Magnesium Salts

Drug Description

Magnesium is the second most abundant intracellular cation. It is has been identified as a cofactor in more than 300 enzymatic reactions involving energy metabolism and protein and nucleic acid synthesis. Several magnesium salts are used clinically. Magnesium chloride, magnesium gluconate, magnesium lactate, and magnesium oxide are oral products used for supplementation in patients with magnesium deficiency due to malnutrition, restricted diet, alcoholism, or magnesium-depleting drugs. Magnesium oxide may also be used as an antacid or laxative.

Magnesium sulfate is the most commonly used of the magnesium salts and can be administered orally or parenterally. It is used orally as a laxative and parenterally as a neuromuscular depressant or to treat hypomagnesemia. Oral magnesium sulfate belongs to the class of saline laxatives, which are used primarily to empty the bowel before surgery or radiologic, proctoscopic, or sigmoidoscopic procedures. Magnesium sulfate is also a useful cathartic in combination with charcoal to treat acute drug overdose because charcoal will not bind inorganic compounds like magnesium sulfate. The primary use of parenteral magnesium sulfate is to prevent and control seizures in preeclampsia and eclampsia. Parenteral magnesium sulfate is also useful in controlling seizures due to epilepsy, glomerulonephritis, or hypothyroidism. Parenteral magnesium may also be considered in the treatment of cardiac glycoside-induced arrhythmias. The 2000 ECC/AHA guidelines conclude that IV magnesium during cardiopulmonary rescuscitation has shown effectiveness only for the treatment of patients with hypomagnesemic states or polymorphic ventricular tachyardia (torsade de pointes).[26331] Therefore, IV magnesium is not recommended in cardiac arrest except in suspected hypomagnesemic states or for the treatment of torsade de pointes.[26331] The routine prophylactic use of magnesium in patients with acute myocardial infarction is no longer recommended.[26331] Magnesium sulfate was officially approved by the FDA in 1939.

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Classifications

- Electrolytic and Renal Agents
  - Electrolyte Replacements
- Hormones and Hormone Modifiers
  - Tocolytics
- Nutritional Supplements
  - Minerals
    - Multimineral Formulas

Chemical Structures

Magnesium Salts
MgO_4S $MgSO_4 \cdot 7H_2O$

Mechanism of Action

Mechanism of Action: Magnesium is a cofactor to all enzymes involved in phosphate transfer reactions that use ATP and other nucleotides as substrates. Magnesium ions are a cofactor for the normal function of the ATP-dependent sodium-potassium "pump" found in muscle membranes. Without magnesium, the efficiency of this pump is compromised. It is believed that hypomagnesemia is an important aspect of hypokalemia. Drugs that cause severe hypokalemia, such as cisplatin, amphotericin B, and loop diuretics, also cause hypomagnesemia. Correction of hypomagnesemia facilitates the treatment of hypokalemia by improving the pump's ability to distribute potassium into the intracellular space. This mechanism also may explain the effectiveness of intravenous magnesium sulfate in treating cardiac glycoside-induced arrhythmias,[23695] although magnesium may exert therapeutic effects independently of a direct action on the sodium-potassium pump. Spector et al[23696] did not observe magnesium reactivation of digoxin-inhibited sodium-potassium ATPase and instead postulated that magnesium is effective via its ability to decrease calcium uptake and decrease potassium efflux at the myocardial cell membrane. Conversely, calcium is a direct antagonist of magnesium.

Magnesium is also necessary for binding of intracellular macromolecules to organelles and mRNA to ribosomes. As a laxative, magnesium sulfate exerts its action primarily in the small intestine. The accepted mechanisms include a hyperosmotic effect from magnesium in the small intestine and stimulation of stretch receptors and peristalsis through retention of water. Other evidence indicates, however, that hyperosmolarity does not occur and that cholecystokinin release or decreased transit time are potential contributory mechanisms.

The mechanism of the antacid effects of magnesium oxide involves reaction with water. In the presence of water, magnesium oxide is converted to magnesium hydroxide which rapidly reacts with gastric acid to form water and magnesium chloride, thereby increasing gastric pH.

As an anticonvulsant, magnesium sulfate depresses the CNS and blocks peripheral neuromuscular transmission. Depression in the CNS may be

achieved through inhibition of acetylcholine release by motor nerve impulses. Magnesium is a peripheral vasodilator and an inhibitor of platelet function. Large doses can lower blood pressure and cause CNS depression.

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Pharmacokinetics

Pharmacokinetics: Magnesium sulfate is administered orally or parenterally; magnesium chloride, gluconate, lactate, and oxide are administered orally. Magnesium is distributed throughout the body. Approximately one-half of the total magnesium in the body is present in soft tissue; most of the remaining magnesium is present in bone. Less than 1% of the total body magnesium is present the blood. Normal serum concentrations range 1.4 to 2 mEq/L in adults, 1.5 to 2 mEq/L in children, and 1.5 to 2.3 mEq/L in neonates and infants. As an anticonvulsant, effective serum magnesium concentrations have been reported to range from 2.5 to 7.5 mEq/L. Magnesium crosses the placenta and is excreted into breast milk; however, problems in humans have not been documented. Magnesium is not metabolized. Elimination occurs renally, but the rate of excretion varies. Approximately 1.5 g (12 mEq) of magnesium is excreted in the urine daily. Magnesium ions are reabsorbed in the thick ascending limb of the loop of Henle.

•Route-Specific Pharmacokinetics

Oral Route

Approximately 34 to 40% of oral magnesium salts are absorbed systemically with a normal diet; however, absorption can increase to 76% in those receiving only 2 mEq/day of magnesium.[53924]

Intravenous Route

Intravenous administration of magnesium sulfate produces an immediate effect that lasts for about 30 minutes.

Intramuscular Route

Following IM administration of magnesium sulfate, the onset of action occurs in 1 hour and the duration of action is about 4 hours.

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Indications

Labeled

- bowel preparation
- cardiac glycoside-induced arrhythmias
- constipation
- dyspepsia
- eclampsia
- hypomagnesemia
- nephritis-associated hypertension
- nephritis-associated seizures
- nutritional supplementation
- preeclampsia

Off-Label, Recommended

- cardiac arrest †
- cardiopulmonary resuscitation †
- digoxin toxicity †
- eclampsia prophylaxis †
- hypertension †
- premature labor †
- pulmonary hypertension †
- seizure prophylaxis †
- status asthmaticus †
- torsade de pointes †
- ventricular fibrillation †
- ventricular tachycardia †

† Off-label indication

Elemental Magnesium Content

One (1) gram of the various magnesium salts contain the following amounts of elemental magnesium:

- magnesium chloride: 120 mg (9.8 mEq) elemental magnesium.
- magnesium gluconate: 54 mg (4.5 mEq) elemental magnesium.
- magnesium lactate: 120 mg (10 mEq) elemental magnesium.
- magnesium oxide: 603 mg (50.3 mEq) elemental magnesium.
- magnesium sulfate: 98 mg (8.12 mEq) elemental magnesium.

For the treatment of hypomagnesemia (see indications for specific associated arrhythmias when present):

NOTE: Serum magnesium concentrations do not accurately predict cellular magnesium stores.

