

Does serum magnesium analysis need to be a part of routine dyselectrolytemia investigation?

Tuladhar ET, Pant V, Aryal B, Tumbapo A, Ghimire S, Sharma VK, Bhattarai A, Raut M, Yadav BK

Department of Biochemistry, Maharajgunj Medical Campus, Institute of Medicine, Maharajgunj, Kathmandu

Corresponding Author: Dr. Eans Tara Tuladhar, Assistant professor, Department of Biochemistry, Institute of Medicine.

Email: eanstara@gmail.com

Abstract

Introduction: The fourth most abundant cation in the body and the second most prevalent intracellular cation, magnesium (Mg) is a co-factor for over 300 enzymes. Though magnesium abnormalities frequently accompany other electrolytes abnormalities, during electrolyte investigation, magnesium estimation is often overlooked. This study aims to investigate the occurrence of magnesium abnormalities in serum samples sent, for routine electrolyte measurement like sodium; potassium; calcium and phosphorus, to the biochemistry laboratory of Tribhuvan University teaching hospital.

Methods: Serum magnesium measurement was done in 799 serum samples ordered for various electrolyte estimation. Magnesium, Calcium and phosphorus present in sample was analyzed by BT 3500 machine spectrophotometrically. Sodium and potassium ions were analyzed by direct ion selective electrode method.

Results: Only 14(1.75%) samples were requested by physician for magnesium estimation out of total 799 samples sent for various electrolyte estimation. When all 799 samples were analyzed for magnesium level, magnesium abnormalities were identified in 76(9.5%), out of which hypermagnesemia was found in 22 (2.75%) and hypomagnesemia in 54 (6.76%) samples.

Conclusion: Since, significant numbers of patient's serum sample, sent for estimation of various electrolytes, are found to have magnesium abnormalities, we recommend routine measurement of this analyte along with other electrolytes.

Keywords: Magnesium, Sodium, Potassium, Calcium, Phosphorus, Dyselectrolytemia

Introduction

The fourth most abundant cation in the body and the second most prevalent intracellular cation, magnesium(Mg) is a co-factor for over 300 enzymes. The normal adult human body contains approximately 1,000 mmoles of magnesium (22–26 g). About 60% of the magnesium is present in bone, 20% is in skeletal muscle, 19% in other soft tissues and less than 1% in the extracellular fluid.¹ Kidneys and gastrointestinal system plays a major role in magnesium homeostasis. In a day 80% of the total plasma magnesium is filtered daily and 95% of this is reabsorbed.¹

Various factors regulate magnesium concentration in body. Parathyroid hormone (PTH) increases reabsorption of magnesium in distal tubule by a process mediated by cyclic adenosine monophosphate.² Thus, phosphate depletion in body can lead to increase in urinary magnesium excretion and causes hypomagnesemia. With hypercalcemia, there is reduced reabsorption in proximal tubule causing increased delivery of sodium; water; calcium and magnesium to the loop of Henle.³ This increased flow to loop of Henle causes reduction in calcium and magnesium transport. Thus, hypercalcemia lead to increased urinary excretion of magnesium.

Hypomagnesemia is biochemically diagnosed when its level is below 1.5 mg/dl. ³Hypermagnesemia is a very rare phenomenon. Magnesium deficiency is present in up to 10% of patients admitted to hospital and in up to 60% admitted to critical care.⁴It often coincides with deficiencies of other ions. Hypomagnesemia is associated with hypokalemia, hypocalcemia, hypophosphatemia and hyponatremia.⁵

Serum magnesium concentration is not routinely ordered when a request form is sent for evaluation of dyselectrolytemia. In a retrospective analysis of electrolyte request forms, during one-month period in the Institute of Medicine, only 65 (2.05%) forms mentioned request order for serum magnesium out of 3165 forms ordered for electrolytes estimation. It is mostly requested in patients who are critically ill. As magnesium being mainly an intracellular cation and total body magnesium deficiency can exist with normal plasma levels, during electrolyte investigation, magnesium estimation is often overlooked. However, there is higher prevalence of magnesium imbalance during workout of dyselectrolytemia and in the backdrop of magnesium imbalance, dyselectrolytemia cannot be treated unless magnesium factor is considered. Also, clinical manifestation of magnesium deficiency is nonspecific or masked by primary disease unless serum level is sought. This study aims to investigate the occurrence of magnesium imbalance in serum samples sent for routine electrolyte assay like sodium, potassium, calcium and phosphorus to the biochemistry laboratory, Tribhuvan University Teaching Hospital (TUTH). This study will contribute to the evidence based medicine practice, that whether magnesium analysis should be or should not be a routine procedure whenever work out for dyselectrolytemia is done.

