Research Journal of Medical Sciences

Research Article
doi: 10.36478/makrjms.2024.8.508.513

OPEN ACCESS

Key Words
Staghorn calculus, perinephric abscess, Idiopathic intracranial hypertension, UTI, Corticosteroids

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Received: 20 June 2024
Accepted: 27 July 2024
Published: 31 July 2024

Citation: Kundavaram Shikara Reddy, L. Karthick, P.E. Dhananjaya, M.A. Uma, Kandula Venkata Sai Raghavendra and Mulgapaka Vinusha, 2024. A Study of Correlation of Serum Magnesium Levels with Prognosis in Patient with Acute Kidney Injury in A Tertiary Care Hospital. Res. J. Med. Sci., 18: 508-513, doi: 10.36478/makrjms.2024.8.508.513

A Study of Correlation of Serum Magnesium Levels with Prognosis in Patient with Acute Kidney Injury in A Tertiary Care Hospital

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Abstract
The study assessed the frequency of magnesium (Mg) imbalances among patients admitted to a multidisciplinary intensive care unit (ICU) and demonstrated a correlation between serum magnesium concentrations and clinical results. A 24-month observational study was conducted on patients with acute kidney injury in tertiary care from January 2021 to June 2022. The study involved purposive sampling and data collection from patients at PES Hospital in Kuppam. Participants included patients with comorbidities like diabetes, hypertension and drug abuse history. The study analysed blood samples to understand the relationship between serum magnesium levels and recovery status, using statistical analysis Pearson correlation and chi-square test, to provide insights into kidney injury impact. The relationship between serum magnesium levels and recovery status in patients with kidney injury was the majority of participants were aged 25-45 years, with a gender distribution of 72.3% males and 27.7% females. Serum creatinine levels were highest at day 1 and lowest at day 6. A weak correlation between serum creatinine and magnesium levels on day 1, but a significant association was found between magnesium levels at day 1 and recovery. The study also showed a significant association between magnesium levels and recovery status, with 70.8% of patients recovering and 58.3% not recovering. According to the study, hypomagnesemia was more prevalent in AKI patients and higher magnesium levels on days 1, 3 and 6 were associated with enhanced recovery. More research is required to ascertain the advantages of blood magnesium infusion and monitoring for AKI patients, as hypomagnesemia is a poor predictor of recovery.

INTRODUCTION

Acute kidney injury (AKI) is a syndrome characterized by rapid increase in serum creatinine, decreased urine output, or both. It is prevalent in 10-15% of hospitalized patients, with a higher prevalence in critically ill patients due to poor nutrition, low blood pressure, sepsis and diuretic usage. AKI can occur over a longer period or follow AKI in a continuum with acute and chronic kidney disease[1,2]. It is crucial to accurately identify AKI and understand the pathophysiologic mechanisms behind its diverse clinical presentations. Serum magnesium levels are often overlooked in recovering AKI cases, as they can cause electrolyte imbalances and decrease glomerular filtration rate and renal blood flow. Biomarkers like interleukin-18 and serum neutrophil gelatinase-associated lipocalin have shown good diagnostic accuracy, but they are expensive and not readily available. Serum creatinine is a reasonable predictor of AKI and measuring severity can help classify patients in risk categories and prevent life-threatening events like stroke and AKI[3,4,5].

Electrolyte disturbances are common in critically ill patients admitted to intensive care units (ICU) and are linked to increased mortality and morbidity. Magnesium, the second-highest intracellular cation concentration, plays a crucial role in physiological and biochemical processes, including enzyme and transport systems, cardiac and smooth muscle tone regulation, and immune function modulation[6,7]. It is not exchanged across cell membranes or under hormonal regulation, making serum magnesium the main determinant of magnesium balance. Magnesium is often overlooked in diagnosis, clinical implications and treatment[8,9].

Abnormalities of magnesium occur in 65% of critically ill patients in the ICU. Hypomagnesemia, caused by inadequate dietary magnesium intake and gastrointestinal and renal disorders, correlates with increased morbidity and mortality in hospitalized patients. It also correlates with prolonged ICU stay, increased mechanical ventilation and increased incidence of sepsis and other electrolyte disturbances. Hypermagnesemia, on the other hand, occurs less frequently and is seen in 5% of hospitalized patients[10,11,12].

