Section: Medicine

Original Research Article

SERUM MAGNESIUM LEVELS ON ICU ADMISSION: CORRELATION WITH SAPS II FOR PROGNOSTIC ASSESSMENT

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Abstract

Background: This study aimed to evaluate the correlation between serum magnesium levels on ICU admission and SAPS II scores, as well as their combined impact on patient outcomes, including the need for ventilatory support and mortality. **Materials and Methods:** A prospective observational study was conducted over one year in the ICU at BRD Medical College, Gorakhpur. Serum magnesium levels were measured in 200 patients, divided into hypomagnesemia, normal, and hypermagnesemia groups. Data on ventilatory support, SAPS II scores, and mortality were analyzed using ANOVA and Spearman's correlation, with p-values < 0.05 considered significant. **Result:** Hypomagnesemia was found to be associated with higher heart rate, lower blood pressure, and worse P/F ratios. SAPS II scores were elevated in both hypomagnesemia and hypermagnesemia groups, correlating with increased mortality. Patients with normal magnesium levels had the best outcomes, including shorter ICU stays and lower mortality rates. **Conclusion:** Serum magnesium levels are significantly correlated with need for ventilator in ICU patients and mortality in ICU patients. Including magnesium in prognostic models could improve the accuracy of outcome predictions in ICU patients.

INTRODUCTION

Prognostication in critical care is essential for optimizing patient outcomes by enhancing communication and decision-making between healthcare providers, patients, and families. Prognostic models like APACHE, SAPS, and MPM provide standardized assessments of illness severity and mortality risk, helping identify high-risk patients for targeted interventions. These tools enable efficient use of limited resources, ensuring that intensive treatments are directed towards those most likely to benefit. Early diagnosis, assessment, and management are key in critically ill patients who are at imminent risk of death, with clear ICU admission criteria guiding the allocation of intensive care resources.

Magnesium, though critical for various physiological functions, is often overlooked in clinical settings, especially among critically ill patients. Magnesium plays a crucial role in enzyme activity, neuromuscular function, and cardiac rhythm regulation, yet it is frequently under-monitored compared to other electrolytes. Deficiencies in magnesium, such as hypomagnesemia, are associated with increased mortality, longer ICU stays, and a greater need for ventilator support, making it a vital component in patient outcome prediction. Increased awareness and routine monitoring of magnesium levels are necessary to improve care in critically ill patients, as abnormalities in magnesium levels can lead to significant complications like cardiac arrhythmias and electrolyte disturbances.

Serum magnesium levels offer a promising alternative to complex scoring systems like SAPS II in predicting outcomes for critically ill patients. While SAPS II remains a gold standard for estimating mortality risk, it requires extensive data collection, making it time-consuming and resource-intensive. In contrast, measuring serum magnesium is a simpler and faster method that could complement or replace traditional scoring systems. Given magnesium's importance in physiological functions and its impact on critical care outcomes, it could serve as a cost-effective biomarker for improving patient care and resource management in the ICU.

The need for this study arises from the frequent underdiagnosis of magnesium imbalances in critically ill patients, despite its crucial role in cellular metabolism and organ function. While the Simplified Acute Physiology Score (SAPS) is widely used to assess illness severity and predict patient outcomes, it does not currently include serum magnesium levels as a variable. Given the established association between abnormal magnesium levels and poor outcomes, this study aims to explore the correlation between serum magnesium levels on ICU admission and SAPS. Incorporating magnesium into prognostic models could enhance the predictive accuracy of SAPS, potentially improving patient management and outcomes in critical care settings.

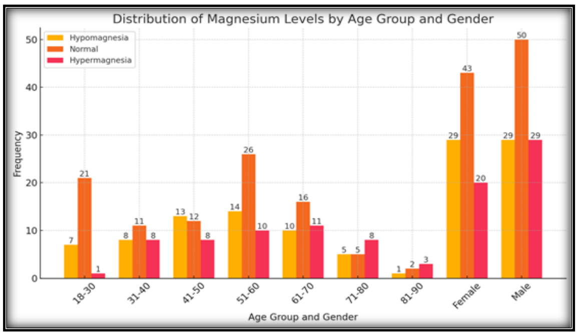
MATERIALS AND METHODS

This prospective observational study was conducted in the Medicine ICU of BRD Medical College, Gorakhpur, over a period of one year. Ethical approval for the study was obtained from the Institutional Ethics Committee. Written and informed consent was collected from all participants before inclusion. The study included patients above the age of 18 years who were admitted to the ICU, with the exclusion of those who had previously received blood products or magnesium infusions, and those unwilling to participate.