Methods

This study was done in the clinical laboratory of the department of biochemistry, Institute of Medicine. All serum samples ordered for various electrolyte estimation for a period of one week were analyzed for magnesium level. Hemolyzed and lipemic samples were excluded. Normal range for electrolytes were taken as, sodium (Na) 135-146 mEq/L; potassium (K) 3.5-5.2 mEq/L; calcium (Ca) 2.1-2.6 mmol/L; phosphorus (P) 2.5-4.8 mg/dl and magnesium (Mg) – 1.5-2.5 mg/dl. Values below or above this reference range were taken as hypo or hyper dyselectrolytemia for that particular electrolyte.

Magnesium, Calcium and phosphorus present in sample was analyzed by BT 3500 machine spectrophotometrically. With xylidyl blue dye, magnesium forms a blue violet complex, whose color is intensely proportional to the magnesium concentration in the sample and absorbance is taken at 512nm of wavelength. Similarly, calcium binds with o-cresolphthalein complex in alkaline medium to form violet colored complex which is measured spectrophotometrically at 580nm of wavelength. Concentration of color is directly proportional to the concentration of calcium in serum. For quantification of phosphorus, the phosphate ion reacts with molybdate to produce phospho-molybdate which is finally reduced to a molybdenum blue, which is spectrophotometrically measured in the uv rays. Similarly, sodium and potassium were analyzed by Ion selective electrode using direct method. Data were analyzed using statistical software SPSS vs 20. Pearson's correlation is used to compare various electrolytes with magnesium.

Results

Total number of samples that were ordered for evaluation of dyselectrolytemia was 799. Out of these, all 799 samples were ordered for sodium and potassium, 220 samples for calcium and 70 samples for phosphorus (Table 1). Estimation of serum magnesium was ordered in only 14 samples. Hyponatremia and hyponatremia was found in 3 (0.38%) and 123 (15.4%) samples respectively. Hyperkalemia and hypokalemia was found in 23 (2.8%) and 75 (9.4%) samples respectively. Hypercalcemia and hypocalcemia was found in 1 (0.13%) and 124 (15.5%) samples respectively. Hyperphosphatemia and hypophosphatemia was found in 16 (2%) and 6 (0.75%) samples respectively. All 799 samples were analyzed for magnesium. Though only 14 samples were ordered by physician for estimation of serum magnesium, we interestingly found hypermagnesemia and hypomagnesemia in 22 (2.75%) and 54 (6.76%) samples respectively, when all 799 samples were analyzed for magnesium level.

Hypomagnesemia was associated with 19 (15.3%) samples with hypocalcemia, 18 (14.6%) samples with hyponatremia, 13 (17.3%) samples with hypokalemia and 1 (16.6%) sample with hypophosphatemia. There was no association with increased serum level of sodium, potassium, calcium and phosphorus with hypomagnesemia. Similarly, hypermagnesemia was found in 2 (66.6%) and 6 (4.8%) samples with

hypernatremia and hyponatremia respectively. Hypermagnesemia was seen in 4(17.4%) and 6 (8.0%) samples with hyperkalemia and hypokalemia respectively. Similarly, hypermagnesemia was seen in 5(31.25%) samples with hyperphosphatemia and 6(0.75%) samples with hypocalcemia. No association of hypermagnesemia was seen with hypercalcemia and hypophosphatemia.

The correlation between magnesium and three minerals (phosphorous, potassium and sodium) are significant at 5% level of significance. Figure 1 illustrates the scatter plot and regression line of phosphorus, potassium, calcium and sodium with magnesium as constant variable.

Table 1: Frequency and mean value of electrolytes.

Variable	Label	N	Mean	Std Dev	Minimum	Maximum
Sodium	Sodium	799	138.53	4.02	107.00	154.00
Potassium	Potassium	799	4.05	0.53	2.30	6.50
calcium	calcium	220	2.03	0.28	1.30	4.80
Phosphorous	Phosphorous	77	4.05	1.65	1.60	11.40
Magnesium	Magnesium	799	1.85	0.30	0.90	3.50