Our study aimed to estimate the incidence of hypomagnesemia and hypermagnesemia in critically ill patients admitted to a multidisciplinary ICU and correlate serum magnesium levels with mortality. The secondary objective was to correlate serum magnesium levels with length of ICU stay, mechanical ventilation, other electrolyte abnormalities and comorbid conditions in critically ill patients.

MATERIALS AND METHODS

The study was a hospital-based observational study conducted from January 2021-June 2022, focusing on patients with acute kidney injury in tertiary care. The study involved 101 participants, selected purposively and involving demographic data, clinical features and associated comorbidities such as diabetes mellitus, hypertension and drug abuse history. Blood samples were collected to measure CBC, serum electrolyte, renal function test, urine routine, and serum magnesium levels on the 0th, 3rd and 6th day of discharge.

We focused on variables including independent variables such as age, gender, haemoglobin, total leukocyte count and dependent variables such as mean serum magnesium level, correlation between serum magnesium and serum creatinine, and recovery status of patients. Ethical considerations were taken into account, with informed consent obtained from participants before data collection and the freedom to withdraw from the study at any time during the interview. The study's ethical considerations included seeking approval from the research Monitoring committee and Institutional Ethics Committee (IEC), obtaining informed consent from participants and explaining the purpose of the study[13,14,15].

Statistical Analysis: Data was entered into MS Excel 2010. Data cleaning was carried out and statistical analysis was carried out using SPSS software version 20.0. Continuous variables following normal distribution such as serum creatinine, serum magnesium, hemoglobin and total leukocyte count were presented as mean (standard deviation). Categorical variables such as gender, recovery status, and age category were presented as frequency and percentage. Data were also tabulated and graphically represented. 23 Pearson correlation was performed between serum magnesium and serum creatinine on days 1st, 3rd and 6th. Association between serum magnesium level (on days 1st, 3rd and 6th) and recovery status was done using the chi-squared test.

RESULTS AND DISCUSSIONS

The study involved a total of 73 participants, with a majority aged 25-45 years. The gender distribution was 72.3 males and 27.7% females. The mean serum creatinine levels were highest at day 1 (4.7.6) mg/dL, and lowest at day 6 (3.3.3) mg/dL. The mean difference in serum creatinine levels at baseline and day 6 was statistically significant. The mean level of serum magnesium was highest at day 6 (1.9.5) mg/dL and the mean difference in serum magnesium levels at day 1 and day 6 was statistically significant.

Table 1: Age distribution of participants (N=101)

Age Groups (in year)	Frequency	Percentage(%)
<25	6 5.9	
25-45	39 38.6	
40-60	35 34.7	
>60	21 20.8	
Total	101	100

Table 2: Gender distribution of participants (N=101)

Gender	Frequency	Percentage(%)
Male	73 72.3	
Female	28 27.7	
Total	101	100

Table 3: Serum Creatinine distribution among participants (N=101)

Serum Creatinine (mg/dl)	Mean	SD	p-value
Baseline	4.4	2.6	-
Day 1	4.7	2.6	<0.001
Day 2	4.4	3.0	0.83
Day 6	3.9	3.3	0.05

Table 4. Serum Magnesium distribution among participants (N=101)

Serum Magnesium (mg/dl)	Mean	SD	p-value
Day 1	1.8	0.6	-
Day 3	1.8	0.5	0.39
Day 6	1.9	0.5	0.01

Table 5: Haemoglobin and Total leukocyte count distribution among participants (N=101)

Parameters	Mean	SD
Haemoglobin (g/dl)	13.1	2.0
Total leukocyte count (/ml)	14.6	5.8

Table 6. Recovery status of participants (N=101)

Recovery status	Frequency	Percentage(%)
Yes	65	64.4
No	36	35.6
Total	101	100

Table 7: Correlation between Serum Creatinine and Serum Magnesium on Day 1

		Serum Mangesium
Serum Creatinine (on day 1)	Pearson Correlation	0.01
	P value	0.31
	N	101

Correlation is non-significant (p value=0.31)

