Original Article

Serum Magnesium Level in Different Stages of Chronic Kidney Disease Patients in a Tertiary Care Hospital

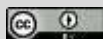**Md Rokib Sadi[1]*** ⓘ **, Md Anwarul Amin[2], Md Hasan Ali[3], Dihan Tahite[4], Md Khalilur Rahman[5]**

ABSTRACT

Introduction: *Chronic Kidney Disease (CKD) is a growing global health concern with complex metabolic implications, including alterations in serum magnesium levels. This study aims to explore the relationship between serum magnesium levels and different stages of CKD, as well as the impact of the duration of illness on this relationship.* ***Methods & materials:*** *This cross-sectional study was conducted on 220 patients admitted to the Department of Nephrology and Medicine, Rajshahi Medical College Hospital, Rajshahi, Bangladesh. Data were collected on demographic variables, CKD stages, and biochemical parameters, including serum magnesium levels. The duration of illness was also recorded and analyzed.* ***Result:*** *The mean age of the study population was 52.89±10.42 years, with a male predominance (63.6%). A high prevalence of advanced CKD stages was observed, with 67.28% of participants in either Stage 4 or Stage 5. A significant negative correlation was found between serum magnesium levels and estimated Glomerular Filtration Rate (eGFR) (r=-0.735, p<0.01). Additionally, a positive association was identified between the duration of illness (12 to 36 months in*

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65.45% of participants) and advanced CKD stages. **Conclusion:** *The study reveals a complex interplay between serum magnesium levels, eGFR, and the duration of illness in CKD patients. The high prevalence of advanced CKD stages and its association with longer duration of illness underscore the need for timely diagnosis and effective early intervention strategies. Monitoring serum magnesium levels could be instrumental in the comprehensive management of CKD patients.*

Keywords: *Chronic, Kidney, Renal, GFR, eGFR*

INTRODUCTION

Chronic Kidney Disease (CKD) is a global public health crisis, affecting approximately 10% of the world's population and up to 17.3% of adults in Bangladesh [1,2]. Defined by abnormalities in kidney structure or function present for more than three months, CKD is diagnosed based on markers of kidney damage and/or a Glomerular Filtration Rate (GFR) of less than 60 mL/min/1.73m [2,3,4].The disease is staged from 1 to 5 based on GFR, albuminuria, and the underlying cause [5]. The mortality rate in CKD is alarmingly high, primarily due to cardiovascular complications, which are intricately linked to mineral imbalances, including magnesium (Mg) [1,6]. Magnesium, the fourth most abundant cation in the body, plays a pivotal role in over 300 intracellular reactions, including energy production and calcium regulation [7,8]. Normal serum magnesium levels range between 1.5-2.3 mg/dl, with levels above or below this range defined as hypermagnesemia and hypomagnesemia, respectively [9]. The kidney's role in regulating these ions becomes compromised in CKD, leading to a cascade of clinical complications ranging from arrhythmias to seizures [7,10]. In CKD, the kidney's ability to excrete magnesium deteriorates as renal function declines. While compensatory mechanisms maintain magnesium levels within the normal range in the early stages of CKD, these become inadequate in advanced stages, leading to elevated serum magnesium levels [7,11]. Despite its physiological importance, the clinical relevance of magnesium in CKD is often underestimated, especially in the context of Bangladesh [12]. This study aims to fill this significant gap by assessing serum magnesium levels in different stages of CKD patients in a tertiary care hospital in Bangladesh. The rationale for this study is further strengthened by the lack of comprehensive data on CKD in lower and middle-income countries, particularly in the South Asian context [2]. Given the subtle signs and symptoms of magnesium imbalances and the absence of universal diagnostic facilities for estimating serum magnesium, there is an urgent need for studies in this area. This study, therefore, not only contributes to the existing body of knowledge but also has the potential to inform clinical practice and public health policies aimed at managing CKD and its complications. The study will also explore the role of magnesium in the body, factors that alter its renal regulation, and its levels in different stages of CKD patients, as supported by previous studies [6,7,13–17]. By focusing on the serum magnesium levels across different stages of CKD, this study aims to provide a comprehensive understanding that could be pivotal for future research and clinical practices.

METHODS & MATERIALS

This cross-sectional descriptive analysis was conducted from July 2019 to June 2020 at the Nephrology and Medicine Department, Rajshahi Medical College Hospital, Rajshahi, Bangladesh. The study population consisted of adult CKD patients of both sexes who met specific inclusion and exclusion criteria. Patients with CKD complicated by chronic diarrhea, pancreatitis, or those on magnesium-containing drugs were excluded, as were those who didn't give consent or were on maintenance dialysis. A sample size of 220 was calculated based on a 17.3% prevalence of CKD in Bangladesh, using a 5% level of significance. Purposive sampling was employed to select participants. Data were collected through semi-structured questionnaires, physical exams, and informed written consent forms in both Bangla and English. Venous blood samples were analyzed for serum magnesium levels using ELISA, with a reference range of 1.5-2.3 mg/dl for adult males and females. Data were processed and analyzed using SPSS Version 22, employing both descriptive and inferential statistics. Statistical significance was set at a p-value of less than 0.05. Ethical clearance was obtained from the relevant committees, and all ethical considerations, including informed consent and confidentiality, were meticulously observed.

