement.

MANAGEMENT STRATEGIES

- Depending on your institution's supply, considerations for reserving IV magnesium for the following scenarios is prudent:
    - Magnesium repletion in symptomatic patients
    - Seizures associated with preeclampsia
    - Cardiac arrhythmias
    - Preterm labor
- Oral/enteral magnesium replacement can be considered as an alternative in certain situations (if not also on shortage)

Table 5 describes selected indications for the above-mentioned drug shortage, specifically in the critically ill.

Table 5. Potential Management Strategies for Drug Shortage

Indication in the critically ill	Suggested strategies	Key points
Electrolyte replacement	• Prioritize usage, saving supplies for the most vulnerable patients: serum magnesium level < 1.2 mg/dL or symptomatic patients. • Use premixed IV magnesium products as much as possible.	• Conversion to oral or enteral magnesium replacement should be sought when feasible but may be limited by the frequency of bowel movements.
Seizures in preeclampsia	• Magnesium sulfate injection is appropriate for this patient population.	• Do not substitute other magnesium salts in preeclampsia because of the lack of data concerning other salts.
Acute asthmatic attacks	• May consider limiting usage of magnesium sulfate injection for this indication given the availability of other therapies	• Oral magnesium replacement in acute attacks has not consistently been shown to have a

	and the potential role of oral/enteral magnesium replacement.	benefit.
Cardiac arrhythmias	• Magnesium sulfate injection is appropriate for this patient population.	• Oral therapies may be appropriate in prophylactic setting.
Tocolytic (slow contractions) in preterm labor	• Magnesium sulfate injection is appropriate for this patient population.	• High doses of magnesium sulfate are generally required; planning is required to ensure availability of adequate supply.

PHARMACOTHERAPEUTIC CONSIDERATIONS

- The use of IV magnesium and management strategies in the setting of drug shortages is indication dependent.
- Oral absorption varies from 20% to 50% of total oral dose absorbed.
- Enteral magnesium preparations should be avoided in malabsorption syndrome; short bowel syndrome; severe nausea; vomiting; diarrhea; or motility disorders of the stomach, esophagus, or intestines.
- Sustained-release preparations are more slowly absorbed, avoid some of the initial renal excretion, and should be considered when appropriate. They also allow for the use of lower doses, which may help minimize the dose-limiting adverse effect of diarrhea (**Tables 6** and **7**).

Table 6. Magnesium-Containing Parenteral Products

Product	Available solutions	Concentration, mEq/L
Magnesium chloride	20%	2
Magnesium sulfate	50%	4.06

Table 7. Magnesium-Containing Enteral Products

Magnesium salt	Elemental magnesium per dose, mEq	Elemental magnesium per dose, mg
Chloride	5 mEq/enteric coated tablet	64 mg/enteric coated tablet
Citrate	167 mEq/300 mL	2000 mg/300 mL
Gluconate	2.3 mEq/tablet	27 mg/tablet
Oxide	25 mEq/tablet	300 mg/tablet
Protein complex	12 mEq/tablet	133 mg/tablet
Sulfate	4 mEq/mL	48 mg/mL
Hydroxide	11 mEq/tablet; 2.8 mEq/mL suspension	130 mg/tablet; 33 mg/mL suspension

Note: Chloride, gluconate, and protein complex salts may cause less diarrhea.

SAFETY IMPLICATIONS

- Assessment and evaluation of feasibility of oral/enteral potassium repletion is required. Magnesium is renally eliminated, and doses may need to be decreased in patients with renal insufficiency to avoid hypermagnesemia.

IV CONCENTRATED PHOSPHATE

Phosphorous is the main intracellular anion, with less than 1% of total body phosphorous in the extracellular fluid. In the serum, phosphorous exist primarily as phosphate. Phosphate provides energy-rich bonds in the form of adenosine triphosphate (ATP) required by all cells for numerous functions.

Because critically ill patients are often hypermetabolic, phosphate requirements may be high; however, it is unclear whether correcting hypophosphatemia affects outcomes in critically ill patients.