NOTE: The appropriate route of administration for replacement magnesium is dependent on patient symptoms and the severity of hypomagnesemia. Intravenous magnesium replacement should be used initially for patients with clinically severe conditions, and follow-up oral therapy may also be required to fully replenish body stores.

Intravenous dosage (magnesium sulfate):

Adults: 1 to 2 g IV (or 15 to 30 mg/kg lean body weight) every 6 hours for 24 hours. Use the higher end of the dosage range for serum magnesium concentrations less than 1.2 mg/dL. For extreme hypomagnesemia, 8 to 12 g/day IV in divided doses have been used. After the first 24 hours, approximately 60 mg/kg/day may be given in divided doses or as a continuous infusion for the next 2 to 5 days.
Neonates, Infants, Children, and Adolescents: 25 to 50 mg/kg/dose IV over 30 to 60 minutes (Max: 2 g/dose). Repeat as necessary based on serum magnesium concentrations.[44772] [53852] [53853]
Intramuscular dosage:
Adults: 1 to 2 g IM (or 15 to 30 mg/kg lean body weight) every 6 hours for 24 hours is recommended in the FDA-approved labeling; however, IV administration is preferred in clinical practice.
Infants, Children, and Adolescents: 20 to 40 mg/kg/dose IM (Max: 2 g/dose) of a 20% solution is recommended in the FDA-approved labeling; however, IV administration is preferred in clinical practice. Doses may be repeated as necessary based on serum magnesium concentrations. The maximum dose recommended in the FDA-approved labeling for older children is 5 g/day for severe hypomagnesemia and 2 g/day for mild or moderate hypomagnesemia.[57079]
Neonates: 20 to 40 mg/kg/dose IM of a 20% solution is recommended in the FDA-approved labeling for pediatric patients; however, IM administration is not commonly utilized in clinical practice.[57079] In general, IM administration of drugs in neonates, particularly very low birth weight premature neonates, is not practical due to small muscle mass, and absorption is unreliable due to hemodynamic instability that is relatively common in this population.[53249] Doses may be repeated as necessary based on serum magnesium concentrations.[57079]
Oral dosage (magnesium chloride, magnesium gluconate, magnesium lactate, magnesium oxide, or magnesium sulfate):
Adults: Dosage is dependent on severity of deficit and individual patient response; 360 to 672 mg elemental magnesium PO daily in divided doses for severe hypomagnesemia or 120 to 336 mg elemental magnesium PO daily in divided doses for mild, asymptomatic hypomagnesemia has been recommended.[46849] Another source suggests 20 to 50 mmol (480 to 1200 mg) PO daily in divided doses, depending on route and extent of loss.[46853]
Infants, Children, and Adolescents: 10 to 40 mg elemental magnesium/kg/day PO in 2 to 4 divided doses is the general dose range.[53914] [53915] [53917] [53918] [53919] [53924] Higher doses (100 mg elemental magnesium/kg/day PO) have been reported [53916]; however, the use of higher doses may be limited by the occurrence of diarrhea.[53918] Titrate dose based on serum magnesium concentrations.
Oral dosage (magnesium sulfate):
Adults: 3 g PO every 6 hours for 4 doses.

For nutritional supplementation:
•the recommended dietary allowance (RDA) of magnesium for nutritional supplementation in healthy individuals:
NOTE: Use dosage based on age for lactating females.
Oral dosage expressed in elemental magnesium:
Adult pregnant females: 350 mg to 360 mg PO per day is the RDA.[53827]
Adult females 31 years and older: 320 mg PO per day is the RDA.[53827]
Adult females up to 30 years of age: 310 mg PO per day is the RDA.[53827]
Adult males 31 years and older: 420 mg PO per day is the RDA.[53827]
Adult males up to 30 years of age: 400 mg PO per day is the RDA.[53827]
Adolescent pregnant females: 400 mg PO per day is the RDA.[53827]
Adolescent females 14 to 18 years of age: 360 mg PO per day is the RDA.[53827]
Adolescent males 14 to 18 years of age: 410 mg PO per day is the RDA.[53827]
Children 9 to 13 years of age: 240 mg PO per day is the RDA.[53827]
Children 4 to 8 years of age: 130 mg PO per day is the RDA.[53827]
Children 1 to 3 years of age: 80 mg PO per day is the RDA.[53827]
Infants 6 to 12 months of age: 75 mg PO per day based on adequate intake (AI); RDA has not been established.[53827]
Neonates and Infants less than 6 months of age: 30 mg PO per day based on adequate intake (AI); RDA has not been established.[53827]
•to prevent hypomagnesemia in patients receiving total parenteral nutrition (TPN):
Intravenous dosage as magnesium sulfate:
Adults: 16 to 24 mEq IV per day admixed with TPN, dosage requirements vary with renal function. Undialyzed patients with renal failure generally require 0 to 8 mEq of magnesium sulfate.
Children and Adolescents: Recommendations are based on weight; individualize dosage according to monitoring. For weight 50 kg and less, 0.3 to 0.5 mEq/kg/day IV. For weight greater than 50 kg, 10 to 30 mEq/day IV.[43369]
Neonates and Infants: 0.3 to 0.5 mEq/kg/day IV.[43369] Individualize dosage according to monitoring.

For use during cardiopulmonary resuscitation† (CPR) (cardiac arrest†) to treat torsade de pointes† (irregular/polymorphic ventricular tachycardia† associated with QT prolongation) or cardiac arrhythmias associated with hypomagnesemia (e.g., ventricular fibrillation†, ventricular tachycardia†:
Intravenous or Intraosseous† dosage (magnesium sulfate):
Adults: Per ACLS: In emergent cases (e.g., cardiac arrest), 1 to 2 g (diluted in 10 mL 5 % Dextrose) may be administered IV or intraosseous over 15 minutes.[45649] Earlier guidelines recommend 1 to 2 g diluted in 50 to 100 mL 5% Dextrose to be administered IV (or intraosseous) slowly over 5 to 60 minutes if a pulse is present.[32366]
Neonates, Infants, Children, and Adolescents: 25 to 50 mg/kg/dose IV or via intraosseous (IO) infusion (Max: 2 g/dose). Administer by rapid bolus (over several minutes) for pulseless torsades and over 10 to 20 minutes for hypomagnesemia/torsade if pulse present.[43713] [44772] [53920] [53922]

For the treatment of cardiac glycoside-induced arrhythmias (e.g., digoxin toxicity†):

Intravenous dosage (magnesium sulfate):
Adults: 1 to 2 g IV diluted in 50 to 100 mL 5% Dextrose and administered over over 15 to 60 minutes (rate dependent on clinical urgency). In clinical trials, higher doses up to 6 g have been administered IV by slow injection over several minutes; however, the risk of hypotension and asystole accompanies rapid IV infusion. Therefore, rapid infusion of high doses of IV magnesium sulfate should be avoided. Correct hypomagnesemia if present. May follow with continuous infusion if needed.
Infants, Children, and Adolescents: 25 to 50 mg/kg/dose (Max: 2 g/dose) IV or via intraosseous (IO) infusion over 15 to 60 minutes. Rapid infusion of high doses of IV magnesium sulfate should be avoided. Correct hypomagnesemia if present.[43713] [44772]

