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Serum magnesium level in peritoneal dialysis patients

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ABSTRACT

Introduction: Electrolyte imbalances are common among dialysis patients, and disorders related to magnesium, calcium, and phosphorus are particularly concerning. However, comparatively less research is available on disorders related to magnesium ion disorders.
Objectives: This paper aims to assess magnesium disorders in patients with renal failure undergoing peritoneal dialysis.
Patients and Methods: In this cross-sectional study, we recruited patients who had been undergoing peritoneal dialysis for at least three months. We collected demographic information, body mass index (BMI), drug history, the underlying disease leading to renal failure, duration of dialysis, and serum magnesium level. Additionally, we measured levels of calcium, phosphorus, parathyroid hormone (PTH), albumin, and 25-hydroxyvitamin D.
Results: A total of 91 patients were undergoing peritoneal dialysis, including 41.8% women and 58.2% men, with a mean magnesium level of 2.86 ± 0.53 mg/dL. More than 70% of patients had hypermagnesemia and only one patient suffered from hypomagnesemia. Diabetic patients had a lower magnesium level than non-diabetics ($P = 0.01$).
Conclusion: Given the frequent occurrence of electrolyte imbalance in peritoneal dialysis, it may be necessary to regularly monitor electrolyte levels and make appropriate adjustments to both the patient's diet and electrolyte levels.

Original

Implication for health policy/practice/research/medical education:
Among dialysis patients, electrolyte imbalances are frequently observed, with particular concern surrounding disorders associated with magnesium, calcium, and phosphorus. However, there is a relative scarcity of research focused on magnesium disorders in peritoneal dialysis patients.

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Introduction

Magnesium is a crucial mineral, ranking fourth in terms of importance in the body. It is also the second most abundant cation found within cells. Its primary role is acting as a cofactor in over 300 enzyme reactions. Magnesium is necessary for the production, metabolism, and storage of ATP (the energy currency of cells), as well as for DNA and RNA synthesis. Moreover, magnesium plays a vital role in various physiological processes including insulin metabolism, blood pressure regulation, neuromuscular conduction, and maintaining vasomotor tone (1,2). For endothelial cell function and smooth muscle tone and preventing the occurrence of diseases such as atherosclerosis, coronary artery disease, congestive heart failure, and cardiac arrhythmias, magnesium plays a significant role (3).

The blood typically contains magnesium levels ranging between 1.46-2.68 mg/dL and a low-serum magnesium level (<1.46 mg/dL) is termed hypomagnesemia (4). Imbalances in magnesium levels, particularly hypomagnesemia, can prompt neuromuscular or heart diseases, such as; hypertension, Alzheimer's disease, cardiovascular diseases, and heightened stress sensitivity (5).

The main sources of magnesium in the diet include plant-based foods like grains, vegetables, and legumes

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(6). These sources include oil seeds, cocoa, nuts, grains, and vegetables (7). The typical daily intake of magnesium from the diet is generally enough to prevent deficiency; however, it may not be sufficient to achieve a consistently high concentration of serum magnesium, which is crucial for protecting against various diseases, particularly in individuals with kidney-related conditions. Changes in magnesium homeostasis primarily affect the extracellular space, as intracellular magnesium concentrations are tightly regulated and sustained. The kidney primarily governs the regulation of extracellular magnesium concentration (8).

Hypomagnesemia is associated with increased mortality in patients suffering from chronic kidney disease (CKD) and those with end-stage renal disease (ESRD) who require hemodialysis (9, 10). In CKD patients undergoing peritoneal dialysis, there is a direct relationship between hypomagnesemia and overall mortality rate (11). On the other hand, hypermagnesemia increases the risk of vascular calcification, left ventricular hypertrophy, and mortality in ESRD patients and kidney transplant patients by inhibiting the secretion of parathyroid hormones (PTHs) (12).

Since the regulation of serum magnesium is dependent on intestinal absorption and renal excretion, a relationship between the use of proton pump inhibitors (PPIs) and hypomagnesemia has been observed. Numerous observational studies have linked the long-term use of PPIs to hypomagnesemia, potentially caused by decreased absorption in the intestines leading to magnesium deficiency. Magnesium relies on the acidic environment of the stomach for proper absorption. However, PPIs hinder the absorption of magnesium by inhibiting the release of hydrogen ions(13).