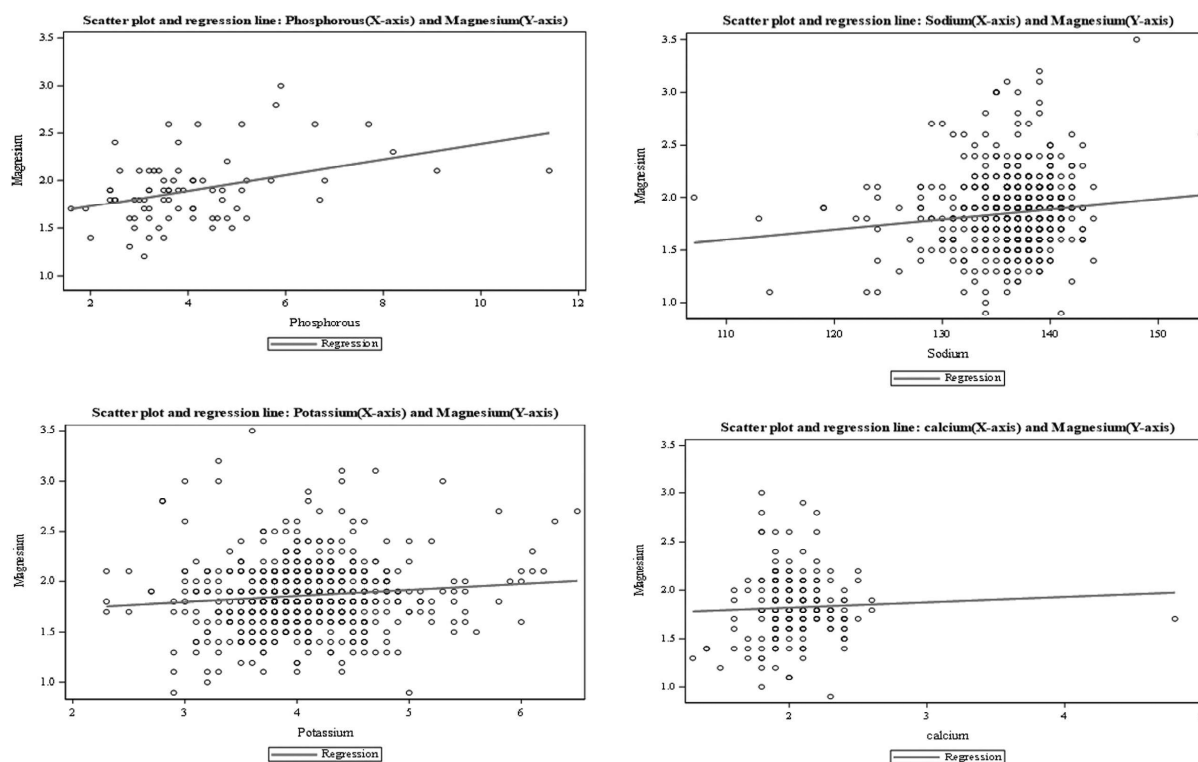


Figure 1: Scatter plot and regression line of phosphorus, potassium, calcium and sodium with magnesium as constant variable

Discussion

We found hypermagnesemia and hypomagnesemia in 22 (2.75%) and 54 (6.76%) samples respectively out of which only 14(18 %)sample were requested for magnesium analysis. Prevalence of hypomagnesemia can range from 7-11% in hospitalized population and the prevalence is higher in critically ill patients which ranges from 20-65%.^{5,6} Measurement of serum magnesium concentration in 1,000 samples received for electrolyte determination showed

that only 10% of the hypomagnesaemia patients had magnesium requested.⁷In patients with other electrolyte abnormalities hypomagnesaemia is more frequent, 40% in hypokalemic patients, 30% in hypophosphatemia patients, 23% in hyponatremic patients and 22–32% in hypocalcemia patients.⁵The results of our study have emphasized the need for magnesium analysis requisite along with other routine electrolyte investigation to improve the treatment modality.

In our study hypomagnesemia is present in 14.6% samples with hyponatremia, 17.33% with hypokalemia, 15.3% with hypocalcemia and 16.6% samples with hypophosphatemia. Similarly, hypermagnesemia is present in 66.6% samples with hypernatremia, 17.4% with hyperkalemia and 31.25% with hyperphosphatemia. Synergistic relation exists in between magnesium and potassium.⁸Potassium depletion cannot be corrected until magnesium depletion is corrected. This linkage may be due to the dependency of potassium channels like $\text{Na}^+\text{K}^+\text{-ATPase}$, $\text{Na}^+\text{K}^+\text{-2Cl}$ on magnesium.^{8,9}This is also true for the relation in between magnesium and sodium. There is a positive correlation in between serum magnesium and calcium ion. Hypocalcemia due to hypomagnesemia cannot be corrected by treatment with calcium or vitamin D. Magnesium therapy alone will restore normal calcium level.³The cause of hypocalcemia in hypomagnesemia is due to defective parathormone synthesis which requires magnesium as a cofactor.

Hypomagnesemia is frequent serum electrolyte abnormalities that occur together with another electrolyte imbalance. Routine inclusion of serum magnesium analysis in the electrolyte panel will enhance the clinical recognition and treatment of patients with magnesium ion disorder. Incorporating serum magnesium as a part of evaluation of dyselectrolytemia is justified as reordering for analysis of serum magnesium will entail multiple visits of patient to hospital with extra costs.

Conclusion

It is important for healthcare providers to be aware of changes in serum magnesium and to institute appropriate treatment whenever necessary by ordering serum magnesium level as a routine investigation for evaluation of dyselectrolytemia.

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Conflict of interest- none declared

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