For the treatment of status asthmaticus†:
Intravenous dosage (magnesium sulfate):
Adults: One hundred thirty-five asthmatic patients aged 18 to 65 years of age with forced expiratory volume in one second (FEV1) less than 75% predicted were randomized to receive 2 grams IV magnesium sulfate or placebo in addition to standardized emergency department procedure for acute asthma. Patients were further categorized as severe (baseline FEV1 less than 25% predicted on presentation) or moderate (baseline FEV1 25 to 75% predicted on presentation). Intravenous magnesium sulfate decreased admission rates and significantly improved FEV1 at 120 minutes and 240 minutes in the severe magnesium-treated group but not in the moderate or placebo groups.[25149]
Infants, Children, and Adolescents: 25 to 75 mg/kg (Max: 2 g/dose) IV infusion as a single dose over 15 to 30 minutes.[24735] [44772] [53885] [53886] [53887] [54288] Higher doses (100 mg/kg/dose) have also been reported in children.[53891] Asthma guidelines recommend adjunct therapies, such as intravenous magnesium, in patients presenting with life-threatening exacerbations and in those with severe exacerbations that are unresponsive to 1 hour of conventional therapy.[33558] [59758] In a meta-analysis (n = 5 studies; 182 patients) examining the use of intravenous magnesium for the treatment of acute asthma in children, 4 studies showed IV magnesium to be effective as additional therapy in patients with moderate to severe acute asthma. Magnesium was effective in decreasing hospitalization rates and improving asthma symptoms and short term pulmonary function tests.[53889]
Intravenous dosage - Continuous infusion (magnesium sulfate):
Infants, Children, and Adolescents: Loading dose of 50 mg/kg (Max: 2 g/dose) IV over 30 minutes, followed by an initial continuous infusion of 25 mg/kg/hour for children weighing less than 30 kg and 20 mg/kg/hour (Max: 2 g/hour) for children weighing 30 kg or more based on limited data from 1 study in 40 children with refractory asthma. Titrate dose based on magnesium serum concentrations (goal 3 to 5 mg/dL), patient response, and tolerability. Continuous infusion dosing has been utilized in order to maintain a stable magnesium concentration vs. peaks and troughs associated with bolus dosing.[53892] Asthma guidelines recommend adjunct therapies, such as intravenous magnesium, in patients presenting with life-threatening exacerbations and in those with severe exacerbations that are unresponsive to 1 hour of conventional therapy.[33558] [59758]
Oral inhalation dosage (isotonic magnesium sulfate, prepared from injectable formulation):
Children and Adolescents 2 years and older: Limited data available. 150 mg/dose administered via nebulization every 20 minutes as needed for 3 doses may be considered as an adjuvant to conventional therapy when mixed with nebulized albuterol and ipratropium in the first hour of treatment for patients with acute severe asthma, particularly those with symptoms lasting less than 6 hours.[59727] [59758] In a large randomized, placebo-controlled trial (n = 508; age range: 2 to 16 years), those receiving adjuvant nebulized isotonic magnesium sulfate (n = 252) showed a statistically significant, but clinically insignificant improvement in mean Asthma Severity Score at 60 minutes. The greatest clinical response was seen in children with more severe attacks (SaO_2 less than 92%) and those with symptoms present for less than 6 hours.[59727]

For the inhibition of uterine contraction in premature labor†:
NOTE: American College of Obstetrics and Gynecology recommends that a tocolytic agent be chosen based on maternal condition and side effects, as a clear-first line drug cannot be recommended. The overall rate of preterm delivery is not reduced by tocolysis, neither acute nor maintenance treatment. Tocolytics typically prolong pregnancy by approximately 2 to7 days, which allows for transfer of the patient to a hospital with appropriate facilities and administration of antenatal corticosteroids to enhance fetal lung maturation.[33039]
Intravenous dosage (magnesium sulfate):
Adults: Initially, 4 to 6 g infused IV over 20 to 30 minutes as a loading dose, followed by 2 to 4 g/hour IV continuous infusion, delivered via controlled infusion pump device, until contractions cease. Continue infusion at the lowest effective dose for 12 to 24 hours as tolerated after cessation of contractions. Average magnesium concentrations associated with cessation of contractions were 5 to 8 mg/dL in clinical studies. Continuous administration should not exceed 5 to 7 days as fetal harm may result; the shortest duration of therapy that can result in fetal harm is unknown. To avoid maternal circulatory fluid overload, the amount of IV fluids administered and the rate of administration should be observed. Deep tendon reflexes, respirations, urinary output, and serum magnesium concentrations should be monitored.[33039] [49674] [54882] [54883]
Oral dosage (magnesium chloride, magnesium gluconate, or magnesium oxide) for maintenance of uterine contraction stabilization:
Adults: 648 to 1200 mg/day PO of elemental magnesium in divided doses. Example regimens: magnesium chloride (128 mg elemental magnesium) PO every 4 hours; magnesium oxide (200 mg elemental magnesium) PO every 4 hours.

For the management of seizures associated with severe toxemia of pregnancy (e.g., preeclampsia, eclampsia):
Intramuscular or Intravenous dosage (magnesium sulfate):
Adults: 4 to 6 g IV loading dose followed by a maintenance dose of 1 to 2 g/hour IV for at least 24 hours is recommended in clinical practice guidelines.[57086] Alternately, 4 to 5 g IV with simultaneous 10 g IM (5 g may be given IM into each buttock) followed by 1 to 2 g/hr continuous IV infusion or 4 to 5 g IM into alternate buttocks every 4 hours until paroxysms cease.[53838] Another manufacturer recommends 1 to 2 g IM then 1 g IM every 30 minutes until relief is achieved.[57079] The daily maximum dosage should not exceed 30 to 40 g/day. In the presence of severe renal insufficiency, frequent serum magnesium concentrations must be obtained, and the maximum dosage of magnesium sulfate is 20 g per 48 hours. [53838]

For eclampsia prophylaxis†, including seizure prophylaxis† and treatment of hypertension†, in women with preeclampsia:
Intramuscular or Intravenous dosage (magnesium sulfate):

Adults: 10 g IM followed by 5 g IM every four hours unless patellar reflex was not present, respirations were fewer than 12/minute, or urine output was less than 100 mL during the preceding 4 hours. If preeclampsia was severe, an initial dose of 4 g IV was given prior to the IM doses.[24414] Alternatively, 4 to 6 g infused IV over 20 to 30 minutes as a loading dose, followed by 1 to 3 g/hour continuous IV infusion, delivered via controlled infusion pump device. Deep tendon reflexes, respirations, urinary output, and serum magnesium concentrations should be observed. In clinical trials, the mean magnesium concentration associated with seizure prevention has ranged from 4 to 7 mg/dL.