RESULTS

The age distribution was as follows: 3.18% were aged 18 to 30 years, 13.64% were between 31 and 40 years, 16.36% were between 41 and 50 years, 34.09% were between 51 and 60 years, and 32.73% were above 60 years. The mean age was 52.89 years with a standard deviation of 10.42, and the age range was between 28 and 56 years. In terms of gender, 63.64% were male and 36.36% were female. Body Mass Index (BMI) showed that 1.82% was underweight, 70.00% had normal weight, 21.82% were overweight, 3.64% were obese, and 2.73% were morbidly obese. The mean BMI was 24.08 with a standard deviation of 2.78. Regarding occupation, 10.45% were service holders, 8.18% were involved in business, 44.09% were unemployed, 15.00% were day laborers, and 22.27% were housewives **[Table-I]**.

Table I: Baseline Characteristics distribution of the participants (N=220)

Baseline Characteristics	Frequency	Percentage
Age Group		
18 to 30 years	7	3.18%
31 to 40 years	30	13.64%
41 to 50 years	36	16.36%
51 to 60 years	75	34.09%
More than 60 years	72	32.73%
Mean±SD	52.89±10.42	
Range	28-56 years	
Gender		
Male	140	63.64%

| Female	80	36.36%
BMI		
Underweight	4	1.82%
Normal weight	154	70.00%
Over weight	48	21.82%
Obese	8	3.64%
Morbidly obese	6	2.73%
Mean±SD	24.08±2.78	
Occupation		
Service holder	23	10.45%
Business	18	8.18%
Unemployed	97	44.09%
Day laborer	33	15.00%
Housewife	49	22.27%

Stage 1 (GFR≥90) accounted for 3.64% of the participants, Stage 2 (GFR 60-89) comprised 9.55%, Stage 3 (GFR 30-59) made up 19.55%, Stage 4 (GFR 15-29) constituted 32.73%, and Stage 5 (ESRF) represented 34.55%. The data indicates a higher prevalence of advanced stages of CKD, with Stage 4 and Stage 5 collectively accounting for 67.28% of the study population **[Table-II]**.

Table II: Distribution of participants by stages of CKD (N=220)

Stages of CKD	Frequency	Percentage
Stage 1 (GFR≥90)	8	3.64%
Stage 2 (GFR 60-89)	21	9.55%
Stage 3 (GFR 30-59)	43	19.55%
Stage 4 (GFR 15-29)	72	32.73%
Stage 5 (ESRF)	76	34.55%

Hypomagnesemia was observed in 6.82% of the participants, normal serum magnesium levels were found in 25.91%, and hypermagnesemia was prevalent in a significant 67.27% of the study population **[Figure 1]**.
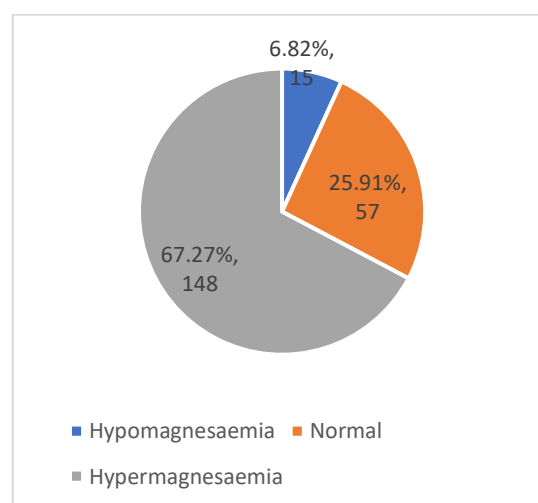
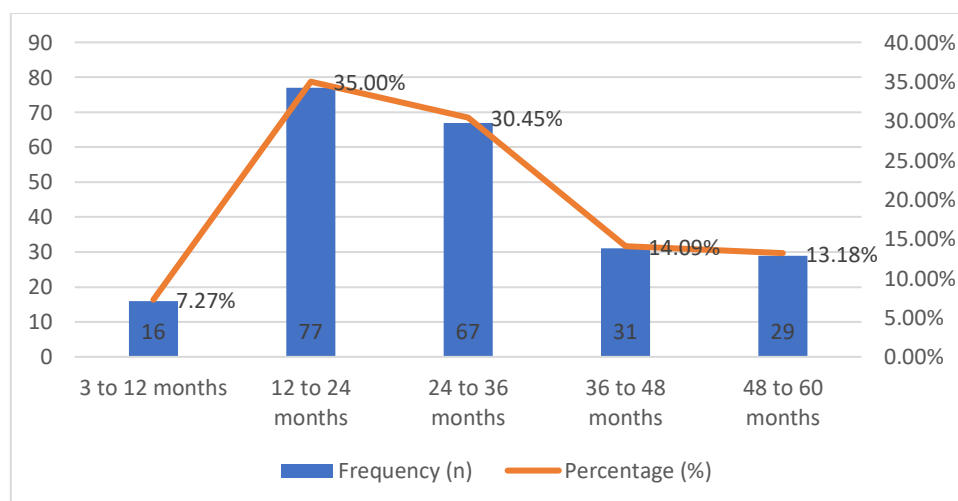**Figure 1: Distribution of participants by serum magnesium level (N=220)**

