Society of
Critical Care Medicine
The Intensive Care Professionals

Drug Shortages Alert
3/6/2014

Recommendations and information provided in Drug Shortage Alerts are compiled by experts in the field. Practitioners always are advised to consult with staff to ensure response to any drug shortage is in line with internal policies and procedures.

Sodium Acetate Injection
Hypertonic Saline Injection
Potassium Acetate and Chloride Injection
Phosphate Injection
Calcium Chloride and Gluconate Injection
Magnesium Sulfate Injection

Introduction

The Society of Critical Care Medicine's Drug Shortages Task Force is aware of ongoing and intermittent shortages of sodium acetate injection, concentrated sodium chloride, potassium acetate and chloride injection, phosphate injection, calcium chloride and gluconate injection, and magnesium sulfate injection.

- Manufacturers report a number of reasons for these shortages, including increased demand, manufacturing delays, suspended production, and manufacturer discontinuation.
This summary provides information on the shortage’s impact in the intensive care unit (ICU); specifically, it provides suggested management strategies, pharmacotherapeutic considerations, and safety concerns.

The recommendations provided are based on a combination of current evidence, clinical experience from multiple clinicians, and the need for conservation during these shortages.

### Sodium Acetate Injection
- Various vial sizes of sodium acetate 2 mEq/mL for injection are affected by this shortage.
- Acetate is converted by the liver and skeletal muscle, and it acts as a “supplier” of bicarbonate ion. It may be used as a buffer in parenteral nutrition and hypertonic saline solutions.

### Concentrated Sodium Chloride
- Concentrated sodium chloride is utilized in the treatment of severe symptomatic hyponatremia and as a treatment for elevated intracranial pressure.

### Potassium Acetate and Chloride Injection
- Potassium acetate and chloride injections have been under national back order, with all vials, bulk bottles, and/or premixed piggybacks impacted.
- Potassium is required for several physiologic processes, including the transmission of nerve impulses, maintenance of normal renal function and intracellular tonicity, and contraction of skeletal, cardiac, and smooth muscle. The acetate salt form of the injection contributes to maintenance of serum bicarbonate levels and serum alkalinity, whereas the chloride salt form contributes to maintenance of chloride levels and serum acidity.

### Phosphate Injection
- Phosphorus is the main intracellular anion; less than 1% of total body phosphorus is found in the extracellular fluid. In the serum, phosphorus exists primarily as phosphate.
- Phosphate provides energy-rich bonds in the form of adenosine triphosphate, which is required by all cells and 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.
- Intravenous phosphate exists in two salt forms, potassium phosphate and sodium phosphate, both of which are experiencing ongoing shortages.

### Calcium Chloride and Gluconate Injection
- Calcium is essential to homeostasis and multiple organ systems function.
- This review contains guidance for calcium replacement in adult patients, including
administration of various calcium salts in life-threatening situations and nutritional supplementation.

**Magnesium Sulfate**
- Various vial sizes of magnesium sulfate for injection are affected by shortage.
- Magnesium is an electrolyte that is essential for many systems in the body, in particular 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, asthma 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.

**Sodium Acetate**

**Management Strategies**
- The primary management strategy for sodium acetate is conservation, because alternatives are limited in its use as a base component in total parenteral nutrition (TPN) or in large volume, balanced salt, hypertonic saline solutions.

**Pharmacotherapeutic Considerations**
- Strategies to manage the shortage of intravenous (IV) sodium acetate are indication-specific. Sodium bicarbonate or sodium chloride may be indicated, but sodium bicarbonate is also on shortage and supplies may be limited. Potassium acetate is an alternative for use in TPN; however, it is also on shortage. Conservation of both acetate salts may be necessary.
- Consider limiting use of parenteral sodium acetate as a buffering solution to critically ill patients with severe acidosis.

