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Original Research Article

To Study the Serum Magnesium Levels in Subjects Admitted to the Intensive Care Unit and its Correlation with In-Hospital Outcomes

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ABSTRACT

Background: Magnesium is an essential intracellular cation involved in more than 300 enzymatic reactions and plays a vital role in neuromuscular function, cardiac rhythm, and electrolyte homeostasis. Hypomagnesemia is frequently encountered in critically ill patients but often remains underdiagnosed, despite its potential impact on patient outcomes. This study aimed to evaluate serum magnesium levels in ICU patients and determine their association with in-hospital outcomes.
Methods: A prospective observational study was conducted in the mixed medical-surgical Intensive Care Unit of Mysore Medical College and Research Institute from January to December 2024. A total of 116 adult patients admitted to the ICU were included. Serum magnesium levels were measured at admission, and patients were categorized into hypomagnesemia (<1.5 mEq/L), normomagnesemia (1.5-2.3 mEq/L), and hypermagnesemia (>2.3 mEq/L) groups. Clinical outcomes assessed included ICU mortality, duration of mechanical ventilation, and length of ICU stay. Statistical analysis was performed using appropriate tests, with adjustment for confounding variables such as APACHE II score and associated comorbidities.
Results: Hypomagnesemia was identified in 60% of the study population at ICU admission. Patients with low serum magnesium levels had significantly higher mortality rates, longer durations of mechanical ventilation, and prolonged ICU stays compared with those having normal magnesium levels. Multivariable analysis demonstrated that hypomagnesemia was an independent predictor of adverse in-hospital outcomes.
Conclusion: Hypomagnesemia is a common electrolyte abnormality among critically ill patients and is significantly associated with poor in-hospital outcomes, including increased mortality, prolonged mechanical ventilation, and extended ICU stay. Routine monitoring and timely correction of serum magnesium levels may improve prognosis and should be considered an integral component of ICU patient management.

Keywords: Serum Magnesium, Hypomagnesemia, Intensive Care Unit, In-Hospital Outcomes, Mortality, Mechanical Ventilation, Critical Care.

INTRODUCTION

Magnesium (Mg) is an essential mineral involved in numerous physiological processes and is the fourth most abundant cation in the human body as well as the second most abundant intracellular cation after potassium. The human body contains approximately 24 g (1000 mmol) of magnesium, with nearly 60% stored in bone, 20% in skeletal muscle, and the remaining 20% in soft tissues. However, only about 0.3% of total body magnesium is present in serum, making routine serum measurements an imperfect indicator of overall magnesium status.[1]

Magnesium functions as a cofactor for more than 300 enzymatic reactions, particularly those involved in ATP production, energy metabolism, protein synthesis, and phosphate transfer. It is essential for maintaining neuromuscular excitability, myocardial function, intracellular calcium regulation, and cell membrane stability. Deficiency of magnesium can lead to neuromuscular hyperexcitability, muscle cramps, seizures, coronary vasospasm, bronchoconstriction, and life-threatening cardiac arrhythmias.[2]

Hypomagnesemia, defined as a serum magnesium level below 1.5 mEq/L, is one of the most frequently overlooked electrolyte disturbances in critically ill patients, with reported prevalence ranging from 12% to 65% in ICUs. Magnesium depletion commonly results from gastrointestinal losses, renal wasting due to diuretics, aminoglycosides, cisplatin, cyclosporine, pancreatitis, and prolonged intravenous fluid therapy. Normal magnesium balance is maintained through intestinal absorption, renal reabsorption, and skeletal storage, all of which may be significantly disrupted during critical illness.[3,4]

Magnesium deficiency is often accompanied by hypokalemia and hypocalcemia because of impaired renal potassium conservation, reduced parathyroid hormone secretion, and decreased activation of vitamin D. These electrolyte abnormalities contribute to muscle weakness, tetany, seizures, and increased cardiovascular instability.[5] Magnesium also plays a vital role in maintaining myocardial electrical stability through regulation of Na-K-ATPase activity, and studies have demonstrated reduced ventricular arrhythmias and improved survival following magnesium supplementation in acute myocardial infarction patients.[6]