IV phosphate exists in two salt forms, potassium phosphate and sodium phosphate.

MANAGEMENT STRATEGIES

- Depending on your institution's supply, considerations for reserving IV phosphate for the following scenario is prudent:
    - Severe symptomatic hypophosphatemia (< 1 mg/dL) (**Table 8**)
- Risk factors for developing hypophosphatemia include acute respiratory alkalosis, malnutrition, diabetic ketoacidosis, alcoholism, liver resection, vomiting, gastric losses, CRRT, and administration of insulin, diuretics, or a carbohydrate load.
- Treatment depends on the degree of hypophosphatemia and the presence of symptoms. Use enteral phosphate replacement product when possible.
- Consider reserving IV phosphate therapy for patients with severe hypophosphatemia or receiving mechanical ventilation.
- Consider providing enteral nutrition therapy when clinically appropriate.
- Oral/enteral phosphate replacement can be considered as an alternative in certain situations (if also not on shortage).

Table 8. Potential Clinical Scenarios for Reservation of Phosphate During Shortages

Drug	Clinical scenario
Sodium phosphate	• Patients with hypophosphatemia who cannot tolerate or ingest oral medications • PN patients requiring phosphate in PN who have concomitant hyperkalemia • Preferred salt in neonates as it contains approximately one-third the amount of aluminum as potassium phosphate
Potassium phosphate	• Use in patients with concurrent hypokalemia who cannot tolerate or ingest oral medications

PN, parenteral nutrition.

Table 9 describes select indications for the above-mentioned drug shortage, specifically in the critically ill.

Table 9. Potential Management Strategies for Drug Shortage

Indication in the critically ill	Suggested strategies	Key points
Asymptomatic and serum phosphate ≥ 2 mg/dL	• No treatment	• May be treated by increasing dietary intake or using oral supplementation

Symptomatic and serum phosphate level between 1 and 1.9 mg/dL,	• Consider oral phosphate therapy	• IV therapy is indicated in patients unable to ingest oral medications or lack of enteral access
Severe hypophosphatemia (≤ 1 mg/dL)	• Consider IV phosphate replacement • Switch to oral replacement if clinically feasible when serum phosphate is greater than 1.5 mg/dL	• IV therapy indicated • Note that phosphate has a wide therapeutic index

PHARMACOTHERAPEUTIC CONSIDERATIONS

- Avoid hypophosphatemia. If serum phosphate is trending down, consider early enteral replacement to avoid the need for IV phosphate.
- Consider stopping phosphate replacement when serum phosphate is greater than or equal to 2 mm/dL unless there is a need for chronic therapy (e.g., persistent urinary phosphate loss) (**Tables 10** and **11**).

Table 10. Enteral and Parenteral Phosphorus Dosing Recommendations

Indication	Phosphorus level	Oral/enteral phosphate dosage	IV phosphate dosage
Mild, asymptomatic hypophosphatemia	2-2.4 mg/dL	• 1000-2000 mg/d divided into 4 doses	• 0.08-0.16 mmol/kg
Moderate, asymptomatic hypophosphatemia	1-1.9 mg/dL	• 1000-2000 mg/d divided into 4 doses	• 0.16-0.32 mmol/kg
Moderate or severe symptomatic hypophosphatemia	1-1.5 mg/dL	• IV treatment recommended	• 0.32-1 mmol/kg

Table 11. Phosphorus Replacement Products

Product	Phosphate content	Sodium content	Potassium content
Oral preparations			
Skim milk, 1 cup (240 mL)	250 mg (8 mmol)	126 mg (5.5 mmol)	406 mg (10 mEq)
Phos-NaK (powder for solution, 1 packet)	250 mg (8 mmol)	160 mg (6.9 mmol)	280 mg (7.1 mEq)
K-Phos Neutral (tablet, 250 mg) Phospha 250 Neutral (tablet, 250 mg)	250 mg (8 mmol)	298 mg (13 mmol)	45 mg (1.1 mEq)
K-Phos No.2 (tablet, 250 mg)	250 mg (8 mmol)	134 mg (5.8 mmol)	88 mg (2.3 mEq)
IV preparations			
Sodium phosphate (1 mL)	11 mg (3 mmol)	4 mEq	0
Potassium phosphate (1 mL)	11 mg (3 mmol)	0	4.4 mEq