For the treatment of persistent pulmonary hypertension† of the newborn (PPHN) in mechanically ventilated neonates†:
Intravenous dosage (magnesium sulfate):
Premature Neonates 33 weeks gestational age and older and Term Neonates: 200 mg/kg IV loading dose over 20 to 30 minutes followed by a continuous infusion of 20 to 150 mg/kg/hour IV titrated to maintain blood magnesium concentrations within the general range of 3 to 5.5 mmol/L (target range varies among studies) has been effective in small studies.[33250] [33251] [33252] [53906] One small randomized study reported targeting a higher serum magnesium range of 5 to 7 mmol/L.[57176] In addition to respiratory status, carefully monitor serum electrolytes, renal function, heart rate, and blood pressure during magnesium therapy.
Premature Neonates 29 to 32 weeks gestational age: 200 mg/kg IV loading dose over 20 to 30 minutes followed by a continuous infusion of 20 to 50 mg/kg/hour IV was used in a small prospective, non-randomized trial of 7 premature neonates (birth weight 1232 to 2346 grams). Serum magnesium concentrations ranged from 2.75 to 6.63 mmol/L during magnesium therapy.[33253] Other reports that include neonates born before 33 weeks gestation as well as neonates of older gestational ages reported loading doses of 200 mg/kg IV followed by infusions of 20 to 150 mg/kg/hour titrated to maintain blood magnesium concentrations in the general range of 3 to 5.5 mmol/L.[33250] [33251] In addition to respiratory status, carefully monitor serum electrolytes, renal function, heart rate, and blood pressure during magnesium therapy.

For the management of nephritis-associated seizures and/or nephritis-associated hypertension related to acute nephritis:
Intravenous or Intramuscular dosage (magnesium sulfate):
Infants, Children, and Adolescents: 20 to 40 mg/kg/dose (Max: 2 g/dose) IV or IM as needed to control seizures.[57079] If giving IM, a 20% solution is recommended. Data for this use in children are lacking.

For use as a laxative to treat constipation or as bowel preparation prior to surgery or radiologic, proctoscopic, or sigmoidoscopic procedures:
NOTE: See separate Magnesium Citrate monograph for dosing information.
Oral dosage (magnesium oxide):
Adults: 2 to 4 g PO at bedtime with a full glass of water.
Oral dosage (magnesium sulfate):
Adults, Adolescents, and Children 12 years and older: 10 to 30 g PO as a single dose or in divided doses.
Children 6 to 11 years: 5 to 10 g PO as a single dose or in divided doses.
Children 2 to 5 years of age: 2.5 to 5 g PO as a single dose or in divided doses.

For the treatment of dyspepsia:
Oral dosage (magnesium oxide):
Adults: 140 mg PO 3 to 4 times per day (capsules) or 400 to 840 mg/day PO (tablets).

Therapeutic Drug Monitoring:

- Normal serum magnesium 1.4—2 mEq/L; may vary depending upon laboratory standards.
- Laboratory monitoring: serum magnesium, serum potassium, and serum creatinine.
- Other: deep tendon reflexes, respirations, and urinary output.

Maximum Dosage Limits
The following apply to the normal dietary intake or dietary supplement intake of magnesium in healthy persons:
•Adults
Tolerable upper intake level for supplemental use is 350 mg/day PO elemental magnesium.
•Elderly
Tolerable upper intake level for supplemental use is 350 mg/day PO elemental magnesium.
•Adolescents
Tolerable upper intake level for supplemental use is 350 mg/day PO elemental magnesium.
•Children
>= 9 years: Tolerable upper intake level for supplemental use is 350 mg/day PO elemental magnesium.
4—8 years: Tolerable upper intake level for supplemental use is 110 mg/day PO elemental magnesium.
1—3 years: Tolerable upper intake level for supplemental use is 65 mg/day PO elemental magnesium.
•Infants
Safe maximum level of daily nutrient intake has not been determined.

Patients with Hepatic Impairment Dosing
Specific guidelines for dosage adjustments in hepatic impairment are not available; it appears that no dosage adjustments are needed.

Patients with Renal Impairment Dosing

Magnesium is eliminated entirely in the kidneys. Dosage should be modified depending on clinical response and degree of renal impairment, but no quantitative recommendations are available.[53838]

Intermittent hemodialysis
Dosage should be modified depending on clinical response, degree of renal impairment, and frequency of hemodialysis; no quantitative recommendations are available.[53838]

†Off-label indication

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Administration Information

General Administration Information
For storage information, see the specific product information within the How Supplied section.

Route-Specific Administration

Oral Administration

Oral Solid Formulations

- *Oral tablets or capsules:* Take magnesium with a full glass of water.
- *Magnesium sulfate crystals:* Dissolve in a full glass of water prior to administration; lemon-flavored carbonated beverages may be used to mask the bitter taste. Administer on an empty stomach for a more rapid effect. Follow each dose with a full glass of water to prevent dehydration. Do not administer at bedtime or late in the evening.

Oral Liquid Formulations

- *Oral solutions:* Mix magnesium with water and administer on an empty stomach.

Injectable Administration

- Magnesium sulfate is administered intramuscularly or intravenously.
- Visually inspect parenteral products for particulate matter and discoloration prior to administration whenever solution and container permit.

Intravenous Administration

- Magnesium sulfate concentration should generally not exceed 200 mg/mL (20%).[36934]
- According to the manufacturer, the rate should not exceed 150 mg/minute, except for emergent indications.[49674] Rapid infusion rates may exceed the urinary magnesium excretion threshold resulting in hypermagnesemia, which may increase the risk of adverse effects.[36934]
- For asymptomatic patients, do not exceed a rate of 1 gram/hour (8 mEq/hour), with a total dose not to exceed 12 grams (approximately 100 mEq) over 12 hours.[36934]
- For severe symptomatic hypomagnesemia, up to 4 grams (32 mEq) may be administered over 4 to 5 minutes. Monitor closely for signs of hypermagnesemia.[36934]
- For pulseless cardiac arrest associated with torsade de pointes, 1 to 2 grams (diluted in 10 mL 5% Dextrose Injection) may be administered IV over 15 minutes.[45649] Previous guidelines recommended that if a pulse was present, 1 to 2 grams diluted in 50 to 100 mL 5% Dextrose Injection, may be infused IV slowly over 5 to 60 minutes.[32366] Infuse more slowly in stable patients; rapid infusions can result in adverse effects (e.g. hypotension).
- During intravenous magnesium therapy, an intravenous calcium preparation (e.g., calcium gluconate) should be readily available as a reversal agent in case symptomatic hypermagnesemia occurs.[49674]

Intramuscular Administration

- For adults, magnesium sulfate concentrations of 250 mg/mL (25%) or 500 mg/mL (50%) are generally used. For infants and children, concentrations should not exceed 200 mg/mL (20%).
- Inject into a large muscle mass, preferably into a gluteal site. Aspirate prior to injection to avoid injection into a blood vessel.

Other Injectable Administration
Intraosseous infusion
NOTE: Magnesium sulfate is not FDA-approved for intraosseous administration.

- During cardiopulmonary resuscitation, the same dosage may be given via the intraosseous route when IV access is not available.[45649]

Inhalation Administration

Oral Inhalation Administration

NOTE: Magnesium sulfate is not FDA-approved for oral inhalation administration.