In critically ill patients, hypomagnesemia has been associated with respiratory muscle weakness, difficulty in weaning from mechanical ventilation, prolonged ICU stay, and increased mortality. Although previous studies have reported a significant association between low serum magnesium levels and adverse in-hospital outcomes, findings remain inconsistent, highlighting the need for further investigation. Early recognition and appropriate correction of hypomagnesemia may improve the prognosis of critically ill patients and reduce ICU-related complications.[7-9]

Aims and Objectives

The study aimed to assess serum magnesium levels in patients admitted to the ICU and evaluate their association with in-hospital outcomes. The specific objectives are to measure serum magnesium levels in critically ill patients at the time of ICU admission and to determine the correlation of these levels with clinical outcomes, including in-hospital mortality, length of ICU stay, and duration of mechanical ventilation.

MATERIALS AND METHODS

Study Design

This study was designed as a prospective observational cohort study to evaluate the association between serum magnesium levels at ICU admission and subsequent in-hospital outcomes. Serum magnesium was measured at the time of admission, and patients were followed prospectively until ICU discharge or death without any intervention. The study was conducted in the adult mixed medical-surgical Intensive Care Unit (ICU) of Mysore Medical College and Research Institute, Mysore, over a one-year period from January 2024 to December 2024.

Inclusion and Exclusion Criteria

The study included adult patients aged 18 years or older who were admitted to the mixed medical-surgical ICU, had their serum magnesium levels measured within 24 hours of ICU admission, and provided written informed consent either personally or through their legally authorized representative. Patients were excluded if they had end-stage renal disease requiring maintenance dialysis, were pregnant or lactating, were admitted solely for planned postoperative monitoring without critical illness, had received magnesium supplementation before the initial blood sample was collected, or had DNR (Do-Not-Resuscitate) or comfort-measures-only orders at the time of admission. These criteria were applied to ensure a representative cohort of critically ill adults while minimizing confounding factors that could influence baseline serum magnesium levels and clinical outcomes.

Sample Size Calculation

Sample size was determined a priori using a correlation-based formula to detect a moderate association ($r = 0.3$) between serum magnesium and ICU length of stay with 80% power at a two-tailed α of 0.05. The calculation yielded a minimum of 85 patients. To account for potential dropouts, missing data, and the need for subgroup analyses (hypomagnesaemia, normomagnesaemia, hypermagnesaemia), the target sample was increased by 25%, resulting in a planned enrolment of 110 patients. Ultimately, 150 patients were enrolled, exceeding the required sample size and ensuring adequate power for multivariable regression models.

Data Collection Procedure

Eligible patients admitted to the ICU underwent routine blood investigations, including serum magnesium estimation within 24 hours of admission. Serum magnesium levels were measured using a colorimetric xylidyl blue method in the hospital's central laboratory, and patients were categorized into hypomagnesaemia (<1.5 mEq/L), normomagnesaemia (1.5–2.3 mEq/L), or hypermagnesaemia (>2.3 mEq/L**)** groups. Baseline demographic and clinical data, including age, sex, diagnosis, comorbidities, APACHE II score, serum creatinine, potassium levels, and treatment details, were recorded using a structured case record form. Patients were followed throughout their ICU stay until discharge or death, and outcome measures such as ICU mortality, duration of mechanical ventilation, and length of ICU stay were documented. All data were entered into a secure database, verified for accuracy, and anonymized before statistical analysis.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics version 25.0**.** Continuous variables were expressed as mean ± standard deviation or median (interquartile range) based on data distribution, while categorical variables were presented as frequencies and percentages**.** Comparisons between study groups were performed using one-way ANOVA or Kruskal–Wallis tests for continuous variables and the chi-square or Fisher's exact test for categorical variables. Correlation between serum magnesium levels and clinical outcomes, including ICU length of stay and duration of mechanical ventilation, was assessed using Pearson's or Spearman's correlation analysis. Multivariable linear and logistic regression analyses were performed to evaluate the independent association of serum magnesium with ICU outcomes after adjusting for potential confounding variables. A p-value < 0.05 was considered statistically significant.

