Original Article

Association of Serum Magnesium Levels with Intradialytic Hypotension among Maintenance Haemodialysis Patients

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Abstract

Background: *Intradialytic complications such as hypotension, muscle cramps, nausea, headache, itching, and fever adversely affect patients' well-being and treatment outcomes. Intradialytic hypotension (IDH) is the most common complication among haemodialysis patients. Previous studies suggest a relationship between serum magnesium levels and IDH in maintenance haemodialysis patients.*

Objectives: *To assess the relation of serum magnesium with intradialytic hypotension in maintenance haemodialysis patients.*

Materials and Methods: *This cross-sectional study included 100 patients receiving maintenance haemodialysis for more than 90 days, selected by purposive sampling. Blood pressure was measured before, during, and after haemodialysis. Serum magnesium and other relevant investigations were performed before and after dialysis. Data were analyzed using SPSS version 25 with paired t-test, Fisher's exact test, and Chi-square test.*

Results: *Among the participants, 62% were male and 38% female. Diabetic nephropathy was the commonest primary disease (55%). IDH occurred in 42% of patients. In hypotensive patients, mean serum magnesium significantly decreased from 2.27±0.46 mg/dL before dialysis to 2.0±0.44 mg/dL after dialysis ($p=0.002$). No significant change was observed among non-hypotensive patients. Serum potassium, calcium, and phosphate levels significantly decreased after dialysis in both groups ($p<0.001$). No significant association was found between IDH and age, dialysis frequency, diabetes mellitus, ischemic heart disease, or interdialytic weight gain.*

Conclusion: *Significant reduction of serum magnesium during haemodialysis was associated with intradialytic hypotension. Maintaining adequate magnesium levels may help improve haemodynamic stability during dialysis.*

Key words: *Serum magnesium, Intradialytic hypotension, Maintenance haemodialysis, Haemodynamic stability, End-stage renal disease.*

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Introduction

End-stage renal disease (ESRD) is a serious health problem affecting millions of people worldwide that render patients in need of receiving renal replacement therapy (Dialysis or Transplant). Haemodialysis (HD) is the most prevalent treatment used in many countries among renal failure patients.[1] Intradialytic complications include hypotension, muscle cramps, nausea and vomiting, headache, itching, fever and chills can have a significant impact on patient's well-being, treatment outcomes and contributes to excessive morbidity and mortality.[2] The incidence of IDH has been ranges from 0.5% to 40% of all treatments, although most recent studies suggested with the prevalence of 11%.3 IDH is defined as, decrease in systolic blood pressure by ≥ 20 mmHg or a decrease in MAP of ≥ 10 mmHg associated with symptoms like dizziness, restlessness, muscle cramp, abdominal discomfort, nausea and vomiting1 IDH has association with notable consequences, commonest are cardiovascular events and mortality. Pathogenesis of IDH is complex. IDH is mainly induced by excessive ultrafiltration, reduced plasma filling, cardiac disease, dialyzer reaction, haemolysis etc.[3] Magnesium is the fourth most abundant ion group in the body, following potassium, and they rank as the primary intracellular

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cations.[4] Magnesium plays a vital role in maintaining normal neuroendocrine function, muscle contraction, and cell signal transmission.[5,6] Magnesium also has a role in regulating vascular tone, atherogenesis, cardiac conduction, and myocardial contraction. As such, magnesium potentially has a major influence on the pathogenesis of cardiovascular disease.[7] Furthermore, Mg may play a role in blood pressure regulation, through directly stimulating prostacyclin and nitric oxide formation, modulating vasodilation, reducing vascular tone and preventing vascular injury and anti-inflammatory functions.[8] As the kidney is the major regulator of magnesium homeostasis, patients with ESRD can potentially lead to both magnesium depletion or overload.[4] Both hypermagnesemia and hypomagnesemia can lead to the development of functional problems. Serious magnesium abnormalities can lead to arrhythmia, neuropsychiatric problems, and respiratory depression.[6,9] According to Kanbays study,[10] insulin resistance, vascular endothelial dysfunction, and systemic inflammation are associated with magnesium in patients with chronic renal disease.[10] However, compared to other electrolytes, magnesium has not gotten as much attention in clinical practice. It has been revealed that the serum magnesium concentration was associated with the prognosis of patients receiving hemodialysis[11] reported a U-shaped curve association between serum magnesium content and mortality in hemodialysis patients. The concentration of magnesium in patients receiving hemodialysis has received increased attention in recent years and magnesium level in dialysis patients have been found to vary widely in previous research, with conflicting results.[12-14] As far as we are aware, although studies have been performed on ESRD patients' quality of life, only a few have focused on IDH and its association with the change in serum magnesium during haemodialysis (HD). Such a study is necessary in light of the potential correlation between serum magnesium with IDH in HD patients.

