Original Article

Evaluation of Serum Magnesium Level and its Significance in Critically ill Patients

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Abstract

Background : Critically ill patients are especially prone to Magnesium deficiency, a condition often overlooked that can worsen their chances of recovery.

Aims and Objectives : This study aimed to assess Serum Magnesium levels in critically ill patients and correlate them with patient outcomes in terms of the duration of ICU stay, need and duration of mechanical ventilation and mortality.

Materials and Methods : This observational study was conducted on 104 patients aged between 18 and 85 years who were admitted to the ICU with an APACHE II score >10 in the Department of General Medicine, VMKV Medical College Hospital, Salem, over a study period of 1 year. Serum Magnesium levels were measured within the first 24 hours of admission for patients fulfilling the inclusion and exclusion criteria. Patients were followed-up until discharge, and the outcomes were noted and statistically analysed to determine the correlation.

Results : Of the 104 patients, 72 (69.2%) had normal Serum Magnesium levels (1.6 to 2.6), while 32 (30.8%) had Hypomagnesaemia (<1.6). Mechanical ventilation was required in 44 of the 104 patients (42.3%). Of the 32 patients in the Hypomagnesaemia group, 19 (59.4%) required mechanical ventilation, 23 (71.9%) were discharged, and nine (28.1%) died. A significant association was observed between Hypomagnesaemia and the requirement for mechanical ventilation ($p = 0.019$) and mortality ($p = 0.016$). ICU stay duration and duration of ventilatory support did not correlate significantly with Magnesium levels.

Conclusion : The study revealed a significant association between Hypomagnesaemia and the need for mechanical ventilation and increased mortality.

Key words : Serum Magnesium, Critically ill Patients, Mechanical Ventilation, APACHE II Score, Mortality.

Minerals play a crucial role in various physiological processes within the human body. Among these, Magnesium (Mg) stands out due to its involvement in over 300 enzyme systems, including those regulating Sodium-potassium ATPase-mediated transport. Magnesium is vital for maintaining Calcium homeostasis, nerve conduction, skeletal muscle activity and the overall balance of electrolytes like Calcium and Potassium[1]. Recently, Serum Magnesium levels have garnered increased attention from the medical community due to mounting evidence linking its deficiency to various health issues.

Several factors contribute to a higher prevalence of magnesium deficiency in elderly patients, including inadequate dietary intake, increased urinary excretion due to medications like diuretics and digitalis, and reduced intestinal absorption[2]. Disorders of Magnesium metabolism, though frequently unrecognised, are among the most common electrolyte disturbances in patients admitted to hospitals, especially in critically ill elderly patients. Hypomagnesemia, defined by low Serum Magnesium levels, exhibits a wide prevalence range of 11% to 61% in this population. The impact of Magnesium on patient outcomes, however, remains a topic of debate, with considerable controversy regarding its influence on morbidity and mortality[3]. For ensuring optimal neuromuscular excitability and cardiac function, maintenance of a specific Magnesium concentration is crucial to ensure optimal neuromuscular excitability and cardiac function. Deviations from normal levels, whether increase or decrease, often result in significant abnormalities with serious consequences. Hypomagnesemia in critically ill individuals carries numerous potential implications and emerges as a notable factor impeding their recovery[4].

Editor's Comment :

- Hypomagnesemia is a common often overlooked electrolyte disturbance in critical care which is found to be associated with patient outcomes like increased mortality and need for mechanical ventilation.
- Management of Hypomagnesemia could potentially improve patient outcomes.

The incidence of Hypomagnesemia is reported to be 50-60% in Intensive Care Unit (ICU) patients, 30-80% in persons with alcoholism, 10-20% in hospitalised patients, 25% in Outpatients with Diabetes Mellitus, and 2% in the

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general population. Clinical manifestations of Hypomagnesemia are Tetany, Vertigo, Reversible Psychiatric Aberrations, Asthma, Seizures, Hypertension, Cardiac Arrhythmias, Muscular Weakness and Acute Cerebral Ischemia[5].

Hypomagnesemia, a deficiency in magnesium levels, arises from various factors. These include gastrointestinal disorders, metabolic acidosis, increased renal excretion due to medications or underlying disease, and other contributors. Critically ill patients are particularly susceptible to Magnesium dysregulation. Studies have shown a concerning association between Hypomagnesemia in this population and poorer outcomes, including increased and prolonged use of mechanical ventilation, extended ICU stays, difficulty weaning from ventilation, and even higher mortality rates[6].

Hypomagnesemia often coexists with other electrolyte imbalances such as hypokalaemia, wherein patients show relative resistance to Potassium Supplementation until Magnesium deficiency is addressed. Similarly, Hypocalcemia frequently accompanies Hypomagnesemia, presenting a challenge in correction, unless Magnesium deficits are addressed first. These electrolyte disturbances compound the morbidity and mortality rates in critically ill patients[7].