SAFETY IMPLICATIONS

- Sodium phosphate is the preferred agent in patients with a serum potassium level greater than 4.5 mEq/L. Potassium phosphate may be administered to patients with simultaneous hypokalemia.
- One millimole of potassium phosphate contains 1.47 mEq of potassium. One millimole of sodium phosphate contains 1.33 mEq of sodium.
- To minimize infusion-related side effects, IV phosphate is usually administered over 4 to 6 hours; however, doses can be infused up to 7 mmol per hour (maximum rate is 15 mmol/hr in patients with severe symptomatic hypophosphatemia).

IV CONCENTRATED POTASSIUM

Potassium is required for several physiologic processes in the body, including the transmission of nerve impulses, maintenance of intracellular tonicity, and contraction of skeletal, cardiac, and smooth muscle. The potassium acetate salt formulation can be utilized to contribute to maintenance of serum bicarbonate levels and serum alkalinity, while the potassium chloride salt formulation contributes to maintenance of chloride levels and serum acidity. Enteral potassium preparations are widely available and relatively inexpensive compared to parenteral preparations; however, these formulations require oral or enteral access and reliable absorption.

MANAGEMENT STRATEGIES

- Depending on your institution's supply, considerations for reserving IV potassium salts for the scenarios shown in **Tables 12, 13,** and **14** is prudent:

Table 12. Potential Clinical Scenarios for Reservation of Potassium Acetate and Potassium Chloride During Shortages

Drug	Clinical scenario
IV potassium acetate	• Electrolyte additive in TPN compounding • Treatment of hypokalemia when hyperchloremic acidosis is present
IV potassium chloride	• Treatment of hypokalemia when oral/enteral access unavailable/unreliable • Treatment of hypokalemia in the setting of active dysrhythmia • Treatment of severe hypokalemia <2.5 mEq/L

TPN, total parenteral nutrition.

Table 13. Potential Management Strategies for Potassium Acetate Drug Shortage

Indication in the critically ill	Suggested strategies	Key points
Electrolyte additive in TPN compounding	• Prioritize usage, saving supplies for the most vulnerable patients. • Reevaluate replacement algorithms or treatment protocols for conservation. • Replace with sodium acetate where appropriate to provide adequate acetate anion. • Consider parenteral or oral sodium bicarbonate if patient	• Acetate is an anion that is a supplier of bicarbonate. • It is used when acidosis is present or a risk. • Sodium bicarbonate is incompatible in TPN solutions because it can form secondary precipitates; it must be given orally or parenterally outside of TPN to manage acidosis.

	develops hyperchloremic acidosis.	
Acidemia	• Alkalinization not recommended in sepsis-induced acidosis in patients with pH ≥ 7.2.	• Treat underlying acidosis as primary management.

TPN, total parenteral nutrition.

Table 14. Potential Management Strategies for Potassium Chloride Drug Shortage

Indication in the critically ill	Suggested strategies	Key points
Hypokalemia	• Prioritize usage, saving supplies for the most vulnerable patients. • Reevaluate replacement algorithms or treatment protocols for conservation. • Consider oral/enteral repletion when access is available/reliable. • If product is available, consider repletion with potassium phosphate IV if patient requires both potassium and phosphorus repletion. • Consider correction of hypomagnesemia first to facilitate correction of hypokalemia.	• Enteral access may need to be placed to facilitate hypokalemia treatment if IV potassium chloride is unavailable.