Given the rise in the number of individuals experiencing acute and CKDs, the utilization of dialysis as an alternative solution has become necessary. However, the use of dialysis can present problems and complications, particularly about electrolyte disorders. Among these, magnesium, calcium, and phosphorus disorders are particularly significant. The fluctuations, either decrease or increase, of these elements within the body of an individual undergoing dialysis can contribute to the development of various complications, including cardiovascular disease, bone disease, and an increased mortality rate among dialysis patients (14). Among these elements, magnesium has not received much attention and is often referred to as the neglected cation. Our study aims to investigate the serum magnesium levels in peritoneal dialysis and the correlation between magnesium levels and various laboratory data. Additionally, we took into consideration the individuals who have a history of PPI consumption as a separate influential factor during the examination.

Objectives

The heightened prevalence of electrolyte disorders, especially magnesium, in peritoneal dialysis patients, contributes to increased morbidity and mortality in these patients. This study aimed to explore the serum magnesium level in peritoneal dialysis patients and analyze the factors associated with a magnesium level.

Patients and Methods

Study design

In this cross-sectional study, all patients who underwent peritoneal dialysis between 2017-2018 in Ghaem, Imam Reza, and Montaserieh hospitals located in Mashhad, Iran, were enrolled. The patients' inclusion criteria were those who visited these centers and had been on peritoneal dialysis for a minimum of three months. During a visit session, with the patient's consent, relevant information such as age, gender, underlying diseases causing kidney failure, duration of dialysis, and PPI consumption were gathered and documented. Subsequently, tests measuring magnesium, calcium, phosphorus, PTH, albumin, and 25-hydroxy vitamin D levels were conducted in a single laboratory.

Statistical analysis

All data were analyzed using SPSS for Windows (version 20). The Mann-Whitney U or *t* tests were conducted to compare magnesium levels between different variables. A correlation test (Pearson's or Spearman's) was used to measure the correlation between quantitative variables. The significance level in all tests was considered less than 0.05.

Results

Out of 91 participants enrolled in this study, 53 were male patients (58.2%) and 38 were female (41.8%). Table 1 details demographic data. Notably, hypertension (41.8%) was a remarkable clinical observation, followed by diabetes mellitus (30.8%). The average age of the peritoneal dialysis patients in this study was 48.58 ± 17.71 years (ranging from 18 to 82 years), while the average body mass index (BMI) of the patients was 23.54 ± 4.82 kg/m^2 (ranging from 14.68 to 34.94 kg/m^2).

The frequency of magnesium levels in this study is indicated in Figure 1. The serum magnesium levels were categorized as hypo (<1.46 mg/dL), normal (1.46-2.68 mg/dL), and hypermagnesemia (<2.68 mg/dL). As seen, out of the 91 patients, one patient (1.1%) was diagnosed with hypomagnesemia. Additionally, 64 patients (70.3%) were found to have hypermagnesemia, while the remaining patients (28.6%) exhibited normal-range magnesium levels. The average magnesium level was 2.86 ± 0.53 mg/dL. Moreover, the average magnesium level is higher in females compared to males (2.96 ± 0.65 mg/dL versus 2.79 ± 0.44 mg/dL). As shown in Table 2, the magnesium level was lower among diabetic patients. In addition, there was a significant relationship between serum magnesium levels in diabetic patients ($P = 0.01$) and polycystic kidney

Table 1. General information of studied patients

Variables		Gender		Overall
		Male	Female	
Age (years), Mean (SD)		49.53±17.57	47.28±18.04	48.58±17.71
Gender, No. (%)		53 (58.2)	38 (41.8)	-
BMI, Mean (SD) (kg/m^2)		22.60±4.75	24.81±4.67	23.54±4.82
Underlying diseases, No. (%)	HTN	21 (39.6)	17 (44.7)	38 (41.8)
	DM	16 (30.2)	12 (31.6)	28 (30.8)
	PKD	10 (18.9)	9 (23.7)	19 (20.9)
	Malignancy, Ischemic heart disease	4 (7.5)	1 (2.6)	5 (5.5)
Duration of dialysis (month), Mean (SD)		49.15±23.25	59.80±27.11	53.43±25.28

BMI, Body mass index; HTN, Hypertension; DM, Diabetes mellitus; PKD, Polycystic kidney disease.

disease ($P=0.006$).