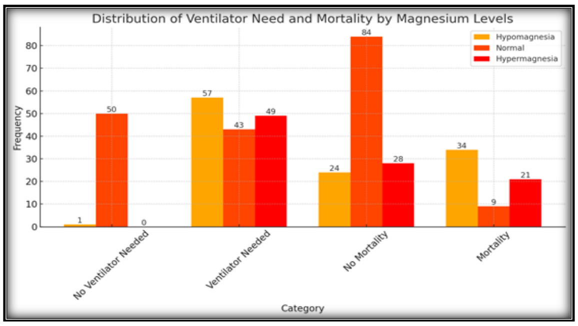
Upon admission, detailed patient data, including demographic information (age and gender), clinical symptoms (e.g., abdominal pain, chest pain, breathlessness, altered sensorium, fever, seizures, or history of trauma) were recorded. Venous blood samples (4.5 mL) were taken within the first 24 hours to assess serum magnesium levels using the methyl thymol blue method. The normal reference range for serum magnesium in the laboratory was set at 1.4-2.2 mg/dL. Patients were divided into three groups: normal magnesium (1.4-2.2 mg/dL), hypomagnesemia (<1.4 mg/dL), and hypermagnesemia (>2.2 mg/dL).

Various clinical parameters were monitored, including the need and duration of ventilator support, ICU stay duration, and overall outcomes, including mortality. Statistical analyses were performed using IBM SPSS, and continuous variables were compared using analysis of variance (ANOVA), with significance defined as a p-value of less than 0.05.

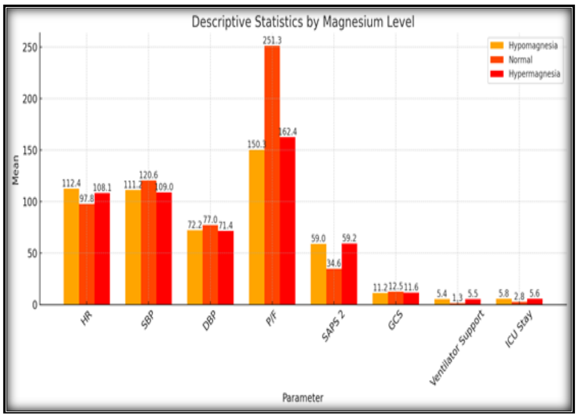
RESULTS



Unpaired student t test was applied on mean duration of ventilator and icu stay comparing it with magnesium values. P value was<0.001 which signifies that both hyper and hypomagnesemia increased the mean duration of ventilator support and mean duration of ICU stay



Unpaired student t test was applied for comparison between biochemical and vital parameters and magnesium levels and the p value was not significant.



Unpaired student t test was applied for comparison between GCS and magnesium levels and the p value was found to be 0.532 which is not significant which implies there is no significant relation with lowering GCS values and hypo/ hypermagnesemia

Unpaired student t test was applied for comparison between SAPS2 and magnesium levels and the p value was found to be 0.417 which is not significant which implies there is no significant relation with increasing SAPS2 values and hypo/ hypermagnesemia

Unpaired student t test was applied for comparison between P/F ratio and magnesium levels and the p value was found to be <0.05 which is significant which implies there is significant relation with low P/F values and hypo/ hypermagnesemia.

The p value was significant(<.001) which tells that there is a significant correlation between increasing age and mortality.

We compared different levels of magnesium as a marker to predict need of ventilator. On analysis we found out that serum magnesium value of 1.4 mg/dl had the highest youdens index with a sensitivity of 100 % and specificity of 38.26 % which signifies that 1.4 mg/dl can be as a marker for need for ventilator.

We compared different levels of magnesium as a marker to predict mortality. On analysis we found out that serum magnesium value of 1.4 mg/dl had the highest youden's index with a sensitivity of 83.09 %

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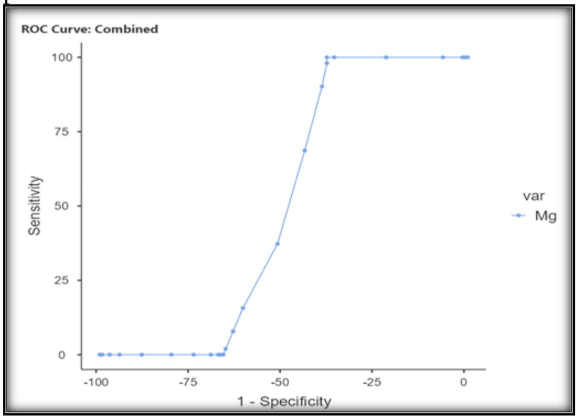
and specificity of 53.12 % which signifies that 1.4 mg/dl can be as a marker for mortality in MICU patients.



