Original Research Article

Assessment of serum magnesium levels in critically ill patients

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Abstract

Background: Hypomagnesaemia occurs in up to 12% of hospitalized patients. The incidence rises to as high as 60 to 65% in patients in intensive care settings in which nutrition, diuretics, hypoalbuminemia and amino glycosides may play important roles. Hence the present study was conducted at a tertiary healthcare institute to assess the relationship between serum magnesium levels and clinical status of the critically ill patients. **Material and methods:** This is a prospective, observational cohort study involving the adult population of critically ill patients. The study was conducted in the Intensive care unit, the Emergency department. The emergency department is facilities at the tertiary healthcare institute which are used for acutely ill critical patients at the accident and emergency unit. Any person meeting the selection criteria, admitted into the critical care units. **Results:** Majority of the subjects had APACHE score between 11 to 20 (49%), followed by less than 10 among 38% study subjects. In this study we assessed the correlation between APACHE score and serum magnesium levels. We observed it to be statistically significant. (R=0.31, p-value=0.0003). **Conclusions:** The study recommends that routine monitoring of serum magnesium and clinical assessment of patients at risk for Mg deficiency remains vital for making a timely diagnosis of magnesium depletion.

Keywords: Critically ill, Intensive care unit, Magnesium levels, electrolytes.

Introduction

Magnesium is the fourth most abundant cation in the body and the second most abundant intracellular cation after potassium. The total body magnesium level of an average adult is 24 g, or 1000 Mmol[1,2]. Approximately 60% of the body's magnesium is present in bone, 20% is in muscle, and another 20% is in soft tissue[2].

Magnesium depletion is described as the most under diagnosed electrolyte abnormality in current medical practice. It commonly occurs in critical illness and correlates with a higher mortality and worse clinical outcomes. Low serum magnesium levels have been directly implicated in hypokalemia, hypocalcemia, and dysrhythmia[3]. The principle causes of Mg loss among the critically ill are gastrointestinal and renal losses.

Magnesium serves as a cofactor in more than 300 enzymatic reactions mainly involving transfer of phosphate group for example formation of ATP[4]. It also maintains neuromuscular excitability and it's important for maintenance of cardiac function[5]. By regulating enzymes controlling intracellular calcium, Mg affects smooth muscle vasoconstriction, important to the underlying pathophysiology of several critical illnesses[4].

The use of Mg therapy is supported by clinical trials in the treatment of symptomatic hypomagnesaemia and preeclampsia[6] and is recommended for torsade de pointes[7]. Magnesium therapy is not supported in the treatment of acute myocardial infarction[8] and is presently undergoing evaluation for the treatment of severe asthma exacerbation[9], for the prevention of post coronary bypass grafting dysrhythmias[10,11], and as a neuroprotective agent in acute cerebral ischemia[12,13].

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Clinical evaluation of magnesium status is associated with numerous difficulties. First, serum ionized Mg2+, the biologically significant fraction of magnesium, is not routinely measured[1]. Second, no single laboratory test tracks total body magnesium stores[1]. Finally, changes in extracellular (serum) magnesium levels may not necessarily reflect intracellular level[1].

Despite the fact that serum levels of magnesium represent only 0.3% of total body magnesium content and that serum magnesium concentrations do not correlate with other tissue pools[1], the total serum magnesium concentration is still used as the standard for evaluating magnesium status in patients[1].

Hypomagnesaemia occurs in up to 12% of hospitalized patients[13].The incidence rises to as high as 60 to 65% in patients in intensive care settings in which nutrition, diuretics, hypoalbuminemia and amino glycosides may play important roles[14,15,16]. Most of the studies carried out previously have measured total serum magnesium. The prevalence of hypomagnesaemia was in the range of 14% to 70%. More important, patients who develop Mg deficiency in the ICU have mortality rates 2 to 3 times higher and prolonged hospitalization compared with those who are not Mg deficient. A retrospective study was done on 100 patients in Isfahan by Safavi and colleagues[17]. At the time of admission, 51% of patients had hypomagnesaemia. They reported significant differences in mortality rates (55% vs. 35%) and the length of hospital or ICU stay between hypomagnesaemic and normomagnesemic patients.

