

# Association Between 25-Hydroxyvitamin D Level and Inflammatory and Nutritional Factors in Hemodialysis and Peritoneal dialysis Patients in Qom, Iran

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**Introduction.** This study aimed to evaluate the prevalence of vitamin D inadequacy in patients receiving maintenance hemodialysis and peritoneal dialysis (PD) and its association with inflammatory and nutritional factors.

**Materials and Methods.** A total of 176 hemodialysis and 32 PD patients participated in the study. Serum levels of 25-hydroxyvitamin D, albumin, parathyroid hormone, calcium, phosphorus, high-sensitivity C-reactive protein (HSCRP), and neutrophil-lymphocyte ratio (NLR) were measured. Data on body mass index were also collected. Stepwise multiple logistic regression analysis was used to identify predictors for 25-hydroxyvitamin D deficiency and its relationship with the nutritional and inflammatory factors.

**Results.** No significant association was found between 25-hydroxyvitamin D and age, body mass index, serum calcium, serum phosphorus, parathyroid hormone, serum albumin, dialysis quality, and duration of dialysis; while NLR and HSCRP were significantly associated with 25-hydroxyvitamin D in the hemodialysis patients only ( $P < .001$  and  $P = .001$ , respectively). A positive correlation was found between NLR and HSCRP in both hemodialysis and PD patients. ( $r = 0.817$ ;  $P < .001$ ). This association was confirmed between an NLR greater than 3 and an HSCRP level greater than 3.

**Conclusions.** Vitamin D deficiency was highly prevalent in our dialysis patients, and inadequate level of vitamin D was associated with inflammatory factors such as HSCRP and NLR in both hemodialysis and PD patients. An easy and inexpensive test of an NLR greater than 3 could be used as a measure of inflammation instead of HSCRP in both PD and hemodialysis patients.

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## INTRODUCTION

Recent data show that vitamin D has endocrine and immunoregulatory activity through its active metabolite 1,25-dihydroxyvitamin D<sub>3</sub>, which is produced by renal 1- $\alpha$  hydroxylase. In addition, autocrine and paracrine activity from local metabolism of vitamin D through extrarenal

pathway by tissue 1- $\alpha$  hydroxylase has an impact on cellular proliferation and differentiation and also inflammatory process in different tissues.<sup>1,2</sup> Inadequate level of vitamin D is associated with increased risk of a wide range of disorders including diabetes mellitus, hypertension, hyperlipidemia, peripheral vascular disease, cardiovascular

disease, autoimmune disorders, and some type of cancers.<sup>3-5</sup> Additionally, patients with chronic kidney disease (CKD) and end-stage renal disease (ESRD) have decreased amounts of circulating 1,25-dihydroxyvitamin D<sub>3</sub> due to loss of nephron mass and decreased renal hydroxylation, and also low levels of 1,25-dihydroxyvitamin D<sub>3</sub> have been shown in CKD, hemodialysis, and ESRD patients.<sup>6-10</sup> Optimal level of 25-hydroxyvitamin D is considered to be greater than 30 ng/dL<sup>5</sup>; however, studies on the optimum dose and the time required to replace and maintain the reservoir in dialysis patients and safety or effectiveness of the replacement is still ongoing.<sup>11</sup>

Furthermore, CKD and ESRD are thought to be a state of micro-inflammation which causes atherosclerosis, cardiovascular disease, and increased incidence of microbial infection; thus, inflammation is responsible for increased mortality and morbidity in these patients.<sup>12-13</sup> Several inflammatory markers have been proposed to measure inflammation in CKD and ESRD patients, but most of them are costly and are unnecessary. High-sensitivity CRP (HSCRP) is a factor of poor prognosis and decreased survival in ESRD patients and is used for assessing inflammation and cardiovascular risk stratification in this group of patients. Recently, neutrophil-lymphocyte ratio (NLR) is proposed as a representation of inflammation in different disorders.<sup>14</sup>

Data are limited and there is no guidelines available on managing vitamin D deficiency in hemodialysis and peritoneal dialysis (PD) patients. Supplementation with 25-hydroxyvitamin D may decrease mortality and morbidity in ESRD patients,<sup>12</sup> but generalizing this theory needs further studies since metastatic calcification is a dramatic result of high phosphate and calcium levels, which may be triggered by using vitamin D supplementation.<sup>12,15</sup> Hence, the aim of this study was to evaluate the prevalence of 25-hydroxyvitamin D deficiency in ESRD patients receiving hemodialysis and PD, and finding the association between 25-hydroxyvitamin D level and nutritional factors like body mass index (BMI), albumin, and inflammatory factors like HSCRP and NLR. In addition, we aimed to assess the association of HSCRP with NLR in these patients.