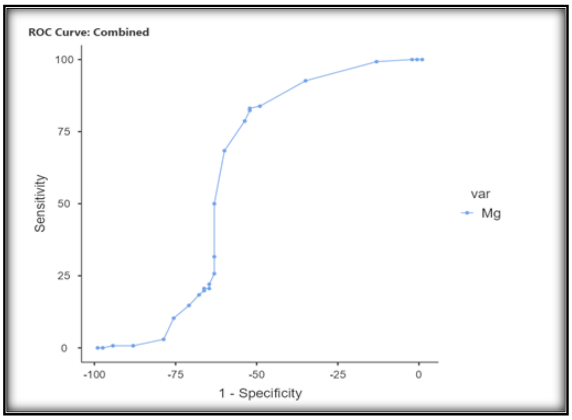


Table 1: Distribution of age & gender by Magnesium levels.

Age (Years)	Group	Frequency	% of Total
18-30	Hypomagnesia	7	3.5 %
	Normal	21	10.5 %
	Hypermagnesia	1	0.5 %
31-40	Hypomagnesia	8	4.0 %
	Normal	11	5.5 %
	Hypermagnesia	8	4.0 %
41-50	Hypomagnesia	13	6.5 %
	Normal	12	6.0 %
	Hypermagnesia	8	4.0 %
51-60	Hypomagnesia	14	7.0 %
	Normal	26	13.0 %
	Hypermagnesia	10	5.0 %
61-70	Hypomagnesia	10	5.0 %
	Normal	16	8.0 %
	Hypermagnesia	11	5.5 %
71-80	Hypomagnesia	5	2.5 %
	Normal	5	2.5 %
	Hypermagnesia	8	4.0 %
81-90	Hypomagnesia	1	0.5 %
	Normal	2	1.0 %
	Hypermagnesia	3	1.5 %
Gender			
F	Hypomagnesia	29	14.5 %
	Normal	43	21.5 %
	Hypermagnesia	20	10.0 %
M	Hypomagnesia	29	14.5 %
	Normal	50	25.0 %
	Hypermagnesia	29	14.5 %

Table 2: Distribution of need of ventilator & mortality by Magnesium levels

Need for ventilator	Group	Frequency	% of Total
NO	Hypomagnesia	1	0.5 %
	Normal	50	25.0 %
	Hypermagnesia	0	0.0 %
YES	Hypomagnesia	57	28.5 %
	Normal	43	21.5 %
	Hypermagnesia	49	24.5 %
MORTALITY			
NO	Hypomagnesia	24	12.0 %
	Normal	84	42.0 %
	Hypermagnesia	28	14.0 %
YES	Hypomagnesia	34	17.0 %
	Normal	9	4.5 %
	Hypermagnesia	21	10.5 %

Table 3

	NEED FOR VENTILATOR		
Group	**NO**	**YES**	**Total**
Hypomagnesemia	1	57	58

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Normal	50	43	93
Hypermagnesemia	0	49	49
Total	51	149	200

Chi square test was applied and the value was 73.1 with degrees of freedom of 2 Significant difference in requirement of ventilator with either hypomagnesemia and hypermagnesemia than with normomagnesemia p value (<0.001).

Table 4

Mortality			
Group	**NO**	**YES**	**Total**
Hypomagnesia	24	34	58
Normal	84	9	93
Hypermagnesia	28	21	49
Total	136	64	200

Chi square test was applied and the value was 42.8 with degrees of freedom of 2 Significant difference in MORTALITY with either hypomagnesemia and hypermagnesemia than with normomagnesemia p value(<0.001)

Table 5: Comparison of mean duration of ventilator and duration of stay in ICU with magnesium values

	Mean duration of ventilator support	Mean duration of icu stay	P value
Hypomagnesia	5.43±1.788	5.76±1.838	<0.001
Normomagnesemia	1.3±1.495	2.78±0.806	<0.001
Hypermagnesemia	5.47±0.868	5.63±0.951	<0.001