Hypomagnesemia has been identified as a significant indicator of mortality risk in critically ill patients. Many studies corroborate that individuals with Hypomagnesemia upon admission exhibit elevated mortality probabilities[8]. The current investigation sought to examine the factors mentioned earlier and evaluate serum Magnesium levels in critically ill patients admitted to an Intensive Care Unit (ICU) within a Tertiary Care Facility.

Aims and Objectives

This study investigated Serum Magnesium levels in critically ill ICU patients, examining correlations with ICU stay length, need for mechanical ventilatory support, ventilator use duration and mortality.

Materials and Methods

This observational study included 104 patients aged between 18 and 85 years who were admitted to the ICU, Department of General Medicine, Vinayaka Mission's Kirupananda Variyar Medical College and Hospital, Salem, between October, 2022 and October, 2023.

Inclusion Criteria :

Patients aged between 18 and 85 years and critically ill patients admitted to the ICU with an APACHE II score of >10 were included in the study.

Exclusion Criteria :

Patients who received Magnesium Supplements, Calcium Infusions, Diuretics, Proton Pump Inhibitors, Aminoglycosides, or Blood Transfusions before ICU admission, chronic alcoholics and pregnant women with eclamptic seizures were excluded from the study.

All patients were informed of the study at the time of enrolment, and informed consent regarding their willingness to participate was obtained. Ethical Committee Approval was obtained before proceeding with this study.

A detailed history was obtained and a clinical examination of the patients who met the inclusion and exclusion criteria was performed. Serum Magnesium samples of the patients were taken within 24 hours of admission to the ICU. The serum Magnesium levels were evaluated using the methylene blue Spectrophotometric method. The normal reference range for serum Magnesium is between 1.6 and 2.6 mg/dL. Value less than 1.6 mg/dL was considered as Hypomagnesemia and more than 2.6 mg/dL as Hypermagnesemia. Other routine blood investigations, including RBS, CBC, RFT, Serum electrolytes, LFT, serology, urine routine, chest radiography, and ECG, were also performed. Patient outcomes in terms of mortality, need, duration of ventilator support, and duration of ICU stay were noted.

Statistical Analysis :

Data were collected, entered into Microsoft Excel, and analysed using SPSS software (version 22). Categorical data were presented as frequencies and percentages. The p-value was calculated using the Chi-square test, and a p-value <0.05 was considered significant.

Results

Of the 104 patients, 55 (52.9%) were Males and 49 (47.1%) were Females. When stratified based on age, 8 patients (7.7%) were aged ≤40 years, 29 patients (27.9%) were aged between 41 and 50 years, 27 (26%) were aged 51-60 years, 23 (22.1%) were aged 61-70 years, and 17 (16.3%) were aged >70 years. Based on Sr-Mg levels, 72 patients (69.2%) had a value range of 1.6 to 2.6, and 32 (30.8%) had <1.6 (Hypomagnesemia). None of the patients had serum Magnesium values >2.6 (Hypermagnesemia).

Sixty patients (57.7%) did not require mechanical ventilation and 44 (42.3%) required mechanical ventilation. 37 patients (84.1%) had a duration of ≤5 days of mechanical ventilation and seven (15.9%) had a duration of >5 days. Based on the duration of ICU stay, 63 patients (60.6%) had a duration of ≤5 days, 37 (35.6%) had a duration of 6-10 days and 4 (3.8%) had a duration of >10 days. Based on the outcomes, 88 (84.6%) patients were discharged and the remaining 16 patients (15.4%) died (Table 1).

Table 1 — *Demographic details of the study population*

		Number of patients	Percentage
Age group	≤40	8	7.7
	41 to 50	29	27.9
	51 to 60	27	26
	61 to 70	23	22.1
	>70	17	16.3
Gender	Female	49	47.1
	Male	55	52.9
Sr Magnesium	<1.6	32	30.8
	1.6 to 2.6	72	69.2
Need for mechanical ventilation	No	60	57.7
	Yes	44	42.3
Duration of mechanical ventilation	≤5	37	84.1
	≥6	7	15.9
Duration of ICU stay	≤5	63	60.6
	6 to 10	37	35.6
	>10	4	3.8
Outcome	Discharged	88	84.6
	Expired	16	15.4

There was no significant correlation between Serum Magnesium levels and duration of ICU stay (Table 2).

Among patients with Sr Magnesium values <1.6, 19 (59.4%) required mechanical ventilation and among those with Sr Magnesium levels between 1.6 and 2.6, 25 (35.7%) required mechanical ventilation. There was a statistically significant correlation between the need for mechanical ventilation and low Mg levels (p = 0.019). The outcome status was that in patients with Sr Magnesium values <1.6, 9 (28.1%) died. Seven patients (9%) died in the group with Sr-Mg values from 1.6 and 2.6. There was a statistically significant correlation between low serum magnesium level and mortality (p = 0.016) (Table 3).

In patients with hypomagnesaemia (Sr Mg <1.6), 14 (73.7%) required mechanical ventilation for ≤5 days, whereas 5 (26.3%) required ventilatory support for >5 days.