PHARMACOTHERAPEUTIC CONSIDERATIONS

- Potassium repletion can be administered orally/enterally even with severe potassium deficit because all enteral potassium preparations are highly bioavailable (> 70%) (**Table 15**).
- Enteral potassium preparations should be avoided in malabsorption syndrome, short-bowel syndrome, severe nausea and vomiting, diarrhea, or motility disorders of the stomach, esophagus, or intestines.
- Potassium chloride injection may be an additive electrolyte in PN or large-volume IV fluids for potassium replacement.
- Consider reserving potassium chloride injection for patients unable to absorb or tolerate oral/enteral potassium repletion products.

Table 15. Suitable Alternative Products for IV Potassium Chloride Drug Shortage

Product	Route	Packaging
Potassium chloride extended-release	Oral	8 mEq; 10 mEq; 15 mEq; 20 mEq
Potassium chloride packet	Oral	20 mEq per packet
Potassium chloride oral solution	Oral Enteral tube	20 mEq/15mL unit dose cups 40 mEq/15ml bulk bottle
Potassium bicarb-citric acid effervescent tablet	Oral Enteral tube	10 mEq; 20 mEq; 25 mEq

SAFETY IMPLICATIONS

- Assessment and evaluation of feasibility of oral/enteral potassium repletion is required.

- Compounding potassium-containing products poses significant safety risks.
- The introduction of alternative concentrations of parenteral potassium products to a system must be done with utmost concern for safety risks.
- Follow Institute for Safe Medication Practices (ISMP) recommendations. Concentrated potassium for injection products should be removed from all patient care areas and stored only in the pharmacy.

IV CONCENTRATED SODIUM ACETATE

Acetate is converted by the liver to bicarbonate, which ultimately raises serum pH. Sodium acetate may be utilized as repletion for sodium and/or acetate depending on the clinical scenario. Sodium acetate can be used as a buffer in PN or it can be used as a component of hypertonic saline solutions. Lack of availability of buffering solutions presents a challenge for the management of acidotic patients requiring PN, potentially resulting in prolonged acidosis and subsequent physiologic effects.

MANAGEMENT STRATEGIES

- Depending on your institution's supply, consideration for reserving IV sodium acetate for the scenarios in **Table 16** is prudent:

Table 16. Potential Clinical Scenarios for Reservation of Sodium Acetate During Shortages

Drug	Clinical scenario
IV sodium acetate	• Electrolyte additive in TPN compounding • Treatment of hyponatremia when hyperchloremic acidosis is present • For use in hypertonic saline solutions when hyperchloremic acidosis is present

Table 17 describes selected indications for the above-mentioned drug shortage, specifically in the critically ill.

Table 17. Potential Management Strategies for Drug Shortage

Indication in the critically ill	Suggested strategies	Key points
Electrolyte additive in TPN compounding	• Prioritize usage, saving supplies for the most vulnerable patients. • Reevaluate replacement algorithms or treatment protocols for conservation. • Replace with potassium acetate where appropriate to provide adequate acetate anion. • Consider parenteral or oral sodium bicarbonate if patient develops hyperchloremic acidosis.	• Acetate is an anion that is a supplier of bicarbonate. • It is used when acidosis is present or a risk. • Sodium bicarbonate is incompatible in TPN solutions because it can form secondary precipitates; it must be given orally or parenterally outside of TPN to manage acidosis.
Acidemia	• Alkalinization is not recommended in sepsis-induced acidosis in patients with pH ≥ 7.2.	• Treat underlying acidosis as primary management.

Hyponatremia, or for use in hypertonic saline solutions	• Utilize sodium chloride as primary management. • Consider reserving sodium acetate for patients who develop hyperchloremic metabolic acidosis.	• Acetate solution is not routinely used for lager volume IV fluids.

TPN, total parenteral nutrition.

PHARMACOTHERAPEUTIC CONSIDERATIONS

- Strategies to manage the shortage of IV sodium acetate are indication specific.
- Sodium bicarbonate or sodium chloride, based on indication, are alternatives; however, sodium bicarbonate may also be on shortage with limited supplies.
- If sodium bicarbonate is substituted in times of acetate shortage, consider the greater number of drug incompatibilities with bicarbonate and the potential need for additional IV access.
- Potassium acetate is an alternative for use in TPN; however if it is also on shortage, conservation of both acetate salts may be necessary.
- Consider limiting the use of parenteral sodium acetate as a buffering solution to include only critically ill patients with severe acidosis.

