Validation of Diagnostic Tests for Determination of Magnesium Status in Horses with Reduced Magnesium Intake (21-Nov-2003)

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Abstract
Measurement of urinary Mg excretion (EMg) provides the most sensitive indicator of reduced Mg intake in horses. Spot sample fractional clearance of total Mg (FCtMg) provides a valid indication of Mg intake without the need for volumetric urine collection.

1. Introduction
Less than 1% of body magnesium (Mg) is contained within the extracellular fluid; thus, serum Mg concentrations may not adequately reflect total body Mg stores. With dietary Mg deficiency, renal tubular reabsorption of Mg increases to maintain serum concentrations of Mg within narrow physiological limits [1a]. Severe chronic dietary Mg deficiency or acute Mg redistribution is required to alter serum Mg concentrations. Determination of urinary excretion is, therefore, a more sensitive indicator of low Mg intake.

Our objectives were to validate diagnostic tests for the identification of reduced Mg intake in the horse by comparing serum total Mg (tMg) and ionized Mg (Mg²⁺), muscle Mg and sublingual epithelial intracellular Mg (iMg) concentrations, and urinary Mg excretion (EMg), clearance of total Mg (CMg), and fractional clearance of total Mg (FCtMg) and ionized Mg (FCiMg) in horses fed grass hay compared to horses fed diets with Mg content below and above recommended allowances (>13 mg/kg body weight (BW)/d, equating to 1,600 ppm of Mg in feed [2a]).

2. Materials and Methods
Nine yearling fillies were studied. After baseline sampling, treated horses (n = 6) were fed a low Mg diet (600 ppm) for 29 days, followed by Mg supplementation (Mg oxide at 40 mg/kg BW/d, PO [3a]) for 24 days. Control horses (n = 3) were fed grass hay throughout the study period. Blood, urine, and tissue samples were collected at baseline and after Mg restriction and supplementation for determination of serum tMg, Mg²⁺, muscle Mg, iMg, and urine Mg concentrations. Twenty-four-hour EMg, CMg, FCtMg, and FCiMg were calculated. An Mg retention test was performed at baseline and after Mg restriction and supplementation phases. This involved intravenous infusion of 100 mg of magnesium sulfate/kg BW (equivalent to 10 mg of elemental Mg/kg BW) as a 5% solution in 0.09% saline over 1-hour period [4a]. Serum and pooled urine samples were collected for 24 hours. Repeated measures ANOVA was used to detect differences in means between each phase. Significance of all tests was set at P < 0.05.

3. Results
Reductions in urinary 24-hr EMg, CMg, FCtMg, and FCiMg were obtained after feeding the low Mg diet for 29 days. No differences were found in serum tMg and Mg²⁺ concentrations and muscle Mg content between baseline values and values obtained after Mg restriction, but serum tMg and Mg²⁺ concentrations did increase after Mg supplementation. The magnesium retention test did not predict low Mg intake. Spot urine sample FCtMg accurately reflected FCtMg calculated from Mg concentrations in 6- and 24-hr pooled urine samples. Values were approximately 5-fold higher for EMg (P = 0.0004) and CMg (P = 0.0002) and approximately 3-fold higher for FCtMg (P = 0.0003) at baseline compared with after 29 days of restricted Mg intake.
4. Discussion
A diet containing 600 ppm of Mg induced detectable urinary conservation of Mg by 13 days in yearling fillies, with significant reduction of urine Mg concentration, EMg, CMg, FCmMg and FCmMg2+. Serum total and ionized Mg concentrations and muscle Mg content were not changed by the end of the phase of restricted Mg intake; however, a decrease in sublingual epithelial iMg concentration was detectable. Our study validates the use of 6-hr EMg as an estimate of 24-hr EMg and the use of spot sample FCmMg to detect reduced urinary excretion of Mg. Spot sample collection provides a more convenient indicator of Mg status compared to volumetric urine collections and the measurement of either 6- or 24-hr Mg excretion. Results of our study indicate that the intravenous Mg retention test is not as sensitive an indicator of reduced Mg intake in the horse as is measurement of total daily urinary excretion of Mg. In this study, diagnostic tests for the detection of reduced Mg intake in the horse were validated. Although 24-hr urinary EMg was the most sensitive indicator of Mg status, spot sample FCmMg can be conveniently used to identify low Mg intake.