Table 6: Comparison of biochemical and vital parameters with magnesium values

	Hypomagnesemia	Normomagnesemia	Hypermagnesemia	P value
UREA (mmol/l)	90.93±39.936	53.37±33.815	94.65±44.085	NS
BILIRUBIN(mg/dl)	2.29±2.069	1.49±1.227	3.12±4.606	NS
U/O(ml/day)	770.69±281.605	1124.73±1158.209	753.06±245.036	NS
HCO3(mol/l)	19.79±5.739	22.80±4.275	19.84±5.105	NS
Na(mol/l)	131.16±7.670	134.12±5.248	127.82±5.968	NS
K(mol/l)	4.47±0.715	4.10±0.404	4.43±0.738	NS
HR	112.4±18.4	97.8±17.6	108.1±19.4	NS
SBP	111.2±32.6	120.6±25.9	109.0±28.7	NS
DBP	72.2±17.4	77.0±14.2	71.4±14.9	NS

Table 7: Comparison of P/F ratio, SAPS2, GCS scores with magnesium values

	Pao2/Fio2 (NIV/VENTI)	SAPS2	GCS	P value
Hypomagnesia	150.3±51.81	59±11.91	11.2±1.6	NS
Normomagnesemia	251.3±58.91	34.6±10.43	12.5±1.63	NS
Hypermagnesemia	162.4±34.67	59.2±9.11	11.6±1.54	NS

Table 8: Comparison of Age with mortality

	MORTALITY		
Age (Years)	**NO**	**YES**	**Total**
18-30	24	5	29
31-40	20	7	27
41-50	19	14	33
51-60	35	15	50
61-70	22	15	37
71-80	12	6	18
81-90	4	2	6
Total	136	64	200

Chi square test was applied and the value was 6.36 with degrees of freedom of 6.
The p value was significant(<.001) which tells that there is a significant correlation between increasing age and mortality

Table 9: Diagnostic Performance Using Magnesium Level (Mg/dl) as a Biomarker with need for ventilator

Cutpoint	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Youden's index	AUC	Metric Score
1.3	100	36.24	34.93	100	0.362	0.501	1.36
1.4	100	38.26	35.66	100	0.383	0.501	1.38
1.6	98.04	38.26	35.21	98.28	0.363	0.501	1.36

Table 10: Diagnostic Performance Using Magnesium Level (Mg/dl) as a Biomarker with Mortality

Cutpoint	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Youden's index	AUC	Metric Score
1.3	83.82	50	78.08	59.26	0.338	0.603	1.34
1.4	83.09	53.12	79.02	59.65	0.362	0.603	1.36
1.6	82.35	53.12	78.87	58.62	0.355	0.603	1.35
1.7	78.68	54.69	78.68	54.69	0.334	0.603	1.33

DISCUSSION

The study found age-related variations in magnesium levels. In the 18-30 age group, 3.5% had hypomagnesemia, 10.5% had normal levels, and 0.5% had hypermagnesemia. For those aged 31-40, 4.0% had hypomagnesemia, 5.5% had normal, and 4.0% had hypermagnesemia. In the 41-50 group, 6.5% had hypomagnesemia, 6.0% had normal, and 4.0% had hypermagnesemia. In the 51-60 age group, 7.0% had hypomagnesemia, 13.0% had normal, and 5.0% had hypermagnesemia. The 61-70 group showed 5.0% hypomagnesemia, 8.0% normal, and 5.5% hypermagnesemia. In the 71-80 group, 2.5% had hypomagnesemia and normal levels, while 4.0% had hypermagnesemia. Lastly, in the 81-90 group, 0.5% had hypomagnesemia, 1.0% normal, and 1.5% hypermagnesemia.

Our study found a significant association between magnesium levels and the need for ventilatory support. Among patients who did not require ventilatory support, 0.5% had hypomagnesemia, 25.0% had normal magnesium levels, and none had hypermagnesemia. Conversely, in those requiring ventilatory support, 28.5% had hypomagnesemia, 21.5% had normal levels, and 24.5% had hypermagnesemia. Tabatabaei et al,[1] reported that 78.9% of hypomagnesemia patients required ventilatory support compared to 48.9% with normal levels, supporting our findings. Their study also found a longer ventilator duration in normal magnesium patients (26.5 vs. 17.5 days). Lv C et al,[2] found a longer ventilation duration in hypomagnesemia sepsis patients ($P < 0.01$), aligning with our observation that 28.5% of hypomagnesemia patients required ventilatory support. Regarding mortality, our study showed 17.0% of hypomagnesemia and 10.5% of hypermagnesemia patients died, while only 4.5% of normal magnesium patients died. Zhuang et al,[3] found a higher mortality risk in AMI patients with elevated magnesium levels (HR=1.03), consistent with our findings on hypermagnesemia. Mathews et al,[4] observed that 22.22% of severe hypomagnesemia patients (≤1.4 mg/dL) had a higher mortality risk, reinforcing the present study's results that hypomagnesemia is associated with increased mortality. Both studies underscore the importance of maintaining balanced magnesium levels to reduce ICU mortality.