SAFETY IMPLICATIONS

- Limiting the use of sodium acetate in TPN and hypertonic sodium solutions may lead to worsening acidosis in selected patients and may increase the risk for hyperventilation, dysrhythmias, decreased myocardial contractility, vasoconstriction, and central nervous system depression. These patients may require secondary management with other parenteral medications (e.g., sodium bicarbonate, THAM) that are also in short supply.
- Follow ISMP recommendations for storage of concentrated sodium for injection.

IV CONCENTRATED SODIUM CHLORIDE

Hyponatremia is the most common electrolyte disturbance encountered in clinical practice.

- Concentrated sodium chloride is used in the treatment of severe symptomatic hyponatremia.
    - In patients with mild symptoms of hyponatremia (e.g., headache, lethargy, dizziness), or who are asymptomatic with a serum sodium > 120 mEq/L, conservative management is recommended.
    - In patients with chronic hyponatremia whose serum sodium level is >120 mEq/L, conservative management is recommended.
    - In patients with severe symptoms of hyponatremia (confusion, ataxia, seizures, obtundation), hypovolemic hyponatremia, or a serum sodium <120 mEq/L, aggressive management should be considered.
- Concentrated sodium chloride is also used as a treatment for elevated intracranial pressure (ICP).

MANAGEMENT STRATEGIES

- Depending on your institution's supply, considerations for reserving IV concentrated sodium chloride for the scenarios in **Table 18** is prudent.

Table 18. Potential Clinical Scenarios for Reservation of Concentrated Sodium Chloride During Shortages

Drug	Clinical scenario
IV concentrated sodium chloride	• Severe symptomatic hyponatremia • Elevated ICP management

ICP, intracranial pressure.

Table 19 describes selected indications for the above-mentioned drug shortage, specifically in the critically ill.

Table 19. Potential Management Strategies for Concentrated Sodium Chloride Drug Shortage

Indication in the critically ill	Suggested strategies	Key points
Severe symptomatic hyponatremia	• Hypertonic saline is the first therapy in this patient population. • Administer at a rate of 15-80 mL/hr or up to 1 mL/kg/hr for the first 2-3 hours. In nonhypovolemic patients, addition of a loop diuretic can be considered, depending on the suspected etiology. When a patient is asymptomatic or if target serum sodium has been achieved, IV fluids can be changed from 3% to 0.9% sodium chloride depending on target serum sodium and monitoring parameters • In patients with serum sodium <120 mmol/L, 0.9% sodium chloride may be tried initially. If serum sodium does not increase by 0.5mmol/L/hr, then 3% sodium chloride should be considered. When patient's serum sodium is >120 mmol/L, consider changing IV fluids from 3% to 0.9% sodium chloride. • In patients with SIADH or edema-producing states, a trial of fluid restriction (<1-1.25 L/day), depending on the degree of hyponatremia, should be attempted • In patients with hypovolemic hyponatremia, fluid restriction should NOT be attempted, as it can worsen hyponatremia.	• Reversible causes of hyponatremia should be identified and corrected. • Administration of oral/enteral sodium chloride tablets may be considered. However, they should be used with caution and avoided in patients with edema, especially those with congestive heart failure.
Elevated ICP management	• 3%, 5% or 23.4% sodium chloride may be required. • Consider mannitol if concentrated sodium chloride is unavailable.	• Use mannitol with caution in patients who are hypovolemic.

ICP, intracranial pressure, SIADH, syndrome of inappropriate antidiuretic hormone.

PHARMACOTHERAPEUTIC CONSIDERATIONS

- Hypertonic saline is used for a variety of indications including symptomatic hyponatremia and elevated ICP.
- The approach to treating hyponatremia includes an assessment of the patient's volume status, the presence and severity of symptoms, and the time course of the decline in serum sodium concentration.
- Determining whether the hyponatremia developed acutely (over a few days) or chronically (over days to weeks) is important for management. The rapidity of correction of serum sodium is determined by the suspected time over which the hyponatremia has developed.
- Traditional therapies for hyponatremia include fluid restriction, diuretics, and sodium administration.