**Select Indications**

<table>
<thead>
<tr>
<th>Electrolyte additive in TPN compounding</th>
<th>Recommendation</th>
<th>Key Points</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Prioritize usage, saving supplies for the most vulnerable patients</td>
<td>• Acetate is an anion that is a &quot;supplier&quot; of bicarbonate</td>
</tr>
<tr>
<td></td>
<td>• Reevaluate replacement algorithms or treatment protocols for conservation</td>
<td>• Used when acidosis is present or a risk</td>
</tr>
<tr>
<td></td>
<td>• Replace with potassium acetate where appropriate to provide adequate acetate anion</td>
<td>• 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</td>
</tr>
<tr>
<td></td>
<td>• Consider parenteral or oral sodium bicarbonate if patient develops hyperchloremic acidosis</td>
<td></td>
</tr>
</tbody>
</table>
Acidemia

Alkalinization not recommended in sepsis-induced acidosis in patients with pH >7.15

Treat underlying acidosis as primary management

Hyponatremia or in hypertonic saline solutions

- Utilize sodium chloride as primary management
- Consider reserving sodium acetate for patients who develop hyperchloremic acidosis

Acetate solution not routinely used for larger volume IV fluids

Safety Implications

- Limiting use of sodium acetate in TPN and hypertonic sodium solutions may lead to worsening acidosis in select 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 (i.e., sodium bicarbonate, tris[hydroxymethyl]aminomethane [THAM]) that are also in short supply.

Additional Resources


Hypertonic saline 14.6% and 23.4%

Management Strategies

- Hypertonic saline is used for a variety of indications, including symptomatic hyponatremia and elevated intracranial pressure.
- Treatment of 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.
  - Whether the hyponatremia developed acutely (over a few days) or chronically (over days to weeks) determines the rapidity of the serum sodium correction.
  - Determination of the urgency for intervention should be based on the patient’s neurologic status.
  - Traditional therapies for hyponatremia include fluid restriction, diuretics, and sodium administration.

Pharmacotherapeutic Considerations

- In patients with mild symptoms of hyponatremia (i.e., headache, lethargy, dizziness) or who are asymptomatic, and whose serum sodium level is >120 mmol/L, conservative management is recommended.
  - First, reversible causes of hyponatremia (i.e., excessive IV administration of hypotonic fluids, such as 5% dextrose) should be identified and corrected.
  - In patients with the syndrome of inappropriate antidiuretic hormone (SIADH) or edema-producing states, a trial of fluid restriction (<1.25 L/d depending on the degree of hyponatremia) should be attempted. Fluid restriction should not be undertaken in patients with hypovolemic hyponatremia, as it can worsen hyponatremia.
- In patients with severe symptoms of hyponatremia (confusion, ataxia, headache, seizures, obtundation), hypovolemic hyponatremia, or a serum sodium level <120 mmol/L, aggressive management should be considered.
  - Reversible causes of hyponatremia should be identified and corrected, including restriction of hypotonic fluid.
  - For severe symptomatic hyponatremia, hypertonic saline is the initial therapy. It should be administered at a rate of 15-80 mL/h or up to 1 mL/kg/h for the first 2-3 hours. In patients who are not hypovolemic, addition of a loop diuretic (i.e., furosemide, torsemide, bumetanide) 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% sodium chloride to 0.9% sodium chloride, depending on target serum sodium and monitoring parameters.
  - For patients with serum sodium level <120 mmol/L, normal saline may be tried initially. If serum sodium does not increase by 0.5 mmol/L/h, then 3% sodium chloride should be considered. When the patient’s serum sodium is >120 mmol/L, consider changing IV fluids from 3% sodium chloride to 0.9% sodium chloride.
For patients with chronic hyponatremia whose serum sodium level is >120 mmol/L, conservative management is recommended.
- Reversible causes of hyponatremia should be identified and corrected, including restriction of hypotonic fluids.
- Administration of oral sodium chloride tablets may be considered, but these tablets should be used with caution. They should be avoided in patients with edema, especially those with congestive heart failure.

For patients with elevated intracranial pressure:
- Mannitol can be considered, but use caution in patients who are hypovolemic and/or hypotensive.
- 3% or 5% concentrated sodium preparations may be necessary. Hypertonic saline 23.4% should be reserved for rescue therapy for patients with clinical evidence of acute central nervous system herniation.

Safety Implications
- Administration of IV solutions with sodium concentrations that exceed 0.4 mEq/L require central venous access.
- Care must be employed when administering hypertonic saline because of the risk of rapid overcorrection and increased risk of osmotic demyelination. The rate of correction of serum sodium should not exceed 0.5 mmol/L/h.