Table 8: Correlation between Serum Creatinine and Serum Magnesium on Day 3

		Serum Mangesium
Serum Creatinine (on day 3)	Pearson Correlation	0.14
	P value	0.17
	N	101

Correlation is non-significant (p value=0.17)

Table 9: Correlation between Serum Creatinine and Serum Magnesium on Day 6

		Serum Mangesium
Serum Creatinine (on day 6)	Pearson Correlation	0.02
	P value	0.88
	N	101

Correlation is non-significant (p value=0.88)

Table 10: Association between Magnesium Levels at Day 1 and Recovery Level

Magnesium levels (Day 1)	Recovery		
	Yes N(%)	NoN (%)	p-value
Hypomagnesaemia	21(32.3)	12(33.3)	
Normal	42(64.6)	17(47.2)	0.02
Hypomagnesaemia	2(3.1)	7(19.4)	
Total	65(100)	36(100)	

Chi squared test was used

Table11. Association between Magnesium Levels at Day 3 and Recovery Level

Magnesium levels (Day 3)	Recovery		
	Yes N(%)	No +N (%)	p-value
Hypomagnesaemia	18(28.7)	11(30.6)	
Normal	46(70.8)	21(58.3)	0.09
Hypomagnesaemia	1(1.5)	4(11.1)	
Total	65(100)	36(100)	

Chi squared test was used

Table 12: Association between Magnesium Levels at Day 6 and Recovery Level

Magnesium levels (Day 6)	Recovery		
	Yes N(%)	NoN (%)	p-value
Hypomagnesaemia	17(25.7)	9(25.0)	
Normal	45(69.2)	27(75.0)	0.41
Hypomagnesaemia	3(4.6)	0(0.0)	
Total	65(100)	36(100)	

Chi squared test was used

Table 13. Serum Magnesium levels among recovered and not-recovered patients from Acute Kidney Injury

	Magnesium levels	Mean	SD	p-value
	Day 1	1.7	0.4	
Recovered	Day 3	1.8	0.5	<0.001
	Day 6	2.0	0.6	
	Day 1	1.9	0.8	
Not-Recovered	Day 3	1.8	0.5	<0.001
	Day 6	1.8	0.4	

Repeated ANOVA test was used

The recovery status of the participants was 64.4% (65 patients) and 35.6% (36 patients) did not recover. The Pearson correlation coefficient was 0.10 and the association between serum creatinine and serum magnesium on day 1 was not statistically significant. The association between magnesium levels at day 1 and recovery level was statistically significant, with 64.6% of patients who recovered having normal levels of magnesium. The association between magnesium levels at day 3 and recovery level was not statistically significant.

Among the recovered patients, the mean levels of magnesium were highest at day 6 (2.0 (0.6) mg/dL) and lowest at day 1 (1.7 (0.4) mg/dL). The mean levels of magnesium were highest at day 1 (1.9 (0.8) mg/dL) and lowest at day 3 and day 6 (1.7 (0.4) mg/dL).

A 24-month observational study was conducted on patients with acute kidney injury in a tertiary care centre from January 2021-June 2022. The study involved purposive sampling and data collection from patients with comorbidities like diabetes, hypertension and drug abuse history. The study analyzed blood samples to understand the relationship between serum magnesium levels and recovery status using statistical analysis Pearson correlation and chi-squared test. The majority of participants were aged 25-45 years, with a gender distribution of 72.3% males and 27.7% females. Serum creatinine levels were highest at day 1 and lowest at day 6, while magnesium levels were highest at day 6 and lowest at day 1. A weak correlation was found between serum creatinine and magnesium levels on day 1, but a significant association was found between magnesium levels on day 1 and recovery. The study concluded that hypomagnesemia is more prevalent in AKI patients, and higher magnesium levels on days 1, 3 and 6 are associated with enhanced recovery. More research is needed to determine the advantages of blood magnesium infusion and monitoring for AKI patients.
A similar study was conducted by Vineesha Gonuguntla *et al.,* the study investigated the incidence of magnesium disturbances in critically ill patients admitted to a multidisciplinary intensive care unit (ICU). The results showed a high incidence of magnesium disturbances, with both hypomagnesemia and hypermagnesemia. Hypomagnesemia was associated with higher mortality rates (51.3%) compared to normomagnesemia (29.3%) and hypermagnesemia (23.1%). The need for mechanical ventilation was also higher in hypomagnesemia patients. The association of baseline APACHE II and SOFA scores with serum magnesium levels was statistically significant. The incidence of gastrointestinal disorders was higher in hypomagnesemic patients, while chronic kidney disease was higher in hypermagnesemic patients. Electrolyte disorders were associated with hypokalemia and hypocalcemia, while hyperkalemia and hypercalcemia were associated with hypermagnesemia. The study underscored the importance of magnesium monitoring in critically ill patients and its value for favorable outcomes[16].