In Stage 1, the mean serum magnesium level was 1.56 with a standard deviation of

0.47. For Stage 2, the mean was 1.55 with a standard deviation of 0.58. In Stage 3, the mean serum magnesium level increased to 1.74 with a standard deviation of 0.52. A more pronounced increase was observed in Stage 4, with a mean of 2.76 and a standard deviation of 0.42. Finally, in Stage 5, the mean serum magnesium level was 2.84 with a standard deviation of 0.34. The mean serum magnesium levels varied significantly across different stages of CKD among the 220 participants, with a P value of less than 0.01 indicating statistical significance **[Table-III]**.

Table III: Distribution of the respondents according to mean serum magnesium value in different stages of CKD patient (N=220)

Stage of CKD	Serum magnesium (Mean±SD)	P value*
Stage 1	1.56+0.47	
Stage 2	1.55+0.58	
Stage 3	1.74+0.52	**<0.01**
Stage 4	2.76+0.42	
Stage 5	2.84+0.34	

In terms of illness duration, 7.27% had been diagnosed for a period of 3 to 12 months, 35.00% for 12 to 24 months, 30.45% for 24 to 36 months, 14.09% for 36 to 48 months, and 13.18% for 48 to 60 months. The data indicates that a majority of the participants (65.45%) had been living with the illness for a duration ranging from 12 to 36 months **[Figure 2]**.

Figure 2: Distribution of the respondents according to Duration of illness (N=220)

Among the 220 participants, mean ± SD Serum Magnesium levels were 2.43±0.69 mg/dl, Serum Sodium levels were 140.92±2.86 MEq/L, and Serum Potassium levels were 5.2±0.52 MEq/L. Calcium levels averaged at 9.07±0.97 mg/dl, Urea levels were 114.25±3.74 mg/dl, Phosphorus levels were 5.03±0.70 mg/dl, Creatinine levels were 9.76±4.11, and Hemoglobin levels were 9.27±1.40.

These values provide a comprehensive overview of the biochemical profile of the study population, highlighting not only the elevated serum magnesium levels but also other key parameters that are critical in the management and understanding of CKD **[Table-IV]**.

Table IV: Distribution of the respondents according to laboratory Investigation (N=220)

Investigation	Mean±SD
Serum Magnesium (mg/dl)	2.43±0.69
Serum Sodium (MEq/L)	140.92±2.86
Serum Potassium (MEq/L)	5.2±0.52
Calcium (mg/dl)	9.07±0.97
Urea (mg/dl)	114.25±3.74
Phosphorus (mg/dl)	5.03±0.70
Creatinine	9.76±4.11
Hemoglobin	9.27±1.40

The comparison of serum magnesium levels across different stages of CKD among the 220 participants revealed statistically significant differences, with a P value of less than 0.01. In Stage 1, 12.5% had hypermagnesemia, 62.5% had normal levels, and 25.0% had hypomagnesemia. In Stage 2, the frequencies were 4.76%, 57.14%, and 38.1% for hypermagnesemia, normal levels, and hypomagnesemia, respectively. Stage 3 showed 4.65% with hypermagnesemia, a notable 83.72% with normal levels, and 11.63% with hypomagnesemia. In contrast, Stage 4 had a striking 95.83% with hypermagnesemia and only 4.16% with normal levels. Stage 5 was even more skewed, with 98.68% having hypermagnesemia and a mere 1.31% with normal levels **[Table-V]**.

Table V: Comparison of serum magnesium level in different stages of CKD (N=220)

Stages of CKD	Hyper magnesium >2.3 mg/dl	Normal	Hypo magnesium <1.5 mg/dl	P value
	Frequency (%)	Frequency (%)	Frequency (%)	
Stage 1	1 (12.5)	5 (62.5)	2 (25.0)	*<0.01
Stage 2	1 (4.76)	12 (57.14)	8 (38.1)	
Stage 3	2 (4.65)	36 (83.72)	5 (11.63)	
Stage 4	69 (95.83)	3 (4.16)	-	
Stage 5	75 (98.68)	1 (1.31)	-	

The correlation between serum magnesium levels and estimated Glomerular Filtration Rate (eGFR) in the 220 CKD patients was found to be -0.735, with a statistically significant P value of less than 0.01 **[Table-VI]**.