Materials and Methods

This Observational Cross sectional study was conducted in the Department of Nephrology, Combined military Hospital Dhaka from 20 July 2024 to 10 June 2025. Study population were patients who have received hemodialysis treatment for a period of more than 90 days and experienced one documented episodes of hypotension, that meeting the criteria of IDH . Study sampling was done by purposive sampling. The study population consisted of 100 haemodialysis patients with IDH who met the inclusion and exclusion criteria. Inclusion criteria were age > 18 years, patients who experienced hypotension during earlier haemodialysis treatment and both genders were included. Those who Received hemodialysis therapy for a period of less than 90 days, patients on magnesium supplementations, heart failure with EF <35%, active cancer, recent hospitalization due to other acute illness, history of diarrhoea in last 72 hours were excluded . Patients were observed for three month for episode of IDH and who had developed at least single episode of IDH during observational period were enrolled.Patient information including demographic data, primary diseases, hemodialysis treatment frequency, comorbidity, self-medication history, and prescription was collected. Two sets of blood samples, one sample has taken thirty minutes before and another sample has taken thirty minutes after haemodialysis and sent to the laboratory for magnesium, sodium, potassium, phosphorus and calcium concentration. Blood pressure was checked for three times, five minutes before starting of haemodialysis, then at two hours of haemodialysis or when patient developed symptoms of hypotension during harmodialysis and five minutes after HD for IDH and were recorded accordingly. Patients who developed hypotension were managed as per standard protocol. All the data was collected by the researcher to avoid errors. At the very beginning it was clarified that the participants had the right to refuse to answer any question while completing the data. They had the right to withdraw themselves from studying at any time and refusing to participate did not affect his/her treatment in any way. It also clarified to all participants about the aim of the study. Participants were ensured that any personal information will not be published anywhere. The data was coded, categorized, cleaned & entered computer. The data collected were analyzed with the help of SPSS-25.

Results

Table I: Relation of Dialysis frequency 3 days per week, interdialytic weight gain with blood pressure during dialysis

Interdialytic Weight gain (kg)	Hypotensive	Non - Hypotensive	p - value
1-2	04	28	0.147
3-4	08	38	
>4	04	06	

Table I shows the relationship between interdialytic weight gain (IDWG) and the occurrence of hypotension during dialysis among patients receiving dialysis three days per week. Among patients with an IDWG of 1–2 kg, 4 patients developed hypotension while 28 remained non-hypotensive. In the group with an IDWG of 3–4 kg, 8 patients experienced hypotension and 38 patients were non-hypotensive. Among patients with an IDWG greater than 4 kg, 4 patients developed hypotension whereas 6 patients remained non-hypotensive.

Table II: Relation of Dialysis frequency 2 days per week, interdialytic weight gain with blood pressure during dialysis

Interdialytic Weight gain (kg)	Hypotensive	Non - Hypotensive	p - value
1 - 2	0	02	0.46
3 - 4	02	06	
>4	02	0	

Table II shows the relationship between interdialytic weight gain (IDWG) and the occurrence of hypotension during dialysis among patients receiving dialysis two days per week. Among patients with an IDWG of 1–2 kg, none developed hypotension, while 2 patients remained non-hypotensive. In the group with an IDWG of 3–4 kg, 2 patients experienced hypotension and 6 patients were non-hypotensive. Among patients with an IDWG greater than 4 kg, all 2 patients developed hypotension and none remained non-hypotensive.

Table III: Relation of age with blood pressure during dialysis.