- Although evidence is limited, studies report administering injectable isotonic magnesium sulfate, sometimes mixed with albuterol or ipratropium, via a nebulizer for the treatment of acute asthma.[59727] [59732] [59733]
- One study reports using isotonic magnesium in the form of a 6.3% solution of magnesium heptahydrate, which is equivalent to 3.18% anhydrous magnesium sulfate.[59732]

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Contraindications / Precautions

Absolute contraindications are italicized

- *AV block*
- *GI obstruction*
- *ileus*
- breast-feeding
- cardiac disease
- dehydration
- electrolyte imbalance
- hypermagnesemia
- pregnancy
- renal disease
- renal failure
- renal impairment

Parenteral magnesium should be avoided in patients with *AV block* because it can exacerbate this condition. If parenteral treatment with magnesium salts is necessary, magnesium should be infused at a slower rate and magnesium levels monitored closely. Cardiac disease in the form of myocardial damage generally is considered a contraindication of magnesium salts; however, magnesium sulfate has been used in acute myocardial infarction patients to prevent arrhythmias. Magnesium salts should be used with caution in patients with electrolyte imbalance; do not use magnesium salts in patients with preexisting hypermagnesemia.

Magnesium salts should be used with caution in patients with renal disease, including patients with renal impairment or renal failure. Magnesium salts are renally eliminated, so patients with renal impairment have an increased risk of developing magnesium toxicity from decreased excretion of magnesium. In patients with severe renal dysfunction, no more than 20 grams (162 mEq) of magnesium should be administered within a 48-hour period. Parenteral magnesium should be avoided in patients with a creatinine clearance of less than 20 mL/minute. Up to 30% of an orally administered dose is absorbed systemically.

When used as laxatives, oral magnesium salts should be avoided in patients with GI obstruction or ileus.

Use oral magnesium salts cautiously in dehydrated patients. Repeated administration of oral magnesium salts may lead to severe dehydration due to fluid losses via the gastrointestinal tract.

Parenteral magnesium sulfate is classified as FDA pregnancy risk category D [49674] and oral magnesium sulfate and other oral magnesium salts are classified pregnancy category B. Parenteral magnesium chloride is classified as pregnancy risk category C.[49675] Parenteral magnesium sulfate readily crosses the placenta and rapidly attains fetal serum concentrations that approximate those in the mother. Serum magnesium concentrations and clinical status must be carefully monitored in the mother during parenteral therapy, especially with high dose use prior to delivery. In addition, all neonates with a history of prolonged in utero exposure to parenteral magnesium sulfate should be monitored carefully for hypocalcemia and bone abnormalities. Continuous administration of magnesium sulfate as a tocolytic during pregnancy beyond 5—7 days has resulted in bone abnormalities, including skeletal demineralization, osteopenia, and neonatal fracture. The shortest duration of therapy that can result in fetal harm is unknown. [49674] Eighteen cases of skeletal abnormalities have been identified in neonates exposed in utero to magnesium sulfate in the FDA's Adverse Event Reporting System (AERS). The average duration of in utero exposure to magnesium sulfate was 9.6 weeks (range 8—12 weeks) with an average total maternal dose of 3700 g. Skeletal abnormalities included osteopenia and multiple fractures of the ribs and long bones. In cases with reported outcomes, fractures were transient and resolved. An epidemiologic study also found an association for an increase in bone abnormalities in neonates with in utero exposure to magnesium sulfate for more than 7 days compared with those exposed < 3 days. The long-term effects of altered laboratory tests and/or radiographic findings suggestive of skeletal abnormalities are unknown. One study in 11 babies reported no radiographic bone abnormalities at 1 and 3 years of age in those that had evidence of bone abnormalities at birth.[54880] Other adverse neonatal effects after in utero exposure to magnesium sulfate, particularly when given more than 24 hours before delivery, include hypotonia (reduced reflexes), drowsiness/somnolence, and respiratory depression. [49674] When used short-term prior to delivery in patients with preeclampsia or eclampsia, the effects of magnesium in the neonate may be similar to those in the mother; however, such effects appear rare with proper use and monitoring. [38699]

Magnesium sulfate is distributed into breast milk. Intravenous magnesium sulfate therapy only increases magnesium concentrations in human milk slightly, and oral magnesium products should not raise human milk concentrations much at all, particularly if not used for extended periods.[46884]

Problems with other magnesium salts have not been demonstrated with normal daily recommended amounts during breast-feeding.

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Pregnancy / Breast-feeding

Parenteral magnesium sulfate is classified as FDA pregnancy risk category D [49674] and oral magnesium sulfate and other oral magnesium salts are classified pregnancy category B. Parenteral magnesium chloride is classified as pregnancy risk category C.[49675] Parenteral magnesium sulfate readily crosses the placenta and rapidly attains fetal serum concentrations that approximate those in the mother. Serum magnesium concentrations and clinical status must be carefully monitored in the mother during parenteral therapy, especially with high dose use prior to delivery. In addition, all neonates with a history of prolonged in utero exposure to parenteral magnesium sulfate should be monitored carefully for hypocalcemia and bone abnormalities. Continuous administration of magnesium sulfate as a tocolytic during pregnancy beyond 5—7 days has resulted in bone abnormalities, including skeletal demineralization, osteopenia, and neonatal fracture. The shortest duration of therapy that can result in fetal harm is unknown. [49674] Eighteen cases of skeletal abnormalities have been identified in neonates exposed in utero to magnesium sulfate in the FDA's Adverse Event Reporting System (AERS). The average duration of in utero exposure to magnesium sulfate was 9.6 weeks (range 8—12 weeks) with an average total maternal dose of 3700 g. Skeletal abnormalities included osteopenia and multiple fractures of the ribs and long bones. In cases with reported outcomes, fractures were transient and resolved. An epidemiologic study also found an association for an increase in bone abnormalities in neonates with in utero exposure to magnesium sulfate for more than 7 days compared with those exposed < 3 days. The long-term effects of altered laboratory tests and/or radiographic findings suggestive of skeletal abnormalities are unknown. One study in 11 babies reported no radiographic bone abnormalities at 1 and 3 years of age in those that had evidence of bone abnormalities at birth.[54880] Other adverse neonatal effects after in utero exposure to magnesium sulfate, particularly when given more than 24 hours before delivery, include hypotonia (reduced reflexes), drowsiness/somnolence, and respiratory depression. [49674] When used short-term prior to delivery in patients with preeclampsia or eclampsia, the effects of magnesium in the neonate may be similar to those in the mother; however, such effects appear rare with proper use and monitoring. [38699]

Magnesium sulfate is distributed into breast milk. Intravenous magnesium sulfate therapy only increases magnesium concentrations in human milk slightly, and oral magnesium products should not raise human milk concentrations much at all, particularly if not used for extended periods.[46884] Problems with other magnesium salts have not been demonstrated with normal daily recommended amounts during breast-feeding.