Additional Resources


Potassium Acetate and Chloride Injection

Management Strategies

- Given the shortages and inconsistent supplies of potassium acetate and chloride used commonly in the ICU, enteral or alternative parenteral potassium replacement strategies must be considered.

- Strategies to manage the shortage of IV potassium acetate are indication-specific. No combination alternatives to potassium acetate can facilitate both potassium replacement and serum alkalinization. Therefore, sodium bicarbonate injection, sodium acetate injection and/or potassium chloride injection, and oral/enteral products are alternatives based on indication. Both sodium bicarbonate and sodium acetate injection have been on shortage as well, and supplies may be limited. Conservation of both acetate salts may be necessary.

- The following are key considerations for potassium acetate injection shortage:

<table>
<thead>
<tr>
<th>Select Indications</th>
<th>Recommendation</th>
<th>Key Points</th>
</tr>
</thead>
</table>
| 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 to provide adequate acetate anion  
- Recommend parenteral or oral sodium bicarbonate if patient develops hyperchloremic acidosis due to limited acetate | - Acetate is an anion "supplier" of bicarbonate  
- 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 not recommended in sepsis-induced acidosis in patients with pH >7.15 | - Treat underlying acidosis as primary management |
The following are suitable alternatives for potassium chloride injection:

<table>
<thead>
<tr>
<th>Product</th>
<th>Route</th>
<th>Packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium chloride extended-release tablets</td>
<td>Oral</td>
<td>10-20 mEq</td>
</tr>
<tr>
<td>Potassium chloride oral solution</td>
<td>Oral (enteral administration feasible)</td>
<td>40 mEq/30 mL unit-dosed cups, or 1.33 mEq/mL bulk bottle</td>
</tr>
<tr>
<td>Potassium chloride oral powder for solution</td>
<td>Oral (enteral administration feasible)</td>
<td>20 mEq-25mEq/packet</td>
</tr>
</tbody>
</table>

- Potassium chloride injection may be an additive electrolyte in TPN or large volume IV fluids for potassium replacement.
- Consider reserving potassium chloride injection for patients unable to absorb or tolerate oral/enteral potassium replacement alternatives.

**Pharmacotherapeutic Considerations**
- Potassium repletion can be achieved orally even in severe potassium deficit, because all enteral potassium preparations are highly bioavailable (>70%).
- Enteral potassium preparations should be avoided in malabsorption syndrome, short-bowel syndrome, severe nausea, vomiting, diarrhea, or motility disorders of the stomach, esophagus, or intestines.
- Magnesium should be repleted if hypomagnesemia is present or suspected.

**Safety Implications**
- Assessment and evaluation of feasibility of oral/enteral potassium repletion is required.
- Agents that are not typically ordered or utilized may need to be added to stock, as well as to the medication ordering system.

**Additional Resources**


Phosphate Injection

Management Strategies
- Risk factors for developing hypophosphatemia include acute respiratory alkalosis, malnutrition, diabetic ketoacidosis, alcoholism, liver resection, vomiting, gastric losses, continuous renal replacement therapy, and administration of insulin, diuretics, or a carbohydrate load.
- Treatment depends upon the degree of hypophosphatemia and the presence of symptoms.
- Enteral phosphate replacement product should be used when possible.
- Intravenous phosphate therapy may be reserved for patients with severe hypophosphatemia.
- Enteral nutrition therapy should be considered when clinically appropriate.
- Indication for patients on parenteral nutrition therapy should be evaluated.

Pharmacotherapeutic Considerations
- Avoid hypophosphatemia. If serum phosphate is trending down, consider early enteral replacement to avoid the need for IV phosphate.