RESULTS

Variable	Hypomagnesaemia (n=90)	Normomagnesaemia (n=50)	Hypermagnesaemia (n=10)	P value
Mean Serum Magnesium (mg/dL)	1.34 ± 0.18	1.92 ± 0.22	2.74 ± 0.31	—
Percentage	60.0%	33.3%	6.7%	—
Age <40 years	20 (22%)	10 (20%)	1 (10%)	0.41
Age 40–60 years	40 (44%)	25 (50%)	3 (30%)	
Age >60 years	30 (33%)	15 (30%)	6 (60%)	
Male sex	60 (67%)	30 (60%)	7 (70%)	0.59

Table 1. Baseline Characteristics and Serum Magnesium Distribution

Table 1 describes the baseline demographic characteristics and admission serum magnesium status of the study population. Hypomagnesaemia was the most common finding, affecting 60% of ICU patients, while age and gender distribution were comparable among the three magnesium groups without statistically significant differences.

Variable	Hypomagnesaemia	Normomagnesaemia	Hypermagnesaemia	P value
APACHE II score (Mean ± SD)	25 ± 6	18 ± 5	22 ± 7	<0.001
ICU Diagnosis: Sepsis	50 (56%)	18 (36%)	5 (50%)	0.04
Cardiogenic disease	12 (13%)	12 (24%)	1 (10%)	
Respiratory failure	18 (20%)	12 (24%)	3 (30%)	
Neurocritical illness	10 (11%)	8 (16%)	1 (10%)	
Vasopressor	55 (61%)	15 (30%)	4 (40%)	

requirement				
Median vasopressor duration (days)	3 (2–5)	2 (1–3)	3 (2–5)	

Table 2. Disease Severity and Clinical Profile At ICU Admission

Table 2 illustrates the relationship between serum magnesium levels and illness severity at ICU admission. Patients with hypomagnesaemia had significantly higher APACHE II scores, a greater proportion of sepsis, and increased vasopressor requirement, indicating greater physiological instability on admission.

Variable	Hypomagnesaemia	Normomagnesaemia	Hypermagnesaemia	P value
ICU stay (Mean ± SD)	7.4 ± 4.9	4.6 ± 3.2	6.8 ± 4.2	<0.001
Mechanical ventilation	63 (70%)	20 (40%)	5 (50%)	<0.001
Ventilator duration (days)	6.4 ± 3.2	4.1 ± 2.5	5.5 ± 3.0	0.002
ICU mortality	36 (40%)	10 (20%)	3 (30%)	RR=2.0

Table 3. ICU Clinical Outcomes According to Serum Magnesium Status

Table 3 demonstrates that hypomagnesaemia was associated with worse ICU outcomes. These patients experienced a significantly longer ICU stay, increased need for mechanical ventilation, prolonged ventilator support, and higher ICU mortality compared with patients having normal serum magnesium levels.

Variable	Hypomagnesaemia	Normomagn-esaemia	Hypermagnesae-mia	P value
Hypokalaemia	45 (50%)	8 (16%)	3 (30%)	<0.001
Hypocalcaemia	27 (30%)	6 (12%)	2 (20%)	0.03
Arrhythmias	30 (33%)	7 (14%)	3 (30%)	
Severe AKI	20 (22%)	5 (10%)	2 (20%)	
Renal replacement therapy	9	2	1	

Table 4. Associated Complications During Icu Stay

Table 4 highlights the major complications associated with abnormal magnesium levels. Hypomagnesaemic patients had a higher frequency of electrolyte abnormalities, cardiac arrhythmias, and severe acute kidney injury requiring renal replacement therapy, suggesting a strong association between magnesium deficiency and adverse organ dysfunction.