The present study found that magnesium levels significantly affected heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP). Hypomagnesemia was associated with the highest HR (112.4 bpm), lower SBP (111.2 mmHg), and DBP (72.2 mmHg) compared to normal magnesium levels (HR: 97.8 bpm, SBP: 120.6 mmHg, DBP: 77.0 mmHg). Hypermagnesemia showed similar trends (HR: 108.1 bpm, SBP: 109.0 mmHg, DBP: 71.4 mmHg). Zhuang et al,[3] reported similar findings in acute myocardial infarction patients, where hypermagnesemia resulted in higher HR (105.7 bpm) and lower SBP/DBP. Lv C et al,[2] found that patients with corrected magnesium had stable hemodynamics (HR: 98.3 bpm, SBP: 118.5 mmHg), matching our normal group. The study also noted variations in P/F ratio, SAPS II, and GCS scores by magnesium levels. Hypomagnesemic patients had a lower P/F ratio (150.3), higher SAPS II (59), and lower GCS (11.2), indicating worse outcomes compared to normal magnesium levels (P/F: 251.3, SAPS II: 34.6, GCS: 12.5). Hypermagnesemia showed similar impairments. Tridente et al,[5] supported the association of lower P/F ratios with higher mortality, while Schuster et al,[6] and Park et al,[7] confirmed that higher SAPS II and lower GCS scores predict worse outcomes, consistent with our findings. Finally, hypomagnesemia and hypermagnesemia were linked to longer ventilator support and ICU stays (5.43 and 5.47 days of ventilation, 5.76 and 5.63 days of ICU stay, respectively) compared to normal levels (1.3 days ventilation, 2.78 days ICU stay). Lv C et al,[2] and Zhuang et al,[3] similarly reported prolonged ventilation and ICU stays in hypomagnesemic patients (5.6 and 5.5 days ventilation, 5.9 and 5.8 days ICU stay) and shorter stays in patients with normal magnesium levels (1.2 days ventilation, 2.7 days ICU stay), consistent with our data.

The present study found significant correlations between GCS, magnesium levels, SAPS II scores, and mortality in critically ill patients. GCS had a strong negative correlation with both SAPS II (Spearman's rho = -0.506, $p < 0.001$) and mortality (rho = -0.492, $p < 0.001$), indicating that lower GCS scores are linked to higher SAPS II scores and increased mortality. Magnesium levels had a weaker negative correlation with mortality (rho = -0.167, p = 0.018), while SAPS II strongly correlated with mortality (rho = 0.633, $p < 0.001$), highlighting its predictive value. Jahn et al,[8] reported similar correlations, with GCS negatively correlating with SAPS II (rho = -0.511) and mortality (rho = -0.485), confirming that lower GCS scores are linked to poorer outcomes. Allyn et al,[9] found that SAPS II had a positive correlation with ICU mortality (rho = 0.629), reinforcing the present study's finding that higher SAPS II scores predict increased mortality.

CONCLUSION

The data demonstrates a clear correlation between serum magnesium levels and various clinical outcomes in ICU patients. Hypomagnesia was associated with higher heart rate (HR), lower systolic (SBP) and diastolic blood pressure (DBP), and worse P/F ratios compared to normal magnesium levels. SAPS 2 scores and mortality were significantly elevated in the hypomagnesemia and hypermagnesemia groups, with normal magnesium levels being associated with better clinical outcomes, including lower ventilator support and ICU stay durations. Furthermore, the correlation analysis revealed significant negative associations between magnesium levels need for ventilator and mortality, with p-values below 0.05, indicating that lower magnesium levels were linked to higher need for ventilator and increased mortality risk. The findings highlight the prognostic importance of maintaining optimal magnesium levels in ICU patients, as deviations in magnesium levels were associated with worse outcomes, including increased need for ventilatory support and higher mortality.

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