<table>
<thead>
<tr>
<th>Indication</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>If patient asymptomatic and serum phosphate &gt;2 mg/dL</td>
<td>No treatment</td>
</tr>
<tr>
<td>If patient symptomatic and serum phosphate level is between 1 to 1.9 mg/dL</td>
<td>Consider oral phosphate therapy</td>
</tr>
<tr>
<td>For patients with severe hypophosphatemia (≤1 mg/dL)</td>
<td>Consider IV phosphate replacement</td>
</tr>
<tr>
<td>Switch to oral replacement if clinically feasible when serum phosphate &gt;1.5 mg/dL</td>
<td></td>
</tr>
<tr>
<td>Consider stopping phosphate replacement when serum phosphate ≥2 mg/dL unless needed for long-term therapy (e.g., persistent urinary phosphate loss).</td>
<td></td>
</tr>
</tbody>
</table>

- Oral Phosphate Products: Amounts of Sodium and Potassium

<table>
<thead>
<tr>
<th>Product</th>
<th>Phosphate (mmol)</th>
<th>Sodium (mEq)</th>
<th>Potassium (mEq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutra-Phos® (capsule/packet)</td>
<td>8</td>
<td>7.1</td>
<td>7.1</td>
</tr>
<tr>
<td>Neutra-Phos K® (capsule/packet)</td>
<td>8</td>
<td>0</td>
<td>14.25</td>
</tr>
<tr>
<td>Skim milk per 8 oz (1 cup)</td>
<td>8</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>K-Phos ® Neutral (tablet)</td>
<td>8</td>
<td>13</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Glycophos™ 20 mL injection may be an alternative to phosphate.

Due to the critical shortage of phosphate injection, the U.S. Food and Drug Administration is allowing for the importation of Glycophos™ 20 mL injection.

Glycophos contains sodium glycerophosphate, an organic phosphate that is different from any phosphate product available in the United States.

There are key differences in the formulation between U.S.-marketed phosphate injection and Glycophos. Glycophos contains 1 mmol of phosphate per 1 mL of solution compared to phosphates marketed in the United States, which contain 3 mmol of phosphate per 1 mL.

Glycophos does not contain a preservative and is intended for single use.

Limited compatibility data are available for Glycophos.

Glycophos should be used with caution in patients with dehydration, hypernatremia, severe renal insufficiency, and shock.

Bar coding systems should not be used on Glycophos vials as incorrect information may be provided if the item is scanned.

To learn more about Glycophos, please visit two sites:


Safety Implications

- Sodium phosphate is the preferred agent in patients with a serum potassium >4.5 mEq/L.
- Potassium phosphate may be administered to patients with concurrent 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 at a rate as high as 7 mmol/h (maximum rate is 15 mmol/h in patients with severe symptomatic hypophosphatemia).
Additional Resources

U.S. Food and Drug Administration. Current Drug Shortages O–R.


Tozzi WA, Luitpold Pharmaceuticals. Potential for crystallization of sodium phosphates injection, USP.
Calcium Chloride and Gluconate Injection

Management Strategies

- Calcium preparations

<table>
<thead>
<tr>
<th>Preparation</th>
<th>Route</th>
<th>mEq</th>
<th>Elemental calcium (mg)</th>
<th>Packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium chloride, 1 g</td>
<td>Parenteral</td>
<td>13.6</td>
<td>273</td>
<td>1 g/10 mL</td>
</tr>
<tr>
<td>Calcium gluconate, 1 g</td>
<td>Parenteral</td>
<td>4.6</td>
<td>93</td>
<td>1 g/10 mL IV</td>
</tr>
<tr>
<td></td>
<td>Oral</td>
<td></td>
<td></td>
<td>500-1000 mg tab</td>
</tr>
<tr>
<td>Calcium glubionate, 1 g</td>
<td>Oral</td>
<td>3.2</td>
<td>64</td>
<td>1.8 g/5 mL</td>
</tr>
<tr>
<td>Calcium lactate, 648 mg</td>
<td>Oral</td>
<td>4.2</td>
<td>84</td>
<td>100 - 648 mg tabs</td>
</tr>
<tr>
<td>Calcium citrate, 1 g</td>
<td>Oral</td>
<td>10.5</td>
<td>211</td>
<td>150-1040 mg tabs; 760 mg/3.5 g granules</td>
</tr>
<tr>
<td>Calcium carbonate, 1 g</td>
<td>Oral</td>
<td>20</td>
<td>400</td>
<td>260-1500 mg tabs</td>
</tr>
<tr>
<td>Calcium acetate, 667 mg</td>
<td>Oral</td>
<td>8.5</td>
<td>169</td>
<td>667 mg/5 mL; 667 mg tabs or capsules</td>
</tr>
</tbody>
</table>