Age group (Years)	Hypotensive	Non - Hypotensive	p - value
≥50	37	52	0.77
<50	05	10	

Table III shows the relationship between age and blood pressure status during dialysis. Among patients aged 50 years and above, 37 developed hypotension during dialysis while 52 remained non-hypotensive. In patients younger than 50 years, 5 experienced hypotension and 10 remained non-hypotensive.

Table IV: Relation of comorbidities with blood pressure during dialysis.

Comorbidities	Hypotensive	Non - Hypotensive	p - value
Diabetes Mellitus	14	30	0.251
Ischemic Heart Disea	12	10	0.08

Table IV shows the relationship between comorbidities and blood pressure status during dialysis. Among patients with diabetes mellitus, 14 developed hypotension during dialysis while 30 remained non-hypotensive. In patients with ischemic heart disease, 12 experienced hypotension and 10 remained non-hypotensive.

Table V: Magnesium and other electrolytes before and after dialysis

Variable	Pre - hemodialysis	Post - hemodialysis	p - value
Magnesium	2.23±0.42	1.96±0.50	0.001
Sodium	136.83±2.51	136.83±2.84	0.590
Potassium	4.63±0.73	3.86±0.68	<0.001
Calcium	10.05±1.19	8.68±1.30	<0.001
Phosphate	6.03±2.06	3.56±1.16	<0.001

Table V shows the comparison of serum magnesium and other electrolyte levels before and after hemodialysis. The mean serum magnesium level significantly decreased from 2.23±0.42 mg/dL before hemodialysis to 1.96±0.50 mg/dL after hemodialysis (p = 0.001). Serum sodium levels remained almost unchanged before and after dialysis (136.83±2.51 vs. 136.83±2.84 mmol/L), and the difference was not statistically significant (p = 0.590).

Table VI: Relation of variables with blood pressure during dialysis

Variables	Hypotensive	p - value	Non - Hypotensive	p - value
Mean Na level before dialysis	136.285±2.90	p=0.908	136.89±2.19	p=0.590
Mean Na level after dialysis	136.38±3.12		137.17±2.57	
Mean K level before dialysis	4.76±0.59	p=0.001	4.51±0.89	p=0.017
Mean K level after dialysis	3.89±0.66		2.87±0.71	
Mean PO4 level before dialysis	6.214±1.68	p=0.001	5.93±2.29	p=0.001
Mean PO4 level after dialysis	3.48±1.27		3.63±1.07	
Mean Ca level before dialysis	9.65±1.64	p=0.003	9.67±1.01	p=0.041
Mean Ca level after dialysis	8.14±1.33		8.96±1.10	

Table VI shows the relation of different electrolyte levels with blood pressure status during dialysis among hypotensive and non-hypotensive patients.

There was no statistically significant difference in serum sodium (Na) levels before and after dialysis in either hypotensive or non-hypotensive groups. In the hypotensive group, the mean sodium level changed from 136.285±2.90 mmol/L before dialysis to 136.38±3.12 mmol/L after dialysis (p=0.908). Similarly, in the non-hypotensive group, the mean sodium level changed from 136.89±2.19 mmol/L to 137.17±2.57 mmol/L (p=0.590).

Serum potassium (K) levels showed a statistically significant reduction after dialysis in both groups. In the hypotensive group, the mean potassium level decreased from 4.76±0.59 mmol/L to 3.89±0.66 mmol/L (p=0.001). In the non-hypotensive group, it decreased from 4.51±0.89 mmol/L to 2.87±0.71 mmol/L (p=0.017).

Serum phosphate (PO4) levels also decreased significantly after dialysis in both groups. Among hypotensive patients, the mean phosphate level declined from 6.214±1.68 mg/dL to 3.48±1.27 mg/dL (p=0.001). In the non-hypotensive group, it decreased from 5.93±2.29 mg/dL to 3.63±1.07 mg/dL (p=0.001).

A significant reduction in serum calcium (Ca) levels was observed after dialysis as well. In the hypotensive group, the mean calcium level decreased from 9.65±1.64 mg/dL to 8.14±1.33 mg/dL (p=0.003), while in the non-hypotensive group it decreased from 9.67±1.01 mg/dL to 8.96±1.10 mg/dL (p=0.041).