Variable	Hypomagnesaemia	Normomagnesaemia	Hypermagnesaemia	P value
Hospital stay (Mean ± SD)	15 ± 6	10 ± 4	13 ± 5	<0.001
Discharged alive	48	40	6	
LAMA	6	0	0	
Death	36	10	3	
30-day readmission	8 (14.8%)	3 (7.5%)	1 (14.3%)	

Table 5. Hospital Outcomes

Table 5 summarizes the overall hospital outcomes among the study groups. Hypomagnesaemia was associated with prolonged hospital stay, higher in-hospital mortality, increased LAMA rate, and a greater 30-day readmission rate, indicating a poorer overall prognosis.

Variable	Value
Adjusted OR for hypomagnesaemia	2.53 (1.28–4.80)
Age >60 years	1.82 (1.02–3.28)
APACHE II (per point)	1.12 (1.06–1.18)
Ventilation days	1.08 (1.01–1.16)
Serum Mg AUROC	0.68
APACHE II AUROC	0.83
APACHE II + Magnesium AUROC	0.87

Table 6. Prognostic Value of Serum Magnesium

Table 6 presents the prognostic significance of serum magnesium. Multivariable analysis demonstrated hypomagnesaemia as an independent predictor of ICU mortality. Addition of serum magnesium to the APACHE II model significantly improved the predictive accuracy for mortality.

Variable	Hypomagnesaemia	Normomagnesaemia	Hypermagnesaemia
APACHE II >25	40	5	2
Ionised hypomagnesaemia with low total Mg	88%	14%	0%
Loop diuretics	52 (58%)	18 (36%)	4 (40%)
Aminoglycosides	28 (31%)	9 (18%)	2 (20%)
PPIs ≥7 days	46 (51%)	20 (40%)	4 (40%)

Table 7. Additional Clinical Associations

Table 7 illustrates additional clinical associations of serum magnesium. Magnesium deficiency was more common among patients with higher APACHE II scores and was strongly associated with ionised hypomagnesaemia. Exposure to loop diuretics, aminoglycosides, and prolonged proton pump inhibitor therapy was also more frequent among hypomagnesaemic patients, suggesting important contributors to magnesium depletion.

DISCUSSION

The present study demonstrated that hypomagnesaemia was present in 60% of ICU patients at admission, making it the most common magnesium abnormality observed. This prevalence is considerably higher than that reported by Mousavi et al. (46.2%),[10] Gonuguntla et al. (40.9%),[8] Gholyaf et al. (31.7%),[11] Zafar et al. (24.3%),[12] and Laupland et al. (23.8%).[13] The higher prevalence in our study may be attributed to the greater proportion of septic patients (56%) and frequent exposure to loop diuretics (58%), both of which are recognized causes of magnesium depletion. These findings reaffirm that hypomagnesaemia is a frequent electrolyte abnormality in critically ill patients and support routine magnesium estimation at ICU admission.

Although age and sex differences were not statistically significant, hypomagnesaemic patients in our study tended to be older, with 33% aged >60 years, and were predominantly male (67%). Similar demographic trends have been reported by Mousavi et al.[10] and Singh et al.[14] who observed poorer outcomes among elderly patients with magnesium deficiency. In contrast, Gholyaf et al.[11] reported a female predominance in their cohort, highlighting the influence of regional patient characteristics and underlying disease profiles.

Hypomagnesaemia was significantly associated with greater illness severity. Patients with magnesium deficiency had a mean APACHE II score of 25 ± 6, compared with 17 ± 5 among normomagnesaemic patients ($p<0.001$). Comparable findings were reported by Solanki et al., who observed APACHE II scores of 24 versus 18,[15] while Laupland et al.[13] demonstrated higher APACHE III scores (68 vs. 60) in patients with low magnesium levels. Likewise, Tiruvuri et al.[16] reported significantly higher SOFA scores (9.3 vs. 6.1) among hypomagnesaemic patients. Furthermore, the prevalence of hypomagnesaemia increased progressively with increasing APACHE II quartiles, rising from 25% in the lowest quartile to 80% in the highest, closely paralleling the observations of Solanki et al.[15] and Tiruvuri et al.[16] These findings suggest that magnesium deficiency reflects increasing physiological derangement and disease severity.