- Calcium chloride should be reserved for life-threatening situations, including:
  - Hyperkalemia with electrocardiographic disturbances
  - Cardiac resuscitation/advanced cardiopulmonary life support
  - Overdose of calcium channel blockers or beta-adrenergic blockers
- Massive transfusion of packed red blood cells

- Signs and symptoms of calcium deficiency usually seen when ionized calcium $\leq 2.8$ mg/dL ($\leq 0.7$ mmol/L) or total calcium $\leq 7.5$ mg/dL ($\leq 1.875$ mmol/L), which include:
  - Cardiovascular
    - Hypotension
    - Impaired contractility
    - Bradycardia
    - Cardiac arrest
    - Digitalis insensitivity
    - QT and ST prolongation
  - Neuromuscular
    - Tetany
    - Chvostek and Trousseau signs
- Muscle spasms
- Seizures
- Paresthesia
- Hyperactive reflexes
- Respiratory
  - Laryngeal spasm
  - Bronchospasm
- Psychiatric
  - Anxiety
  - Dementia
  - Depression
  - Irritability
  - Psychosis
  - Confusion

- Stable patients who are able to take oral medications may receive the oral formulation of calcium.
- Total parenteral nutrition
  - Calcium gluconate is the preferred form of calcium in multi-compartment parenteral nutrition.
  - If calcium gluconate is removed from parenteral nutrition, monitor serum calcium concentrations along with albumin or preferably ionized calcium concentrations.
  - If calcium replacement is required, infuse calcium gluconate separately from parenteral nutrition.
  - Use of alternative standardized, commercial parenteral products that contain calcium should be considered if applicable.
Pharmacotherapeutic Considerations

- Parenteral calcium dosing recommendations

<table>
<thead>
<tr>
<th>Ionized calcium</th>
<th>Signs and symptoms</th>
<th>Dose</th>
<th>Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe symptomatic hypocalcemia</td>
<td>Tetany, seizures, arrhythmias, etc.</td>
<td>Calcium gluconate, 2-3 g* IV X 1 dose over 10 min <strong>or</strong> Calcium chloride,** 1 g* IV X 1 dose over 10 min</td>
<td>Repeat every 60 minutes until clinical manifestations resolve Avoid administration of sodium bicarbonate or phosphate during calcium administration</td>
</tr>
<tr>
<td>Moderate to severe hypocalcemia</td>
<td>Ionized calcium ≤ 4 mg/dL (≤1 mmol/L) Without seizure or tetany</td>
<td>Calcium gluconate,* 4 g* IV over 4 h</td>
<td>Repeat ionized calcium 6-10 h after IV calcium</td>
</tr>
<tr>
<td>Mild hypocalcemia</td>
<td>Ionized calcium 4-5 mg/dL (1-1.2 mmol/L) Without seizure or tetany</td>
<td>Calcium gluconate,* 1-2 g* IV over 2 h</td>
<td>Repeat ionized calcium 6-10 h after IV calcium</td>
</tr>
</tbody>
</table>

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

- Check for hypomagnesemia and correct if present.
- Consider continuous calcium infusion if hypocalcemia is caused by an ongoing process, such as pancreatitis or hungry bone syndrome.
- Obtain an ionized calcium level in patients who have hypoalbuminemia and hypocalcemia. If this measure is unavailable, calculate corrected calcium.
  - Corrected calcium = total calcium +0.8 X (4 - measured serum albumin)
- Watch for common side effects of parenteral calcium administration: hypertension, nausea/vomiting (triggers chemoreceptor zone), skin flushing, bradycardia, heart block, and chest pain. Symptoms are most frequent with rapid administration.
- Patients who require continuous renal replacement therapy may or may not require anticoagulation therapy to prevent clotting in the hemofilter and to maximize circuit life. If anticoagulation is required, consider using heparin instead of citrate (trisodium citrate or anticoagulant citrate dextrose formula A) to prevent the need for massive calcium repletion.
Safety Implications

- Calcium chloride is two to three times more potent than calcium gluconate.
- Calcium gluconate is generally preferred for nonemergent situations when oral or enteral administration is not feasible, as it is associated with a 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 to 1 mL per minute (i.e., 1 g over 10 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.