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Interactions

Level 1 - Severe

Level 2 - Major

- Cardiac glycosides
- Cefditoren
- Cellulose Sodium Phosphate
- Citric Acid; Glucono-Delta-Lactone; Magnesium Carbonate
- Edetate Disodium, Disodium EDTA
- Nifedipine
- Quinolones
- Sodium Polystyrene Sulfonate
- Tetracyclines
- Thyroid hormones
- Vitamin D analogs

Level 3 - Moderate

- Calcium Salts
- Diuretics
- Ethanol
- Etidronate
- General Anesthetics
- Local Anesthetics
- magnesium carbonate
- Magnesium Citrate
- Magnesium Hydroxide
- Neuromuscular blockers
- Sodium Phosphate Monobasic Monohydrate; Sodium Phosphate Dibasic Anhydrous

Level 4 - Minor

- Antidepressants
- Barbiturates
- Benzodiazepines
- Opiate agonists
- Phenothiazines
- Sedating H1-blockers

Concurrent use of magnesium salts with other magnesium-containing products (e.g., magnesium citrate, magnesium carbonate, magnesium hydroxide or other magnesium-containing antacids) may result in magnesium toxicity, especially in patients with renal impairment. Single use of magnesium citrate solution for bowel cleansing or magnesium hydroxide as a laxative may warrant caution if significant renal impairment exists. Magnesium citrate should not be used chronically as a laxative due to the risk of hypermagnesemia.[7205]

Parenteral magnesium sulfate can enhance the neuromuscular blocking effects of neuromuscular blockers such as d-tubocurarine, and succinylcholine. Caution should be exercised when using these agents concurrently.[7197]

Because of the CNS-depressant effects of magnesium sulfate [7197], additive central-depressant effects can occur following concurrent administration with barbiturates, opiate agonists, sedating H1-blockers, antidepressants, benzodiazepines, general anesthetics, local anesthetics, and phenothiazines.

Concurrent use of oral magnesium salts with sodium polystyrene sulfonate (Kayexalate) is not recommended. Sodium polystyrene sulfonate may bind with magnesium salts administered orally; however, the risk of binding with oral magnesium salts may be less with rectal administration of sodium polystyrene sulfonate.[6116]

Excessive ethanol (e.g., alcoholism) or glucose serum concentrations (e.g., diabetes mellitus) may result in increased urinary excretion of magnesium.[7197] [7198] Avoid high intakes of ethanol and glucose while taking magnesium salts.

Electrolytes and renal function should be closely monitored especially if magnesium salts are used with intravenous calcium salts. Concurrent use of intravenous calcium salts with parenteral magnesium sulfate can neutralize the effects of parenteral $MgSO_4$; however, calcium salts are used clinically to antagonize the toxic effects of hypermagnesemia. Simultaneous use of parenteral magnesium sulfate and intravenous calcium salts is also used in patients with post-parathyroidectomy 'hungry bones' syndrome or tetany associated with hypocalcemia and hypomagnesemia. Calcium and magnesium are often combined together in nutritional supplement and vitamin products. Oral calcium-containing medications may increase serum calcium or magnesium concentrations in susceptible patients, primarily in patients with renal insufficiency.[4692] [7204]

Administration of oral magnesium salts with cellulose sodium phosphate or edetate disodium (EDTA) may result in binding of magnesium. Do not administer oral magnesium salts within 1 hour of cellulose sodium phosphate or edetate disodium.[5919]

Diuretics may interfere with the kidneys ability to regulate magnesium concentrations. Long-term use of loop diuretics or thiazide diuretics may impair the magnesium-conserving ability of the kidneys and lead to hypomagnesemia.[7114] Conversely, long-term use of potassium-sparing diuretics has been found to increase renal tubular reabsorption of magnesium which may cause hypermagnesemia in patients also receiving magnesium supplements, especially in patients with renal insufficiency.

Administration of oral magnesium salts with oral tetracyclines or quinolone antibiotics may form nonabsorbable complexes resulting in decreased absorption of tetracyclines and quinolones. Do not administer oral magnesium salts within 1—3 hours of taking an oral tetracycline or oral fluoroquinolone.[4690] [4691] [6707]

Oral magnesium salts may prevent absorption of oral etidronate. Do not administer magnesium salts within 2 hours of oral etidronate.[5386]

Clinically significant drug interactions including neuromuscular blockade and hypotension have occurred when IV magnesium salts were given concurrently with nifedipine during the treatment of hypertension or premature labor during pregnancy. The women affected presented with either pronounced muscle weakness and/or hypotension. In a few cases, fetal harm was noted as a result of the hypotensive episodes. The effects have been attributed to nifedipine potentiation of the neuromuscular blocking effects of magnesium. It is recommended that nifedipine not be given concurrently with magnesium therapy for pre-eclampsia, hypertension, or tocolytic treatment during pregnancy.[5813]

Supplemental magnesium salts should not be used in patients receiving vitamin D analogs. Vitamin D analogs can increase serum magnesium concentrations in patients with chronic renal failure.

Magnesium salts might interfere with the absorption of cefditoren. If magnesium supplementation is required during cefditoren therapy, cefditoren should be taken at least 2 hours before or after the magnesium salt.[5253]

Magnesium salts, such as magnesium sulfate, can antagonize the electrophysiologic effects of digoxin or other cardiac glycosides. Nevertheless, it is acceptable to administer magnesium salts to patients in order to achieve appropriate serum magnesium concentrations.[6127] Magnesium has also been shown to be an effective adjunct in the treatment of digoxin-induced arrhythmias.[251] [252] [6128] [7197] [7207] However, concurrent use of digoxin or other cardiac glycosides with oral magnesium citrate may inhibit absorption and possibly decrease plasma concentrations of the glycoside.[4999] Saline laxatives such as magnesium citrate must be administered with caution to patients receiving cardiac glycoside therapy as electrolyte disturbances, particularly hypokalemia, are possible with their use. Cardiac conduction changes and heart block may occur in patients with electrolyte imbalances.[6115]

The concomitant use of oral sodium phosphate monobasic monohydrate; sodium phosphate dibasic anhydrous preparations in conjunction with antacids containing magnesium (e.g., magnesium carbonate, magnesium hydroxide) may bind the phosphate in the stomach and reduce its absorption. Phosphate may also bind magnesium salts. If the patient requires multiple mineral supplements or concurrent use of antacids, it is prudent to separate the administration of sodium phosphate salts from magnesium containing products by at least one hour.[7800]

Oral magnesium salts and antacids that contain magnesium have been reported to chelate oral levothyroxine within the GI tract when administered simultaneously, leading to decreased thyroid hormone absorption. To minimize this interaction, administer thyroid hormones at least 4 hours before or after antacids or other drugs containing magnesium.[43942]

Magnesium salts or magnesium-containing medications should not be administered to a patient who is receiving treatment with citric acid; glucono-delta-lactone; magnesium carbonate irrigation solution due to the increased risk of developing hypermagnesemia.[57579]

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Adverse Reactions

- aluminum toxicity
- AV block
- bradycardia
- cardiac arrest
- diaphoresis
- diarrhea
- flushing
- hypermagnesemia
- hypocalcemia
- hyporeflexia
- hypotension
- hypothermia
- injection site reaction
- muscle paralysis
- respiratory arrest
- respiratory depression
- weakness

The most frequently reported adverse reactions of parenteral magnesium sulfate are hypermagnesemia and signs and symptoms of magnesium toxicity. These reactions are characterized by flushing, diaphoresis, hypotension, depressed deep tendon reflexes, muscle paralysis, weakness, hypothermia, circulatory collapse, and cardiac, CNS, or respiratory depression. Deep tendon reflexes may be decreased at serum magnesium concentrations of 4 mEq/L resulting in muscle weakness and hyporeflexia; patellar reflexes usually become hypoactive or disappear at magnesium concentrations > 8 mEq/L. Respiratory depression or cardiac conduction abnormalities (e.g., AV block) are noted most commonly at serum magnesium concentrations >= 10 mEq/L. Magnesium levels > 12 mEq/L may be fatal due to respiratory arrest, or from cardiac arrest secondary to complete heart block. Magnesium toxicity (conduction abnormalities or respiratory depression) can be reversed by discontinuation of the magnesium therapy and the use of intravenous calcium gluconate. Rapid administration (administered faster than 1 g/min) of intravenous magnesium sulfate may result in clinically significant hypotension or asystole and should be avoided. Injection site reaction has been reported following intramuscular injection of magnesium sulfate. Hypocalcemia with signs of tetany has occurred following administration of magnesium sulfate for eclampsia. One case of fetal sinus bradycardia has been reported in the use of magnesium sulfate infusion for pre-term labor; stopping the magnesium infusion resulted in a return to pretreatment basal fetal heart rate. The most common adverse reaction with oral magnesium salts is diarrhea.