Table VI: Correlation of serum magnesium level with eGFR of CKD patients (N=220)

Association	Correlation co efficient	*P value
Serum Mg level vs eGFR of CKD patients	-0.735	*<0.01

DISCUSSION

In the realm of chronic kidney disease (CKD), the role of magnesium (Mg) as the second most abundant intracellular cation cannot be overstated [18]. Our study, conducted on 220 patients admitted to the Nephrology and Medicine Department of Rajshahi Medical College Hospital, Rajshahi, offers a nuanced understanding of this relationship, particularly as it

pertains to different stages of CKD. The age distribution of our study population closely mirrors that of previous research, with a mean age of 52.89±10.42 years [7]. This demographic skew toward older age groups, particularly those above 50 years, could be indicative of the age-dependent progression of CKD, a factor that warrants further exploration. Gender distribution also aligns with earlier studies, showing a male predominance (63.6%), a recurring theme in CKD research [2]. One of the most striking findings is the high prevalence of advanced CKD stages in our study population, with a staggering 67.28% of participants in either Stage 4 or Stage 5. This prevalence is further contextualized by the duration of illness observed in our study, which shows that the majority of these participants (65.45%) had been diagnosed with CKD for a duration ranging from 12 to 36 months. Furthermore, a notable subset (13.18%) had been living with CKD for over two years. This data suggests a positive association between the duration of illness and the severity of CKD stages, aligning with the high prevalence of advanced CKD stages in our study. This finding is in stark contrast to the study by Fatema et al., where no subjects were found in these advanced stages [19]. This discrepancy might be explained by the strong correlation between longer duration of illness and advanced CKD stages which was observed in our study, and not in the study if Fatema et al. This finding raises critical questions about the timing of diagnosis and the effectiveness of early intervention strategies in the population we studied. Moreover, the duration of illness showed a positive correlation with serum magnesium levels, corroborating findings by Vastrad that suggest Mg levels depend on both the duration and stage of the disease [20]. This temporal relationship between disease duration and Mg levels could have implications for long-term patient management and should be a focal point for future research. When it comes to serum magnesium levels, our study reveals intricate dynamics across different CKD stages. While compensatory mechanisms generally regulate Mg levels within the normal range in early CKD stages, these mechanisms falter as the disease progresses, leading to hypermagnesemia [7,11]. Intriguingly, a few outliers in advanced stages maintained normal Mg levels, possibly due to factors like uncontrolled diabetes mellitus or the use of high-dose loop diuretics. This observation suggests that while renal function is a key determinant of Mg regulation, it is not the sole factor, and other comorbid conditions may play a role. The study also found a significant negative correlation between serum magnesium levels and estimated Glomerular Filtration Rate (eGFR), with a correlation coefficient of -0.735 and a P value of less than 0.01. This aligns with observations by De Francisco et al., who noted that compensatory mechanisms to regulate Mg levels fail in advanced CKD, resulting in hypermagnesemia [21]. Our study also provides a comprehensive biochemical profile, including parameters like serum sodium, calcium, and urea, which enriches our understanding of the metabolic landscape in CKD patients. These findings are consistent with those reported by Patel et al., who also observed similar biochemical alterations in their CKD study population [7]. In summary, our study not only underscores the high prevalence of advanced CKD stages and hypermagnesemia but also reveals complex relationships between serum

magnesium levels, eGFR, and the duration of illness. These findings suggest that a multifaceted approach to monitoring and treatment, which includes regular checks on magnesium levels, could be instrumental in the effective management of CKD patients. Given the complexity and gravity of these findings, further research is imperative to unravel the underlying mechanisms and to explore potential therapeutic avenues.

LIMITATIONS OF THE STUDY

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community. Lack of long-term follow-up is also a significant limitation to our study.

CONCLUSION

In conclusion, our study illuminates the intricate relationship between serum magnesium levels and various stages of chronic kidney disease (CKD). We observed a high prevalence of advanced CKD stages and a significant negative correlation between serum magnesium levels and estimated Glomerular Filtration Rate (eGFR). These findings suggest that serum magnesium could serve as a potential biomarker for CKD progression. The study also reveals a positive correlation between the duration of illness and serum magnesium levels, indicating the need for long-term monitoring. While our results provide valuable insights for CKD management, they also highlight the necessity for further research to validate these observations in larger populations.

FUNDING

CONFLICT OF INTEREST

None declared

ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee

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