SAFETY IMPLICATIONS

- Central line administration is preferred for IV solutions with sodium concentrations that exceed 0.3mEq/mL.
- Care must be taken when administering hypertonic sodium chloride because of the risk of rapids overcorrection and increased risk of osmotic demyelination. The rate of correction of serum sodium should not exceed 0.5 mEq/L/hr.

IMPACT ON ICU CARE

- Clear and constant communication is recommended to provide clinicians necessary information regarding affected electrolyte shortages
- Education of staff is necessary to avoid repletion of electrolytes in patients with mild or asymptomatic disorders.

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RESOURCES

- American Society of Health-System Pharmacists. Current Drug Shortages. American Society of Health-System Pharmacists. Accessed January 23, 2018. https://www.ashp.org/Drug-Shortages/Current-Shortages
- American Society of Parenteral and Enteral Nutrition. Parenteral nutrition product shortages. American Society of Parenteral and Enteral Nutrition. Accessed January 23, 2018. http://www.nutritioncare.org/public-policy/product- shortages/
- Ariyan CE, Sosa JA. Assessment and management of patients with abnormal calcium. *Crit Care Med*. 2004 Apr;32(4 Suppl):S146-S154.
- Dirkes S, Hodge K. Continuous renal replacement therapy in the adult intensive care unit: history and current trends. *Crit Care Nurse*. 2007 Apr;27(2):61-66, 68-72, 74-80; quiz 81.
- Evans L, Rhodes A, Alhazzani W, et al. Surviving Sepsis Campaign: International guidelines for Management of Sepsis and Septic Shock 2021. *Crit Care Med*. 2021 Nov 49(11):e1063-e1143.
- Forsythe RM, Wessell CB, Billiar TR, Angus DC, Rosengart MR. Parenteral calcium for intensive care unit patients. *Cochrane Database Syst Rev*. 2008 Oct 8;(4):CD006163.
- French S, Subauste J, Geraci S. Calcium abnormalities in hospitalized patients. *South Med J*. 2012 Apr;105(4):231-237.
- Geerse DA, Bindels AJ, Kuiper MA, Roos AN, Spronk PE, Schultz MJ. Treatment of hypophosphatemia in the intensive care unit: a review. *Crit Care*. 2010;14(4):R147.
- Human T. Current therapeutic options for hyponatremia: indications, limitations, and confounding variables. *Pharmacotherapy*. 2011 May;31(5 Suppl):18S-24S.
- Kraft MD, Btaiche IF, Sacks GS, and Kudsk KA. Treatment of electrolyte disorders in adult patients in the intensive care unit. *Am J Health-Syst Pharm*. 2005 Aug 15;62(16):1663-1682.
- Mirtallo JM, Holcombe B, Kochevar M, Guenter P. Parenteral nutrition product shortages: the A.S.P.E.N. strategy. *Nutr Clin Pract*. 2012 Jun;27(3):385-391.
- Plogsted S, Adams SC, Allen K, et al; Clinical Practice Committee's Nutrition Product Shortage Subcommittee of the American Society for Parenteral and Enteral Nutrition. Parenteral nutrition electrolyte and mineral product shortage considerations. *Nutr Clin Pract*. 2016 Feb;31(1):132-134.
- Rhodes A, Evans LE, Alhazzani W, et al. Surviving Sepsis Campaign: international guidelines for management of sepsis and septic shock 2016. *Crit Care Med*. 2017 Mar;45(3):486-552.
- Yeates KE, Singer M, Morton AR. Salt and water: a simple approach to hyponatremia. *CMAJ*. 2004 Feb 3;170(3):365-369.
- Zaloga GP. Hypocalcemia in critically ill patients. *Critical Care Med*. 1992 Feb;20(2):251-262.

Please contact support@sccm.org if you have any suggestions or feedback on this alert.