Acute kidney injury (AKI) is a common issue with electrolyte disturbances, including hypomagnesemia, which is a common issue in critically ill patients. Raveendra K. R *et al.,* conducted a study between November 2016 and August 2018-evaluate the correlation between serum magnesium levels and AKI. The study included 100 patients aged 18-65 years with AKI, excluding those with diabetes mellitus, multi-organ dysfunction, obstructive uropathy and drug- induced AKI. The results showed a significant prevalence of hypomagnesemia, with 53%, 30% and 36% observed on day 1, day 3 and day 6, respectively. Normal magnesium and hypermagnesemia on days 1, 3 and 6 were associated with recovery, while hypomagnesemia was more associated with non-recovery[17].

A study conducted by Daoqi Shen *et al.,* investigated the correlation between serum magnesium levels and the incidence of acute kidney injury (AKI) in patients with malignancy. The study involved 99,845 patients, with 16,082 divided into three groups based on admission serum Mg levels. Out of these, 2383 (14.8%) cases were diagnosed as AKI. The incidence of AKI showed a V trend with an increase in serum Mg levels. Low serum Mg levels had a greater effect on AKI onset than high levels. Patients with low serum Mg levels spent longer in the hospital. A multivariate logistic regression model was used to assess the importance of serum Mg level in influencing AKI incidence. Results showed a higher AKI incidence in patients with magnesium levels of 0.66mmol/L or less. The study concluded that low serum Mg levels may be an independent risk factor for AKI in patients with malignancy[18].

A study by Jivabhai Solanki *et al.,* aimed to investigate the correlation between serum magnesium levels in critically ill patients admitted to the intensive care unit (ICU) and their mortality rates. The study included 246 patients with Acute Physiology and Chronic Health Evaluation (APACHE) II scores>10 and measured their total magnesium levels at the time of admission. The primary outcome measure was ICU mortality, while secondary outcomes included the patient's need and duration for ventilator support, duration of ICU stay and incidence of cardiac arrhythmias. The results showed that patients with hypomagnesemia had a significantly higher incidence of ICU mortality compared to those with normal magnesium levels. Hypomagnesemia was an independent and statistically significant determinant of ICU mortality[19].

Herein, we found that AKI patients had significantly higher rates of hypomagnesemia, and high and normal magnesium levels on days 1, 3 and 6 were associated with greater recovery than non-recovery. The non-recovery group was more likely to have hypomagnesemia than the recovery group. In comparison to AKI patients with normal and hypomagnesemia, those with hypomagnesemia on days 1, 3 and 6 recovered more slowly and spent longer in the hospital. Thus, hypomagnesemia may be considered a poor predictor of outcome for those with AKI.

CONCLUSION

In our study, AKI patients had significantly higher rates of hypomagnesemia and high and normal magnesium levels on days 1, 3 and 6 were associated with greater recovery than non-recovery. The non-recovery group was more likely to have hypomagnesemia than the recovery group. In comparison to AKI patients with normal and hypomagnesemia, those with hypomagnesemia on days 1, 3 and 6 recovered more slowly and spent longer in the hospital. As a result, hypomagnesemia may be considered a poor predictor of outcome for those with AKI. The results of this study highlight the need for a thorough investigation to determine whether blood magnesium monitoring and infusion are beneficial for AKI patients as well as the connection between magnesium levels and AKI recovery.

The study has strengths such as a strict data collection techniques and the use of statistical packages like SPSS for analysis. However, limitations include inadequate sample size, potential sampling bias due to a single hospital and a lack of correlation between serum magnesium and creatinine levels.

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