Among these patients, 15 patients had a history of PPI administration (16.5%). The average serum magnesium level of patients who took PPI was 2.88±0.44 mg/dL, which was not significantly higher than the patients who did not take PPI (2.86±0.60 mg/dL, $P=0.85$).

Data relating to tests of patients undergoing peritoneal dialysis shows that the average serum calcium, phosphorus, PTH, albumin, and hemoglobin levels of patients were 8.63 ± 0.8 (mg/dL), 5.26 ± 1.34 (mg/dL), 449.90 ± 400.55 (pg/mL), 3.85 ± 0.55 (g/dL), and 11.25 ± 1.77 (g/dL), respectively.

The study measured the correlation between magnesium levels and various laboratory factors. We found a significant correlation between serum magnesium levels and serum phosphorus value in patients undergoing peritoneal dialysis. However, no significant and strong correlation was observed between serum magnesium levels with age, BMI, duration of dialysis, and other laboratory data (Table 3).

Discussion

The rising prevalence of kidney diseases, along with the utilization of certain medications such as diuretics, calcineurin inhibitors, cisplatin, aminoglycosides, amphotericin B, and diseases like diabetes mellitus, have contributed to the occurrence of magnesium disorders, particularly in clinical settings (9,15). The growing occurrence of CKDs in various societies has led to increase usage of diverse types of dialysis, notably peritoneal dialysis. This study focuses on evaluating magnesium levels in peritoneal dialysis patients and explored their correlation with other variables pertinent to these individuals.

It is estimated that the prevalence of hypomagnesemia in the general population is 2.5% to 15%. In patients admitted to hospital, it ranges from 12 to 20% (4,16). On the other hand, the prevalence of hypermagnesemia is less frequent than hypomagnesemia and it occurs in 10 to 15% of hospitalized patients (17). As shown in the result, the average magnesium level of peritoneal dialysis patients is 2.86 ± 0.53 mg/dL and in both groups based on gender, the number of patients with hypermagnesemia was higher than hypomagnesemia and normal level (70.3% versus 1.1% and 28.6%). Furthermore, the level of magnesium in females was generally higher than in males, except in the group of patients with normal magnesium levels. However, there was no significant difference was found

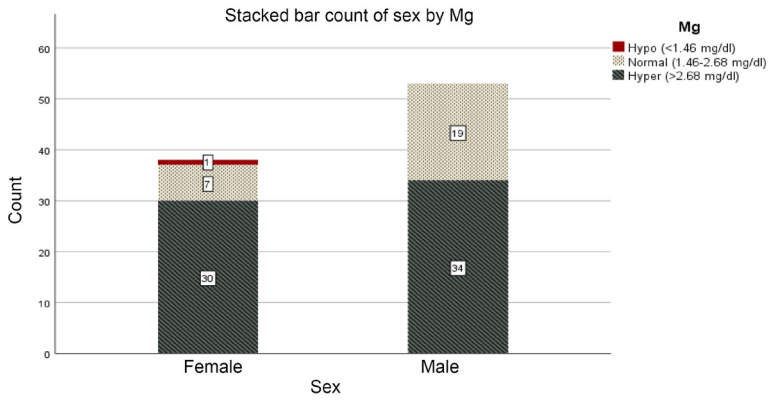

Figure 1. Frequency of magnesium level of studied patients.

Table 3. The correlation between serum magnesium level and laboratory tests

Variable		Correlation coefficient	*P* value
Calcium (mg/dL)	8.63±0.8	0.053	0.62[a]
Phosphorus (mg/dL)	5.26±1.34	0.25	0.02[a]
PTH (pg/mL)	449.9±400.55	0.2	0.07[b]
Albumin (g/dL)	3.85±0.55	0.16	0.13[a]
25 (OH) vitamin D (ng/mL)	22.68±16.64	-0.01	0.93[b]
Hemoglobin (g/dL)	11.25±1.77	-0.04	0.71[a]
Age	48.58±17.71	-0.194	0.07[a]
BMI	23.54±4.82	0.076	0.48[a]
Duration of dialysis	53.43±25.28	0.015	0.89[b]

All data were reported as mean ± SD.
[a] Pearson's correlation; [b] Spearman's correlation.