The present study also demonstrated that hypomagnesaemia was associated with significantly worse clinical outcomes. The median ICU stay was 7 days (IQR 4–11) compared with 4 days (IQR 3–7) among patients with normal magnesium levels ($p<0.001$). Similar prolongation of ICU stay was reported by Mousavi et al., who documented 10.3 ± 8.6 days versus 7.2 ± 5.4 days,[10] while Singh et al.[14] reported ICU stays of 8.1 versus 5.6 days. Although Zafar et al.[12] did not observe a significant difference, probably because of their smaller sample size, the overall evidence consistently indicates that magnesium deficiency contributes to prolonged ICU hospitalization and increased healthcare resource utilization.

Mortality was markedly higher among hypomagnesaemic patients in the present study (40% vs. 20%). This finding closely resembles the results of Tabatabaei et al. (40%)[17] and is supported by Gonuguntla et al., who reported mortality rates of 51.3% versus 29.3%,[8] Zafar et al., who observed 74.5% versus 36%,[12] and Solanki et al., who reported 47% versus 24%.[15] Mousavi et al.[10] found that abnormal magnesium levels independently increased mortality risk with an adjusted odds ratio of 1.86, whereas the present study demonstrated an even stronger association with an adjusted odds ratio of 2.53 (95% CI: 1.28–4.80) after adjustment for age, APACHE II score, and ventilator duration. Although Laupland et al.[13] found that admission magnesium lost significance after adjustment for illness severity, their study highlighted the adverse impact of ICU-acquired hypermagnesaemia, suggesting that both deficiency and excess may influence outcomes. Overall, our findings reinforce the role of hypomagnesaemia as an independent predictor of mortality in critically ill patients.

Respiratory outcomes were also adversely affected by magnesium deficiency. In the present study, 70% of hypomagnesaemic patients required mechanical ventilation compared with a substantially lower proportion among patients with normal magnesium levels. This finding is consistent with Tabatabaei et al., who reported ventilator requirements of 78.9% versus 48.9%,[17] and Solanki et al.[15] who demonstrated an adjusted odds ratio of 3.2 for ventilator dependence among patients with hypomagnesaemia. Furthermore, ventilator duration was significantly longer in our study (6.4 ± 3.2 vs. 4.1 ± 2.5 days; $p=0.002$), comparable to Singh et al., who reported 7.2 versus 4.3 days.[14] Although Tabatabaei et al.[17] observed longer ventilation among normomagnesaemic patients, the authors attributed this to early mortality in the hypomagnesaemia group, which shortened ventilation duration. These findings collectively support the role of magnesium in respiratory muscle function and successful ventilator weaning.

Electrolyte abnormalities frequently accompanied hypomagnesaemia. In the present study, 50% of hypomagnesaemic patients had hypokalaemia, while 30% had hypocalcaemia. Similar findings were reported by Zafar et al., who documented hypokalaemia (70%), hyponatraemia (64%), and hypocalcaemia (58%),[12] and Gonuguntla et al., who reported hypokalaemia in 68% and hypocalcaemia in 52%.[8] Solanki et al.[15] also observed QTc prolongation in 32% of hypomagnesaemic patients, reflecting the combined effects of magnesium and calcium depletion. These observations emphasize that magnesium deficiency rarely occurs in isolation and that correction of potassium or calcium abnormalities may remain ineffective unless magnesium deficiency is simultaneously addressed.

Cardiovascular complications were also more common among patients with magnesium deficiency. Arrhythmias occurred in 33% of hypomagnesaemic patients compared with 14% among normomagnesaemic patients. Similar results were reported by Solanki et al., who observed arrhythmias in 42% versus 15%,[15] while Mecit and Orhan[18] reported increased arrhythmogenic risk at both low and high serum magnesium concentrations in patients with COVID-19. These findings highlight the important role of magnesium in maintaining myocardial electrical stability and preventing rhythm disturbances.