Table VII: Blood pressure changes during dialysis

BP changes	Hypotensive	p - value	Non - Hypotensive	p - value
Mean systolic BP before dialysis	166.19±6.27	P=0.001	139.59±25.09	P=0.492
Mean systolic BP after dialysis	118.24±5.52		141.31±30.65	
Mean diastolic BP before dialysis	79.95±2.52	P=0.001	77.45±12.40	P=0.274
Mean diastolic BP after dialysis	67.76±3.65		73.38±21.22	

Table VII demonstrates the changes in blood pressure during dialysis among hypotensive and non-hypotensive patients.

Among the hypotensive group, a statistically significant reduction in systolic blood pressure was observed after dialysis. The mean systolic blood pressure decreased from 166.19±6.27 mmHg before dialysis to 118.24±5.52 mmHg after dialysis (p=0.001). Similarly, the mean diastolic blood pressure significantly decreased from 79.95±2.52 mmHg to 67.76±3.65 mmHg after dialysis (p=0.001).

In contrast, no statistically significant change in blood pressure was found among the non-hypotensive group. The mean systolic blood pressure slightly increased from 139.59±25.09 mmHg before dialysis to 141.31±30.65 mmHg after dialysis (p=0.492). Likewise, the mean diastolic blood pressure decreased from 77.45±12.40 mmHg to 73.38±21.22 mmHg, but the change was not statistically significant (p=0.274).

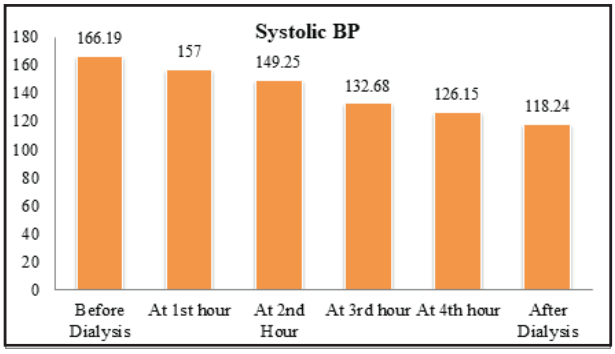

Figure 1: Relation of systolic blood pressure changes with dialysis duration among hypotensive patients.

Figure 1 shows the relation of systolic blood pressure changes with dialysis duration among hypotensive patients. The mean systolic blood pressure progressively decreased throughout the dialysis session. Before dialysis, the mean systolic blood

pressure was 166.19 mmHg, which decreased to 157 mmHg at the 1st hour, 149.25 mmHg at the 2nd hour, 132.68 mmHg at the 3rd hour, and 126.15 mmHg at the 4th hour. After completion of dialysis, the mean systolic blood pressure further declined to 118.24 mmHg. The figure indicates a gradual reduction in systolic blood pressure with increasing dialysis duration among hypotensive patients.

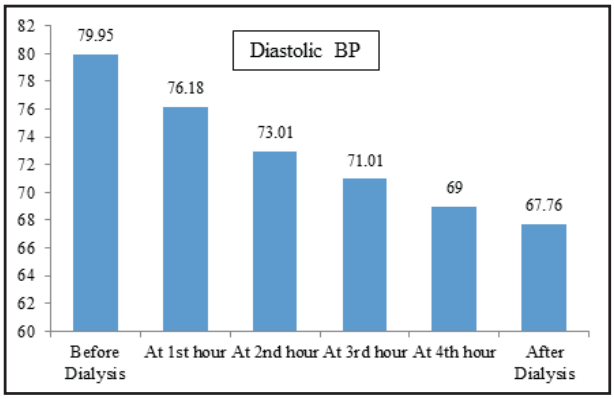

Figure 2: Relation of diastolic blood pressure changes with dialysis duration among hypotensive patients.