Table 2. Average serum magnesium level according to gender and underlying diseases in the studied population

Variables		Magnesium level	*P* value
Gender	Male	2.79±0.44	0.24[a]
	Female	2.96±0.65	
Diabetes mellitus	Yes	2.71±0.46	0.01[b]
	No	2.94±0.45	
Hypertension	Yes	2.84±0.47	0.62[b]
	No	2.9±0.46	
Polycystic kidney disease	Yes	3.13±0.58	0.006[a]
	No	2.8±0.4	

[a] Independent sample *t* test; [b] Mann-Whitney U test.

in the magnesium levels between the two groups based on gender. Additionally, a significant relationship ($P < 0.05$) exists between magnesium and phosphorus levels, unlike other laboratory data. Previously, Tsai and his colleagues examined 180 patients undergoing peritoneal dialysis in northern China in 2017. The average serum magnesium level was found to be 1.02±0.16 mmol/L. Among the patients, 33% exhibited hypermagnesemia, 66% had normal serum magnesium concentrations, and no individuals had hypomagnesemia. The study also revealed a correlation between hypermagnesemia and high serum phosphate, lower PTH levels, and lower CRP levels, showing independent relationships (14). Compared to the current study, we observe that the average serum magnesium levels in patients undergoing peritoneal dialysis are higher than those in the Chinese population. This difference can be attributed to variances in climatic and dietary conditions among the populations being studied. Regarding the relationship between phosphate and magnesium levels, the findings of the two studies yield comparable results.

In the study by Nakashima et al, a clear association between the administration of PPIs and hypomagnesemia within the community was demonstrated, which is in contrast to our study. The study recruited participants from the general population, with the exclusion of individuals undergoing dialysis treatments (18).

Another study in the United States in 2015 investigated the relationship between hypomagnesemia and mortality in hemodialysis patients. In this study, 9359 patients undergoing hemodialysis between 2007 and 2011 were studied. Among these numbers, 2636 people died within five years after dialysis, and there was a significant direct relationship between hypomagnesemia and mortality, while patients with higher magnesium had much lower mortality than the first group (10).

Mitwalli conducted a study examining magnesium levels in patients undergoing hemodialysis and peritoneal dialysis. The study revealed that 8.7% of patients had hypomagnesemia, 32.2% had normal magnesium concentration, while the remaining patients maintained a normal magnesium level. Additionally, the results demonstrated a significant relationship between PTH secretion, calcium levels, and serum magnesium levels. Consequently, correcting the serum magnesium level in dialysis patients can potentially decrease the risk of dyslipidemia and hyperparathyroidism (19). The overall magnesium levels in patients within our study were found to be lower compared to the study referenced. This difference can be attributed to various factors including the limited sample size, as well as variances in geographical and climatic conditions. While the previous study reported a notable association between PTH and calcium levels with magnesium levels, our study did not find a significant relationship. One possible explanation for this disparity may be the variations in the underlying diseases causing dialysis among the patients in both studies.

Several studies have shown that increasing the magnesium content in the dialysis solution directly correlates with a decrease in PTH levels in patients undergoing peritoneal dialysis (20-23). Further investigations are necessary to compare and investigate the relationship between the results of the two studies, taking into consideration that no intervention was made in our study.

Conclusion

This study shows that apart from the electrolyte disorders, especially magnesium, which are common in patients with peritoneal dialysis, this disorder is more pronounced in patients with diabetes and polycystic kidney disease. In addition, there is a remarkable relationship between magnesium level and phosphorus ($P<0.05$). Due to the strong correlation between the serum magnesium level and a patient's nutrition, further studies should be conducted to investigate the link between the dietary intake of dialysis patients and their serum magnesium levels.

Limitations of the study

While this study exhibited certain limitations, including

inadequate data within certain patients' medical records leading to their exclusion from the analysis, and the data being collected from three centers with a relatively low sample size, potentially impacting the precision of the results, it distinguishes itself as one of the few studies delving into serum magnesium levels and their influencing factors among peritoneal dialysis patients.

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Authors' contribution

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Writing–original draft: Mohammadhossein Taherynejad, Maryam Emadzadeh.
Writing–review & editing: Maryam Emadzadeh, Sahar Ravanshad, Mohammadhossein Taherynejad.

Ethical issues

The principles of the Helsinki Declaration were followed in this research. The study protocol was approved by the Ethical Committee of the Mashhad University of Medical Sciences (Ethical code # IR.MUMS.MEDICAL.REC.1397.686). All patients expressed their informed consent through a written form. Besides, ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

Data availability statement

The data are available on reasonable request from the corresponding author.

Conflicts of interest

The authors declare that they have no competing interests.

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