Injectable magnesium formulations contain aluminum. Thus, aluminum toxicity may occur with prolonged administration in high-risk patients, including those with renal impairment and premature neonates. Premature neonates are at particular risk for aluminum toxicity because of immature renal function and they require large amounts of calcium and phosphate solutions, which contain aluminum. Research indicates that patients with renal impairment, who receive parenteral aluminum at rates greater than 4—5 mcg/kg/day, may develop aluminum toxicity (CNS and bone toxicity). Tissue loading may occur at lower administration rates.[49674]

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How Supplied

Calcium, Magnesium, Chloride Oral tablet, gastro-resistant

MagDelay Delayed-Release Tablet	(00904-7911)	(Major Pharmaceuticals Inc)

Magnesium Chloride Oral tablet, gastro-resistant

Mag-64 Delayed-Release Tablet	(68585-0005)	(Rising Pharmaceuticals Inc)	

Magnesium Chloride Solution for injection

Magnesium Chloride 200mg/ml Solution for Injection	(00517-5034)	(American Regent Inc, a division of Luitpold Pharmaceuticals) (off market)
Magnesium Chloride 200mg/ml Solution for Injection	(67457-0134)	(Mylan Institutional LLC formerly BionichePharma Inc.)
Magnesium Chloride 200mg/ml Solution for Injection	(66758-0012)	(Sandoz Inc. a Novartis Company) (off market)

Magnesium Gluconate Oral tablet

Mag-G 500mg Tablet	(60258-0172)	(Cypress Pharmaceutical Inc. a wholly-owned subsidiary of Pernix Therapeutics, LLC)	
Magnesium Gluconate 500mg Tablet	(57394-0399)	(Apothecary Products)	
Magnesium Gluconate 500mg Tablet	(10432-0175)	(Freeda Vitamins, Inc.)	
Magnesium Gluconate 500mg Tablet	(52604-5801)	(Jones Pharma Inc Sub King Pharmaceuticals Inc) (off market)	

Magnesium Gluconate 500mg Tablet (00122-3134) (Rexall Group) (off market)
Magnesium Gluconate 500mg Tablet (60814-0558) (Rexall Group) (off market)
Magtrate 500mg Tablet (00178-0299) (Mission Pharmacal Co)

Magnesium Lactate Oral tablet, extended release

Mag-Tab SR 84mg Extended-Release Tablet (Niche Pharmaceuticals Inc) 

Magnesium Oral tablet

CVS Laxative Dietary Supplement 500mg Caplet (CVS Pharmacy, Inc)
CVS Magnesium 250mg Caplet (CVS Pharmacy, Inc) 
CVS Magnesium 500mg Tablet (CVS Pharmacy, Inc)
GNP Magnesium 250mg Tablet (AmerisourceBergen Corporation)
Health Mart Magnesium 400mg Caplet (McKesson Corporation)
Magnesium 200mg Tablet (11845-0961) (Mason Vitamins)
Magnesium 250mg Caplet (Sundown Nutrition)
Magnesium 250mg Tablet (Natures Bounty)
Magnesium 27mg Tablet (00536-6680) (Rugby Laboratories a Division of The Harvard Drug Group, LLC) (off market) 
Magnesium 500mg High Potency Caplet (Sundown Nutrition)
Magnesium Gluconate 550mg Tablet (11845-0617) (Mason Vitamins)
Magnesium Oxide 400mg Tablet (60258-0171) (Cypress Pharmaceutical Inc. a wholly-owned subsidiary of Pernix Therapeutics, LLC)
Magnesium Oxide 400mg Tablet (57896-0634) (Geri-Care Pharmaceuticals)
Magnesium Oxide 400mg Tablet (00904-5311) (Major Pharmaceuticals Inc) (off market) 
Magnesium Oxide 400mg Tablet (00904-5311) (Major Pharmaceuticals Inc)
Magnesium Oxide 400mg Tablet (63739-0354) (McKesson Packaging Inc)
Magnesium Oxide 400mg Tablet (00603-0209) (Qualitest Pharmaceuticals Inc) 
Magnesium Oxide 400mg Tablet (69618-0023) (Reliable 1 Laboratories LLC)
Magnesium Oxide 400mg Tablet (68585-0006) (Rising Pharmaceuticals Inc) 
Magnesium Oxide 400mg Tablet (00536-3521) (Rugby Laboratories a Division of The Harvard Drug Group, LLC) 
Magnesium Oxide 400mg Tablet (57963-0102) (The Generic Pharmaceutical Company, Inc.)
Magnesium Oxide 400mg Tablet (69543-0217) (Virtus Pharmaceuticals)
Magnesium Oxide 400mg Tablet (76439-0217) (Virtus Pharmaceuticals OPCO II) 
Magnesium Oxide 420mg Tablet (00603-0213) (Qualitest Pharmaceuticals Inc)
MagOx 400 Tablet (00165-0022) (Blaine Pharmaceuticals) 
MgO 400mg Tablet (21st Century HealthCare, Inc)
Radiance Magnesium 500mg Tablet (Feeling Fine Programs Inc.)
Sunmark Magnesium 250mg Tablet (49348-0008) (McKesson Corporation) (off market)
Sunmark Magnesium 250mg Tablet (McKesson Corporation)
Today's Health Magnesium 200mg Tablet (Todays Health, Inc)
Walgreens Finest Nutrition Magnesium 400mg Tablet (11917-0176) (Walgreen Co)

Magnesium Oxide Oral capsule

MagGel 600 Softgel (66663-0211) (Jazz Pharmaceuticals, Inc. Formerly Azur Pharma) (off market)	
MagGel 600 Softgel (66663-0211) (Pharmelle LLC) (off market)	
Uro-Mag 140mg Capsule (00165-0054) (Blaine Pharmaceuticals)	

Magnesium Oxide Oral tablet

Equaline Magnesium 250mg Tablet (Albertson's, Inc)	
Magnesium Oxide 250mg Tablet (00761-0283) (Basic Vitamins)	
Magnesium Oxide 250mg Tablet (52297-0086) (Leiner Health Products) (off market)	
Magnesium Oxide 250mg Tablet (43292-0557) (Magno-Humphries Inc)	
Magnesium Oxide 420mg Tablet (10706-0837) (Manne Company)	
Magnesium Oxide 500mg Tablet (00904-4239) (Major Pharmaceuticals Inc)	
Phillips' Cramp-Free 500mg Caplet (Bayer Corp Consumer Care Div)	
Walgreens Magnesium Oxide 250mg Tablet (Walgreen Co) (off market)	