Hence the present study was conducted at a tertiary healthcare institute to assess the relationship between serum magnesium levels and clinical status of the critically ill patients.

Material and methods

This is a prospective, observational cohort study involving the adult population of critically ill patients. The study was conducted in the Intensive care unit, the Emergency department. The emergency department is facilities at the tertiary healthcare institute which are used for acutely ill critical patients at the accident and emergency unit. Any person meeting the selection criteria, admitted into the critical care units.

Inclusion criteria
1. Age above 13yrs
2. Admission into the critical care units
3. Informed consent from the patient (where feasible) \, surrogate or proxy

Exclusion criteria
1. Patients who declined to participate/ consent to the study
2. Patients admitted to the ICU post –operatively for monitoring
3. Patients with burn injuries
4. Patients with acute or chronic renal failure already on dialysis

Sample size calculation
The sample size was calculated using the following method
N=Z2 xp (1-p) / d2
N=minimum sample size required
Z-confidence interval at 95% (standard value of 1.96)
P=estimated prevalence from the study of reference
D= margin of error
Using the given formula the sample size of 100 study subjects was used in the given study. Consecutive patients admitted into the critical care units of the Hospital were selected to participate in the study on a daily basis.
Serum Magnesium, Serum Calcium, Potassium and Albumin, Arterial blood gas analysis and Full hemogram analysis was done in the laboratory. The patients were then followed up for 2 weeks, noting the following parameters : duration of ventilator support, length of stay in the critical care units and mortality.

Definitions
Serum magnesium
- Hypomagnesemia was defined as serum magnesium <0.7mmol/L
- Normal magnesium levels defined as serum magnesium 0.7-1.1 mmol/L
- Hypermagnaesemia was defined as serum magnesium >1.1mmol/L

Serum calcium, serum potassium and serum albumin
Hypocalcaemia (Alb corrected calcium= measured Ca+[0.25(40-albumin)]/ 10) ; Ca < 2.15mmol/L . Normal range defined as 2.15mmol/L to 2.65mmol/L
Hypokalemia: K<3.5mmol/L. Normal range defined as 3.5mmol/L to 5mmol/L Hypoalbuminemia; Albumin <3.5g/dL. Normal range defined as 3.5g/dL to 5.0g/dL

Severity of illness
Severity of illness was assessed using the acute physiology and chronic health evaluation (APACHE II) score[86]. This is a scoring system that provides a means for describing and predicting acute illness severity over a broad range of intensive care unit (ICU) patients. The Apache-II Score provides an estimate of ICU mortality based on a number of laboratory values and patient signs taking both acute and chronic disease into account. The data used should be from the initial 24 hours in the ICU, and the worst value (furthest from baseline/normal) should be used. The score ranges from 0-71 points, the maximum score is 71. A score of 25 represents a predicted mortality of 50% A score of > 35 represents a predicted mortality of 80%

CCU morbidity and mortality
- Length of stay in ICU –in days/hrs.
- Ventilator use –duration in days/hrs.
- Discharge from CCU-alive or dead

Data management
Data was coded, entered and managed in a pre-designed Microsoft Access database. At the end of data entry, cleaning of data was performed and analysis done using SPSS version 21.0.
Categorical and continuous variables were summarized and presented in form of proportions and means or medians respectively. Prevalence of hypomagnesaemia was reported as a proportion based on the minimum normal magnesium cut off levels in blood.
Serum magnesium levels were correlated with serum calcium,serum potassium and APACHE II score using Pearson correlation coefficient. Prevalence of ECG abnormalities was calculated and presented as a proportion. Associations between hypomagnesaemia and continuous / categorical variables were analyzed using Student's t test and Chi square test respectively. The data was presented using tables, pie charts and graphs. All statistical tests were performed at 5% level of significance (95% confidence interval).

Results
In the current study majority of the study subjects belonged to the age group of 51 to 60 years (30%), followed by 36 to 50 years (25%), and 66 to 80 years (20%). In the current study we observed male preponderance (males were 68%), whereas female subjects were 32%. 26% were alcoholics and 25% subjects had history of diabetes mellitus.