Figure 2 presents the relation of diastolic blood pressure changes with dialysis duration among hypotensive patients. The mean diastolic blood pressure showed a steady decline throughout the dialysis session. Before dialysis, the mean diastolic blood pressure was 79.95 mmHg. It gradually decreased to 76.18 mmHg at the 1st hour, 73.01 mmHg at the 2nd hour, 71.01 mmHg at the 3rd hour, and 69 mmHg at the 4th hour. After completion of dialysis, the mean diastolic blood pressure further decreased to 67.76 mmHg. Overall, the figure indicates a consistent downward trend in diastolic blood pressure with increasing duration of dialysis among hypotensive patients.

Table VIII: Relation of Magnesium level with blood pressure during dialysis.

Change of BP	Mean Mg level before dialysis	Mean Mg level after dialysis	p - value
Hypotensive	2.27±0.46	2.004±0.44	0.002
Non - Hypotensive	1.96±0.78	1.89±0.79	0.293

Table VIII shows the relation of serum magnesium level with blood pressure changes during dialysis among hypotensive and non-hypotensive patients.

In the hypotensive group, there was a statistically significant reduction in mean serum magnesium level after dialysis. The mean magnesium level decreased from 2.27±0.46 mg/dL before dialysis to 2.004±0.44 mg/dL after dialysis (p=0.002), indicating a significant association between magnesium reduction and intradialytic hypotension.

In contrast, among non-hypotensive patients, the change in serum magnesium level before and after dialysis was not statistically significant. The mean magnesium level decreased slightly from 1.96±0.78 mg/dL to 1.89±0.79 mg/dL (p=0.293).

Discussion

This observational study aimed to investigate the changes in serum magnesium levels during hemodialysis (HD) and their relation to intradialytic hypotension (IDH). Previous studies examining the effect of HD on serum magnesium are relatively scarce. However, understanding this relationship is crucial, as magnesium plays a vital role in multiple physiological processes, including muscle function, nerve conduction, and cardiovascular stability, which are often disrupted in patients with end-stage renal disease (ESRD). Magnesium homeostasis is essential for maintaining cardiovascular and neuromuscular function. Disruption of magnesium balance can lead to arrhythmias, muscle cramps, and other complications in HD patients. IDH is one of the most reported complications in patients on HD, with a prevalence ranging from 10-20%, depending on the study population.[15] The pathogenesis of IDH is multifactorial including factors related to dialysis procedure such as ultrafiltration volume, dialysate temperature and patients related factors such as age, interdialytic weight gain, cardiovascular disease.[16] Older age has been linked to impaired autonomic response and reduced vascular compliance, increasing susceptibility to hypotension during dialysis.[17] Similarly, diabetes mellitus is known to impair cardiovascular autonomic regulation, which predisposes patients to haemodynamic instability.[18] Ischaemic heart disease also reduces myocardial reserve, which may impair compensatory mechanisms during fluid removal.[19] In this study dialysis related factors remain constant in all patients. In the present study, factors such as age, diabetes mellitus, and ischaemic heart disease were not found to be significantly associated with the development of intradialytic hypotension (IDH). The discrepancy between our findings and prior literature could be attributed to differences in study population characteristics, dialysis protocols, or the relatively small sample size of our study, which may have limited the statistical power to detect these associations.

In this study, interdialytic weight gain (IDWG), a commonly recognized factor associated with intradialytic hypotension (IDH), was found to be statistically insignificant in contributing to the development of IDH among maintenance haemodialysis patients. This finding contrasts with previous studies, which have identified higher IDWG as a risk factor for IDH due to the need for aggressive ultrafiltration rates.[20] The lack of significant association in present study may be due to better fluid management strategies, individualized ultrafiltration profiling, or differences in dietary sodium adherence. Furthermore, this observation aligns with emerging evidence suggesting that IDH is multifactorial, and volume overload alone may not always predict hypotensive episodes.[17] Therefore, reliance on IDWG as a sole predictor of IDH may be limited, and a more comprehensive approach is warranted. More frequent dialysis sessions