Magnesium Sulfate Powder for Topical solution

CVS Epsom Salt (CVS Pharmacy, Inc)	
CVS Epsom Salt (Green Tea & Chamomile) (CVS Pharmacy, Inc)	
CVS Epsom Salt (Lavender) (CVS Pharmacy, Inc)	
CVS Epsom Salt (Vanilla) (CVS Pharmacy, Inc)	
GNP Epsom Salt (24385-0807) (AmerisourceBergen Corporation)	
Leader Epsom Salt (37205-0602) (Cardinal Health, Inc.)	
Leader Epsom Salt (37205-0602) (Cardinal Health, Inc.)	
Premier Value Epsom Salt (68016-0012) (Chain Drug Consortium, LLC)	
Premier Value Epsom Salt (68016-0012) (Chain Drug Consortium, LLC)	
Sunmark Epsom Salt (49348-0018) (McKesson Corporation)	
Today's Health Epsom Salt (Todays Health, Inc)	
Walgreens Epsom Salt (Walgreen Co)	 
Walgreens Epsom Salt (Lavender) (11917-0143) (Walgreen Co)	

Magnesium Sulfate Solution for injection

Magnesium Sulfate 125mg/ml Solution for Injection (00074-4943) (Hospira Worldwide Inc.) (off market)	
Magnesium Sulfate 20g/500mL in Sterile Water Solution for Injection (00409-6729) (Hospira Worldwide Inc.)	
Magnesium Sulfate 2g/50mL in Sterile Water Solution for Injection (00409-6729) (Hospira Worldwide Inc.) (off market)	
Magnesium Sulfate 2g/50mL in Sterile Water Solution for Injection (00409-6729) (Hospira Worldwide Inc.)	
Magnesium Sulfate 40g/1000mL in Sterile Water Solution for Injection (00409-6729) (Hospira Worldwide Inc.)	
Magnesium Sulfate 40mg/ml in Sterile Water Solution for Injection (00074-6729) (Hospira Worldwide Inc.) (off market)	
Magnesium Sulfate 4g/100mL in Sterile Water Solution for Injection (00409-6729) (Hospira Worldwide Inc.)	
Magnesium Sulfate 50% Solution for Injection (00517-2602) (American Regent Inc, a division of Luitpold Pharmaceuticals) (off market)	
Magnesium Sulfate 50% Solution for Injection (00517-2610) (American Regent Inc, a division of Luitpold Pharmaceuticals) (off market)	
Magnesium Sulfate 50% Solution for Injection (00517-2650) (American Regent Inc, a division of Luitpold Pharmaceuticals) (off market)	

Magnesium Sulfate 50% Solution for Injection (00548-1034) (Amphastar Pharmaceuticals, Inc.) (off market)	
Magnesium Sulfate 50% Solution for Injection (63323-0064) (Fresenius Kabi USA, LLC formerly APP Pharmaceuticals)	
Magnesium Sulfate 50% Solution for Injection (00409-2168) (Hospira Worldwide Inc.)	
Magnesium Sulfate 50% Solution for Injection (00074-2168) (Hospira Worldwide Inc.) (off market)	
Magnesium Sulfate 50% Solution for Injection (00074-4075) (Hospira Worldwide Inc.) (off market)	
Magnesium Sulfate 50% Solution for Injection (00074-4913) (Hospira Worldwide Inc.) (off market)	
Magnesium Sulfate 50% Solution for Injection (00074-4914) (Hospira Worldwide Inc.) (off market)	
Magnesium Sulfate 50% Solution for Injection (00074-9628) (Hospira Worldwide Inc.) (off market)	
Magnesium Sulfate 50% Solution for Injection (00074-1754) (Hospira Worldwide Inc.) (off market)	
Magnesium Sulfate 50% Solution for Injection (00409-1754) (Hospira Worldwide Inc.)	
Magnesium Sulfate 50% Solution for Injection (00702-0899) (Novation LLC)	
Magnesium Sulfate 50% Solution for Injection (00703-5372) (Sicor Pharmaceuticals Inc A subsidiary of Teva Pharmaceuticals USA) (off market)	
Magnesium Sulfate 50% Solution for Injection (00703-5377) (Sicor Pharmaceuticals Inc A subsidiary of Teva Pharmaceuticals USA) (off market)	
Magnesium Sulfate 50% Solution for Injection (00703-5375) (Sicor Pharmaceuticals Inc A subsidiary of Teva Pharmaceuticals USA) (off market)	
Magnesium Sulfate 50% Solution for Injection (00703-5374) (Sicor Pharmaceuticals Inc A subsidiary of Teva Pharmaceuticals USA) (off market)	
Magnesium Sulfate 50% Solution for Injection (39822-4025) (X-Gen Pharmaceuticals Inc)	
Magnesium Sulfate 50% Solution for Injection (NOVAPLUS) (63323-0064) (Fresenius Kabi USA, LLC formerly APP Pharmaceuticals)	
Magnesium Sulfate 80mg/ml in Sterile Water Solution for Injection (00074-6730) (Hospira Worldwide Inc.) (off market)	
Magnesium Sulfate 80mg/ml in Sterile Water Solution for Injection (00409-6730) (Hospira Worldwide Inc.)	

Magnesium Sulfate, Dextrose Solution for injection

Magnesium Sulfate 1g/100ml in Dextrose 5% Solution for Injection (00074-6727) (Hospira Worldwide Inc.) (off market)	
Magnesium Sulfate 1g/100ml in Dextrose 5% Solution for Injection (00409-6727) (Hospira Worldwide Inc.)	
Magnesium Sulfate 2g/100ml in Dextrose 5% Solution for Injection (00074-6728) (Hospira Worldwide Inc.) (off market)	
Magnesium Sulfate 2g/100ml in Dextrose 5% Solution for Injection (00409-6728) (Hospira Worldwide Inc.)	

Magnesium, Calcium Oral tablet

Calcium and Magnesium 500mg-250mg Tablet (00182-4156) (Ivax Corporation a Division of Teva USA) (off market)	
Chelated Magnesium 27mg Tablet (00536-6680) (Rugby Laboratories a Division of The Harvard Drug Group, LLC)	
Magnesium 250mg Tablet (21st Century HealthCare, Inc)	

Magnesium, Magnesium Chloride Oral tablet

Mag-SR Tablet (60258-0173) (Cypress Pharmaceutical Inc. a wholly-owned subsidiary of Pernix Therapeutics, LLC) (off market)	

Magnesium, Magnesium Gluconate Dihydrate Oral solution

Magonate 1000mg/5ml Solution (00256-0184) (Fleming and Co) (off market)	
Magonate 1000mg/5ml Solution (00256-0184) (Valeant Pharmaceuticals) (off market)	
Magonate 1000mg/5mL Solution (00187-5267) (Valeant Pharmaceuticals)	

Magnesium, Magnesium Gluconate, Magnesium Oxide Oral tablet

Premier Value Magnesium 400mg Tablet (68016-0318) (Chain Drug Consortium, LLC)

Magnesium, Magnesium Oxide, Magnesium Amino Acid Chelate Oral capsule

Elemental Magnesium Amino Acid Chelate 300mg Capsule (National Vitamin Company Inc)

Monitoring Parameters

- serum creatinine/BUN
- serum magnesium

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