Additional Resources


Magnesium Sulfate

Management Strategies

- Strategies to manage the shortage of IV magnesium sulfate are indication-specific.

<table>
<thead>
<tr>
<th>Select Indications</th>
<th>Recommendation</th>
<th>Key Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrolyte replacement</td>
<td>Prioritize usage, saving supplies for the most vulnerable patients: serum magnesium level &lt;1.2 mg/dL or symptomatic patients</td>
<td>Conversion to oral or enteral magnesium replacement should be sought when feasible</td>
</tr>
<tr>
<td>Treatment of seizures in preeclampsia</td>
<td>Magnesium sulfate injection is appropriate for this patient population</td>
<td>Do not substitute other magnesium salts in preeclampsia due to lack of data concerning other salts</td>
</tr>
<tr>
<td>Acute asthmatic attacks</td>
<td>May consider limiting usage of magnesium sulfate injection for this indication given the availability of other therapies, and the potential role of oral/enteral magnesium replacement</td>
<td>Oral magnesium replacement in acute attacks has not consistently been beneficial</td>
</tr>
<tr>
<td>Cardiac arrhythmias</td>
<td>Magnesium sulfate injection is appropriate for this patient population</td>
<td></td>
</tr>
<tr>
<td>Tocolytic (slow contractions) in pre-term labor</td>
<td>Magnesium sulfate injection is appropriate for this patient population</td>
<td>High doses of magnesium sulfate are generally required and need planning to ensure adequate supply is available</td>
</tr>
</tbody>
</table>

- Given the shortages and inconsistent supplies of magnesium sulfate injection, enteral replacement options must be considered for many indications.
- The following is a suitable oral/enteral alternative for magnesium sulfate injection:

<table>
<thead>
<tr>
<th>Product</th>
<th>Route</th>
<th>Packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium oxide tablets</td>
<td>Oral (enteral administration feasible)</td>
<td>400 mg (equivalent to approximately 20 mEq and 240 mg of elemental magnesium)</td>
</tr>
<tr>
<td>Magnesium L-lactate SR</td>
<td>Oral</td>
<td>Mag-Tab SR, 84 mg elemental magnesium</td>
</tr>
</tbody>
</table>
Magnesium chloride SR Oral 1 g magnesium chloride (equivalent to approximately 10 mEq and 20 mg elemental magnesium)

**Pharmacotherapeutic Considerations**
- 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.
- Slow-release preparations are more slowly absorbed, avoid some initial renal excretion, and should be considered when appropriate. They also allow for the use of lower doses, which may help to minimize the dose-limiting adverse effect of 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.

**Additional Resources**


Impacts on ICU Care

Lack of availability of any IV electrolyte can have serious consequences. As such, a multiprofessional team should systematically analyze institutional usage patterns and automatic electrolyte replacement protocols and policies. Depending on current availability, routine use of these IV electrolytes should be evaluated, as restrictive criteria (e.g., based on indication or severity of laboratory values) may need to be implemented to conserve existing supply for critical patients and indications.

### Sodium Acetate Injection
- Lack of availability of a buffering solution presents challenges for the management of acidotic patients requiring parenteral nutrition, potentially resulting in prolonged acidosis and subsequent physiologic effects.
- Outsourcing the compounding of sodium acetate solution can present increased medication acquisition costs.

### Hypertonic Saline
- Outsourcing the production of hypertonic saline (a strategy some pharmacies may employ to secure supply) can represent increased drug acquisition costs.

### Potassium Acetate and Chloride Injection
- Enteral potassium preparations are relatively inexpensive compared to parenteral preparations; however, these formulations require oral or enteral access and absorption.

### Phosphate Injection
- Although several studies have shown an association between hypophosphatemia and increased mortality, it is unclear whether hypophosphatemia contributes to higher mortality or is a marker of illness severity.

### Calcium Chloride and Gluconate Injection
- Data are limited on an association between parenteral calcium supplementation and the outcomes of mortality, multiple organ dysfunction, ICU and hospital lengths of stay, costs, or complications in critically ill patients.
- Parenteral calcium chloride should be reserved for life-threatening situations when a shortage exists.

### Magnesium Sulfate
- Magnesium sulfate for injection, and in varying vial sizes, is in shortage.