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Hypomagnesemia in the Clinical Patient
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Severe magnesium (Mg) deficiency results in neuromuscular disturbances, but such overt clinical signs are rarely documented in horses. In contrast, subclinical hypomagnesemia is common in critically ill horses. Clinical manifestations of severe hypomagnesemia include muscle weakness, muscle fasciculations, ventricular arrhythmias, seizures, ataxia and coma. Subclinical hypomagnesemia increases the severity of the systemic inflammatory response syndrome (SIRS), worsens the systemic response to endotoxin, and can lead to ileus, cardiac arrhythmias, refractory hypokalemia, and hypocalcemia.

Magnesium Requirements in the Horse
The maintenance Mg requirement of 13 mg/kg (BW)/day, can be provided by a diet containing approximately 0.16% Mg (1600 ppm = 1600 mg/kg or 1.6 g/kg of feed), which is considered the low-level maintenance requirements for adult horses [1b]. Growing, lactating and exercising animals have a higher requirement of dietary Mg. Substantial amounts of Mg can also be lost in sweat. During early lactation, and for horses undergoing moderate to intense exercise, Mg intake should be increased between 1.5 - 2 times maintenance.

Incidence of Hypomagnesemia in the Horse
A retrospective study found that 48.7% of hospitalized horses had serum total Mg values below the reference range [2b]. Hypomagnesemia was associated with gastrointestinal disease, infectious respiratory disease, and multiorgan system disease [2b]. In an earlier study, 54% of equine surgical colic patients had low serum ionized Mg concentrations, and these horses had a significantly greater prevalence of postoperative ileus than normomagnesemic equine surgical colic patients [3b]. Low serum ionized was recently documented in 78% of horses with enterocolitis at the Ohio State University [4b].

Diagnostic Testing
Serum total Mg, or preferably serum ionized Mg is easily measured, and is considered useful in acute disease processes. In cases of suspected chronic dietary Mg deficiency, measurement of simultaneous serum and urine Mg concentrations allows calculation of fractional clearance of Mg. We found the fractional clearance of Mg in normal horses fed grass hay to be 29 ± 8%. Fractional clearance of less than 6% suggests inadequate dietary intake [5b].

Treatment for Hypomagnesemia
Magnesium sulfate can be infused with a high therapeutic safety index, with the safety dependent on the dose and the infusion rate, but is contraindicated with undiagnosed disturbances in cardiac conduction, renal failure or elevated serum Mg concentration.

Dosages

1. A constant rate infusion (CRI) of 150 mg/kg/day IV of MgSO4 solution (0.3 ml/kg/day of the 50% solution) provides the horse's daily requirements [6b].
2. Plasmalyte-A® and Normosol-R® contain 3 mEq/L (3.6 mg/dL) of elemental Mg. If a horse received 60 ml/kg/day of the replacement fluid (maintenance), they would receive 20 mg/kg/day of MgSO4. Therefore if long-term fluid therapy is required to support an inappetent animal, additional Mg may still be required.

3. Ventricular arrhythmias: 2 - 6 mg/kg/min of MgSO4 IV (1.8 - 5.4 ml of 50% MgSO4/450 kg horse/min) can be given to effect.

4. HIE in neonatal foals: Initial dose of 50 mg/kg/hour IV for one hour, followed by 25 mg/kg/hr CRI for 24 hours. This dose provides 600 mg/kg/day of MgSO4 and is therefore much higher than that required for maintenance. Therapy has been continued for up to 3 days without visible detrimental effects other than possible trembling [7b].

5. Large colon impactions: 0.5 to 1.0 g/kg of MgSO4 (Epsom salts) in 6 - 8 liters of water by stomach tube when the horse is metabolically stable. A second dose can be administered 24 - 36 hours later in severe cases only if serum Mg concentrations have returned to normal.

The typical equine diet contains sufficient Mg for maintenance, with supplementation rarely required. If necessary, oral Mg can be provided with MgO, MgCO3 or MgSO4, which have equivalent digestibilities of approximately 70%. The maintenance requirement of 13 mg/kg/day of elemental Mg could be provided by 31 mg/kg/day of MgO, 64 mg/kg/day of MgCO3 or 93 mg/kg/day of MgSO4. This may be important when formulating oral replacement fluids for inappetent horses.

References


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References


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