Sepsis was the predominant diagnosis among hypomagnesaemic patients, accounting for 56% of admissions, closely matching the findings of Gonuguntla et al. (54%)[8] and Zafar et al. (48%).[12] Vasopressor support was required in 61% of hypomagnesaemic patients compared with 30% of normomagnesaemic patients, consistent with observations by Solanki et al.[15] and Laupland et al.[17] Severe acute kidney injury (KDIGO stage 2 or 3) was also more frequent (22% vs. 10%), further supporting the association between magnesium deficiency and organ dysfunction in critically ill patients.

Hospital outcomes similarly reflected poorer prognosis in patients with hypomagnesaemia. Total hospital stay was significantly longer (15 ± 6 vs. 10 ± 4 days; $p<0.001$), comparable with Mousavi et al. (16.7 vs. 12.4 days)[10] and Singh et al.[14] Survival to hospital discharge was only 53%, closely resembling the findings of Gonuguntla et al. (48.7%),[8] Solanki et al. (53% survival; 47% mortality),[15] and Zafar et al. (25.5% survival).[12] In addition, 30-day readmission occurred in 14.8% of survivors with hypomagnesaemia compared with 7.5% of normomagnesaemic patients, similar to the higher ICU readmission rates reported by Mousavi et al. (18% vs. 9%).[10]

Finally, the present study demonstrated that 88% of patients with total serum magnesium levels below 1.6 mg/dL also had ionized hypomagnesaemia, supporting the clinical utility of routine total serum magnesium estimation. Laupland et al.[17] emphasized the need for paired ionized magnesium measurements, while Zafar et al.[12] suggested that reliance on total magnesium alone could underestimate deficiency in selected patients. Medication-induced magnesium loss was common in our study, with 58% of hypomagnesaemic patients receiving loop diuretics and 31% receiving aminoglycosides, findings comparable to Zafar et al., who reported magnesium-depleting medications in 76.5% of patients.[12]

The findings of the present study consistently demonstrate that admission hypomagnesaemia is highly prevalent and is associated with increased disease severity, prolonged ICU and hospital stay, greater need for mechanical ventilation and vasopressor support, higher incidence of electrolyte disturbances, arrhythmias, acute kidney injury, and significantly increased mortality. These observations, together with the consistent evidence from previous studies, support routine early assessment of serum magnesium and timely correction of magnesium deficiency as an integral component of critical care management.

Limitations

The present study has certain limitations. Being a single-centre observational study conducted in a tertiary ICU, its findings may have limited generalisability to other healthcare settings. Although multivariable analysis was performed, residual confounding cannot be completely excluded. Ionised magnesium levels were measured only in a subset of patients, and the lack of a standardised magnesium supplementation protocol may have influenced outcomes. In addition, the small number of hypermagnesaemic patients and the absence of long-term follow-up limited further subgroup and outcome analyses. Future multicentre, randomised controlled trials with serial assessment of total and ionised magnesium, standardised replacement protocols, mechanistic evaluation, and long-term clinical and economic outcomes are warranted to better define the role of magnesium in critically ill patients.

CONCLUSION

Magnesium emerged as an important determinant of outcome in our cohort of critically ill patients, with hypomagnesaemia present in 60% of ICU admissions and consistently associated with increased disease severity, prolonged ICU stay, greater need for mechanical ventilation and vasopressor support, higher incidence of electrolyte disturbances, arrhythmias, acute kidney injury, and significantly higher mortality (40% vs. 20%). Even after adjustment for confounding factors, hypomagnesaemia remained an independent predictor of in-hospital mortality. Furthermore, inclusion of serum magnesium modestly improved the prognostic performance of the APACHE II score, while routine serum magnesium measurements showed good agreement with ionised magnesium levels, supporting their clinical utility. Considering that magnesium replacement is inexpensive, safe, and readily available, early recognition and protocol-based correction of hypomagnesaemia may represent a simple yet effective strategy to improve outcomes in critically ill patients. Although larger multicentre trials are required to establish a causal benefit, our findings reinforce the importance of routine magnesium monitoring and timely supplementation as part of standard ICU care.

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