Table 1: Demographic variables

Variables		Number of subjects	Percentage
Age distribution	Less than 35	12	12
	36 to 50	25	25
	51 to 65	30	30
	66 to 80	20	20
	More than 80	13	13
Genderwise distribution	Male	68	68
	Female	32	32
Alcoholism	Yes	26	26
	No	74	74
History of DM	Yes	25	25
	No	75	75

Table 2: Examination findings

Systemic examination		Number of subjects	Percentage
Cardiovascular system	Normal	92	92
	Murmur heard	8	8
Respiratory system	Air entry decreased	2	2
	B/L CREPTS	23	23
	RHONCHI	4	4
	NAD	71	71
Per Abdomen	DISTENSION	7	7
	NAD	82	82

	TENDERNESS	11	11
CNS	DROWSY	17	17
	IRRITABLE	12	12
	RESTLESS	15	15
	STUPROUS	2	2
	ALTERED SENSORIUM	3	3
	COMATOSE	3	3
	HEMIPARESIS	4	4
	QUADRIPARESIS	1	1

In this study the examination findings are as per shown in the above table number 2. 12% subjects were irritable, 17% were drowsy, 15% were restless.

Table 3: Serum electrolyte levels

Parameters	Mean	SD
PCV	38.9	4.98
TLC	12713	5751.86
Mg	1.09	0.48
Na	139.19	6.75
K	4.07	0.8
Creatinine	1.38	1.19
APACHE score	11.79	5.59
ICU stay duration	3.31	2.32

In this study we assessed the serum electrolyte levels among the study subjects. The mean levels as shown in the table number 3. The severity among the study subjects was analyzed using APACHE score. The mean score was 11.79. We also assessed ICU stay duration among the study subjects. We observed mean ICU stay as 3.31 days. Majority of the subjects had APACHE score between 11 to 20 (49%), followed by less than 10 among 38% study subjects.

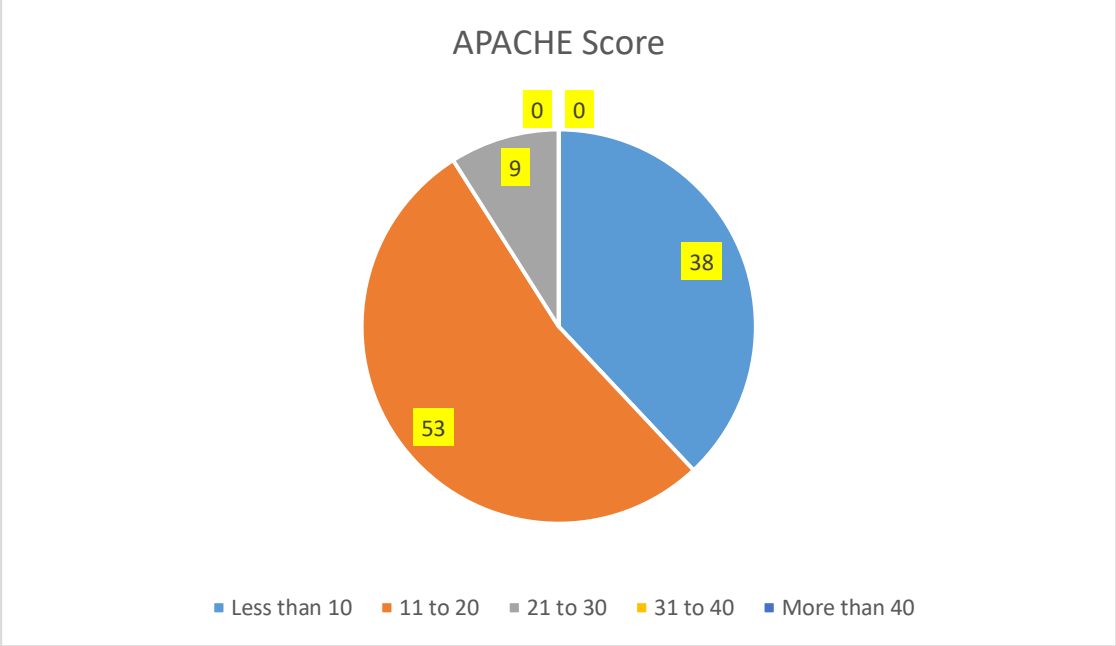

Fig. 1: APACHE II score

Table 4: Mean APACHE score with magnesium levels

Mean APACHE score with magnesium levels		Mean APACHE score	
		Mean	SD
Mg levels	Normal levels	12.2	6..41
	Hypomagnesemia	9.23	3.16
Correlation coefficient		R=0.31, p-value=0.0003	