are thought to reduce interdialytic fluid accumulation, thereby potentially lowering the risk of IDH.[20] However, in our study, we did not observe any statistically significant association between dialysis frequency and the occurrence of intradialytic hypotension. This discrepancy may be due to the relatively homogeneous distribution of dialysis schedules among our patient population, where the majority underwent thrice-weekly sessions, leaving limited variability for comparative analysis. These findings are consistent with those of Flythe JE and Sands JJ,[21,22] who reported that while increased dialysis frequency has theoretical benefits, it does not uniformly translate into reduced intradialytic complications across all patient populations. The present study found that serum magnesium levels significantly decreased during dialysis, from 2.23±0.42 mg/dL before dialysis to 1.96±1.99 mg/dL post-dialysis, while serum sodium levels remained unchanged, consistent with the findings of Barry.[23] Similarly, serum potassium, calcium and phosphate levels showed significant reduction post-dialysis (p-0.001), suggesting that conventional HD effectively removes these products, including magnesium.[1] It is predicted that significant differences in serum potassium, calcium and phosphates have been found among all patients who developed IDH or not, but significant differences have observed only magnesium among patients who developed IDH. These observations indicate possibilities of association of depletion of magnesium with IDH. However, contradictory findings have been reported by some studies. For example, Han Z observed no significant reduction in serum magnesium concentrations post-dialysis.[24] This discrepancy may be due to variations in dialysis techniques, such as different dialysate compositions, dialyzer types or dialysis durations, which could affect the removal of magnesium during HD. Furthermore, the differences in patient characteristics, including the severity of CKD and the presence of comorbidities, might contribute to the variability in serum magnesium changes observed in different studies. In this study, patients who developed IDH had significantly reduced serum magnesium levels ($p<0.002$) post-dialysis, with mean pre-dialysis and post-dialysis magnesium levels of 2.27±0.46 and 2.00±0.44 mg/dL, respectively. This decrease was statistically significant and suggests a potential role of magnesium depletion in the pathogenesis of IDH. These results are consistent with the study by Shayanpour S,[1] who also observed a significant reduction in magnesium levels in patients who developed IDH. Conversely, patients who did not experience IDH showed no significant change in serum magnesium levels during dialysis. The observed association between serum magnesium changes and IDH explains the potential role of magnesium in modulating haemodynamic stability during HD. In subgroup analysis, data from 42 hypotensive patients were evaluated to determine the relationship between the timing of IDH episodes and serum magnesium changes during the dialysis session. The results revealed that the frequency of hypotension increased progressively over the course of dialysis, occurring mostly among patients in the third hour (45.23%), followed by the second (28.57%), fourth (19.04%) and first (7.14%) hours of HD session. Magnesium concentrations in these IDH patients showed the degree of magnesium reduction was statistically significant among patients who developed IDH from the second hour onward ($p<0.001$). In those who developed hypotension in first hour, magnesium decreased slightly 2.10 ± 0.12 to 2.03 ± 0.13 ($p=0.119$), not statistically significant. This temporal relationship between magnesium depletion after haemodialysis and increasing number of patients who developed IDH in mid-to-late phases of haemodialysis treatment strongly suggests a physiological link between intradialytic magnesium depletion and haemodynamic instability. The progressive fall in magnesium in the current study, especially during the second and third hours, correlates with the findings of Yamaguchi S and Han Z, who observed that the onset of hypotension is closely linked to the mid-dialysis phase when electrolytic shifts are most dynamic.[12,24] The statistical analysis revealed that the p-value for the change in serum magnesium levels during dialysis was <0.002, indicating a significant relationship between serum magnesium depletion and IDH. This finding aligns with previous studies suggesting that magnesium deficiency may predispose patients to intradialytic hypotension, possibly by affecting vascular tone, endothelial function, and cardiac contractility.[25,26] Micheal S Balzer has shown that increasing magnesium concentration in dialysate prevents IDH.[27] In relation to these findings, our study observation also supports the increasing of serum magnesium for prevention of IDH.

Conclusion

Our study suggests that serum magnesium levels are significantly reduced during haemodialysis, and this reduction may be related with the development of intradialytic hypotension. Magnesium levels decline progressively during haemodialysis, and this decline temporally correlates with the onset of maximum IDH during the mid-to-late stages of the session. This finding highlights the importance of maintaining adequate magnesium levels in HD patients, as magnesium deficiency may contribute to cardiovascular instability and the occurrence of IDH. Further studies are needed to explore the potential benefits of magnesium supplementation in preventing IDH and improving haemodynamic stability during dialysis.

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