Table 2 — *Correlation of Sr Magnesium with APACHE II Score and Duration of ICU Stay*

		APACHE II Score	Duration of ICU stay
Sr Magnesium	Pearson correlation	-0.16	-0.147
	P value	0.105	0.138

Table 3 — *Comparison of Sr Magnesium with the need for mechanical ventilation and Outcome*

		Sr Magnesium		P value
		<1.6	1.6 to 2.6	
Need for mechanical ventilation	No	13 (40.6%)	47 (65.3%)	0.019
	Yes	19 (59.4%)	25 (35.7%)	
Outcome	Discharged	23 (71.9%)	65 (90.3%)	0.016
	Expired	9 (28.1%)	7 (9%)	

Table 4 — *Comparison of Sr Magnesium with the duration of Mechanical Ventilation*

		Sr Magnesium		P value
		<1.6	1.6 to 2.6	
Duration of Ventilatory support	≤5 days	14 (73.7%)	23 (92%)	0.100
	>5 days	5 (26.3%)	2 (8%)	

In patients with Serum Magnesium levels between 1.6 and 2.6, 23 (92%) required ventilatory support for ≤5 days and 2 (8%) required ventilatory support for >5 days. However, the correlation between Serum Magnesium levels and duration of ventilatory support was found to be statistically insignificant, with a p-value of 0.100 (Table 4).

Discussion

Magnesium is predominantly found in the bones and cells. Magnesium deficiency in critical conditions is associated with morbidity and mortality[9]. In studies conducted on critically ill patients Globally, the typical occurrence rate of Hypomagnesemia ranges from 14% to 70%.

In our study, 30.8% of the patients had Sr-Mg levels <1.6. Among patients with Hypomagnesaemia, 59.4% required mechanical ventilation and 40.6% did not require mechanical ventilation. Of the patients, 69.2% had Sr-Mg values in the range of 1.6 and 2.6, 65.3% did not require mechanical ventilation and 35.7% required mechanical ventilation. There was a statistically significant correlation between Hypomagnesaemia and requirement for mechanical ventilation. A study done by Safavi, *et al* also found that the cases of low Serum Magnesium needed more and longer mechanical ventilation compared with other patients[10].

In our study, the majority of patients (84.1%) had a mechanical ventilation duration of ≤5 days, and the remaining 15.9% of patients had a duration of >5 days. In the Hypomagnesaemia group, 14 (73.7%) patients required ventilatory support for ≤5 days, whereas 5 (26.3%) required for >5 days. However, the p-value is insignificant. 60.6% of patients had a duration of ≤5 days of ICU stay, 35.6% had ICU stay from 6 to 10 days and the remaining 3.8% had >10 days of ICU stay. The p-value for the duration of ICU stay was not statistically significant. However, this result differed from the study done by Jahangirifard, *et al* as the admitted patients in ICU with Low Serum Mg levels, not only had significantly higher rates of mortality but also needed more mechanical ventilation, besides having longer hospital stays[11].

In our study, 84.6% of the patients were discharged; among them, 73.86% of patients had Sr-Mg levels ranging from 1.6 to 2.6 (which makes 62.5% of the total participants in the study), and 26.13% had Sr-Mg levels <1.6 (which makes up 22.11% of the total participants). The remaining 15.4% of patients died; among them, 56.25% had a Sr Magnesium level of <1.6 (which made up 8.6% of the total participants), and 43.75% had a Sr Magnesium level between 1.6 and 2.6 (which makes 6.7% of the total participants). Mortality and Hypomagnesaemia were significantly correlated. However, the correlation between the APACHE II Score of the study population and Serum Magnesium level was considered statistically

insignificant. This differs from the results of the study done by Gonuguntla, *et al* as they reported that the mean APACHE II and SOFA scores were significantly higher in patients with hypomagnesemia followed by those with Normomagnesemia and Hypermagnesemia[12].

The results of the study by Laddhad, *et al* also differed from those of our study. They reported that most participants scored APACHE II below 10, indicating less to nil severity, yet the results were not statistically significant[13].

Limitations :

In this study, we studied Serum Magnesium values only on the day of admission, and any changes in the Serum Magnesium values during the ICU stay and their relationship with outcome were not assessed. Confounding factors such as other electrolyte imbalances including serum Potassium, Sodium, Calcium and Phosphorus were not taken into account which could have affected patient outcomes as well. Further studies with a trial of Magnesium Supplementation in critically ill patients would help develop guidelines regarding the treatment of hypomagnesaemia in Intensive Care.

Conclusion

Serum Magnesium levels <1.6 mg/dL were significantly associated with increased requirements for mechanical ventilation and higher mortality rates. Notably, no significant correlation was observed among Magnesium levels, ICU stay duration, and ventilatory support duration. These findings advocate the assessment and management of Magnesium homeostasis in critical care settings to potentially improve patient outcomes.

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