In this study we assessed the correlation between APACHE score and serum magnesium levels. We observed it to be statistically significant. (R=0.31, p-value=0.0003)

Discussion

In this observational clinical cohort of critically ill admissions, we set out to determine the prevalence of serum hypomagnesaemia and related clinical outcomes. Our study sample was young in age and predominantly male. In the current study majority of the study subjects belonged to the age group of 51 to 60 years (30%), followed by 36 to 50 years (25%), and 66 to 80 years (20%). In the current study we observed male preponderance (males were 68%), whereas female

subjects were 32%. 26% were alcoholics and 25% subjects had history of diabetes mellitus.

In this study the examination findings are as per shown in the above table number 2. 12% subjects were irritable, 17% were drowsy, 15% were restless. In this study we assessed the serum electrolyte levels among the study subjects. The mean levels as shown in the table number 3. The significance of hypomagnesaemia is that it's common and more so in the severely ill patients. Reports on prevalence of hypomagnesaemia in critically ill patients ranges from14-66%.

A plausible explanation for this wide range could be the differences in patients clinical categories. Our study compares favorably with. Rubeiz et al[18] who reported a prevalence of 20% on evaluating 381 acutely ill patients admitted to the emergency department CCU and medical ICU. This similarity may be due to shared baseline patient characteristics, majority of the admissions to the emergency CCU were due to trauma, in patients who were previously healthy. Majority were acutely ill patients whose baseline physiology may not be altered to a large extent. In contrast, Chernow et al reported a prevalence of 61%, they studied 193 post cardiac surgery patients. The high prevalence found by Chernow and colleagues[14] could be attributed to the sample of patients studied. Post cardiac surgery patients are at a higher risk of magnesium depletion due to the large volumes of hypotonic fluid resuscitation infused which may shiftmagnesium. These patients also tend to have blood transfusion hence citrate in blood may chelate magnesium. Limaye C.S et al[19] in India studied 100 medical ICU patients and found a prevalence of 52%. This high prevalence could be attributed to the fact that Limaye and colleagues did their study in an entirely medical ICU as opposed to our study where we had a mix of patients. Our study therefore had a heterogeneous patient population in terms of diagnostic labels.

The severity among the study subjects was analyzed using APACHE II score. The mean score was 11.79. We also assessed ICU stay duration among the study subjects. We observed mean ICU stay as 3.31 days. Majority of the subjects had APACHE score between 11 to 20 (49%), followed by less than 10 among 38% study subjects. In this study we assessed the correlation between APACHE score and serum magnesium levels. We observed it to be statistically significant. (R=0.31, p-value=0.0003).

Chen M, Sun R, Hu B in their study observed that Hypomagnesemia is common in sepsis patients, both in the ICU and in the wards. In order to provide optimal care, ICU clinicians should be familiar with the principles and practice of fluid and electrolyte pathophysiology. Hypomagnesemia should be identified and corrected, because it is associated with increased adverse events and higher mortality in critically ill patients. Total or ionized serum Mg measurement is useful in sepsis patients, and physicians should maintain a high index of suspicion for hypomagnesemia and the need for Mg replacement therapy[20].

Sunil Kumar, Akshay Honmode, Shraddha Jain et al in their study observed that Mg alterations have frequently been observed in critically ill patients. In this study, there is a high prevalence of hypomagnesemia in the critically ill patients, which were associated with adverse outcomes. Physicians should be alert to the high incidence of hypomagensemia in critically ill patients and should consider their routine monitoring[21].

Conclusion

In conclusion this study found that hypomagnesaemia is common in the critical care setting and more so in the severely ill patients. The study recommends that routine monitoring of serum magnesium and clinical assessment of patients at risk for Mg deficiency remains vital for making a timely diagnosis of magnesium depletion. More studies need to be done to determine serial magnesium changes during the patients stay in the critical care units.

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