## MATERIALS AND METHODS

This cross-sectional study was conducted on 208

patients with ESRD receiving maintenance dialysis as hemodialysis (176 patients) and peritoneal dialysis (32 patients) after approval from the Ethics Committee of Qom University of Medical Sciences. This study was carried out in adherence with the Declaration of Helsinki. Written informed consent was obtained prior to participation in this study. Patients with active infection and malignancy and those who had received vitamin D within the past 3 months were excluded.

The enrolled hemodialysis patients were receiving 4-hour dialysis regimens thrice weekly with a standard bicarbonate dialysis solution, using a biocompatible hemodialysis membranes (low-flux polysulfone). Dialysate flow rate was 500 mL/min and blood flow rate was 250 mL/min to 350 mL/min. The enrolled PD patients were receiving continuous ambulatory PD with dialysate fluids containing 1.5% glucose.

Clinical and demographic characteristics of the patients (age, sex, cause of kidney failure, presence of diabetes mellitus, BMI, duration of dialysis, and medication) were recorded at the time of enrollment.

Peripheral blood samples were analyzed for 25-hydroxyvitamin D, HSCRP, calcium, phosphorus, parathormone (PTH), and albumin levels, as well as complete blood count, with automated differential counts including total leukocytes, neutrophils, and lymphocytes in fasting state before starting dialysis in hemodialysis patients and after morning dwell of PD patients. Serum 25-hydroxyvitamin D was measured using an enzyme-linked immunosorbent assay (Euroimmun, Germany). The NLR was calculated as the ratio of neutrophils to lymphocytes in the same sample. Enzyme-linked immunosorbent assay method was used for measurement of HSCRP by photometric method using bionic kits. A serum 25-hydroxyvitamin D concentration greater than 30 ng/dL was considered as the sufficient amount; 15 ng/dL to 30 ng/dL, as insufficiency; less than 15 ng/dL, as deficiency; and less than 5 ng/dL, as sever deficiency. We compared nutritional factors including albumin and BMI and inflammatory factors including HSCRP and NLR in the groups with a concentration less than 10 ng/dL as significant vitamin D deficiency with 10 ng/dL to 30 ng/dL and sufficient amount of greater than 30 ng/dL.

Data analysis was carried out using the the

SPSS software (Statistical Package for the Social Sciences, version 21.0, SPSS Inc, Chicago, IL, USA). The distribution of variables was evaluated by the 1-sample Kolmogorov-Smirnov test. The *t* test and the Mann-Whitney test were used for comparing quantitative variables. The categorical outcome variables were compared using the chi-square test or the Fisher exact test, as appropriate. Stepwise multiple logistic regression analysis was used to identify predictors for 25-hydroxyvitamin D deficiency and its relationship with nutritional factors. The Pearson correlation test was used for quantitative variables. Quantitative variables were presented as mean  $\pm$  standard deviation, whereas percentages were used for categorical variables. Differences were considered significant when the *P* value was less than .05.

## RESULTS

Baseline characteristics of the population studied are shown in Table 1. Laboratory markers by sex are shown in Table 2. As shown in Table 1, the mean age, BMI, duration of dialysis, and serum levels of calcium, PTH, albumin, 25-hydroxyvitamin D were significantly different between the two groups of hemodialysis and PD.

The mean 25-hydroxyvitamin D level was  $13.74 \pm 11.25$  ng/dL in the hemodialysis patients and  $7.67 \pm 7.67$  ng/dL in the PD patients ( $P = .004$ ). Overall, 14 patients (6.7%) had normal 25-hydroxyvitamin D levels. In the hemodialysis and PD groups, 7.4% and 3.1% had normal levels of 25-hydroxyvitamin D ( $> 30$  ng/dL), 26.7% and 9.3% had vitamin D insufficiency (15 ng/dL to 30 ng/dL), 65.8% and 87.6% had vitamin D deficiency ( $< 15$  ng/dL), 17.6% and 50% had severe vitamin D deficiency ( $< 5$  ng/dL), and 50.6% and 78.1%

**Table 2.** Laboratory Markers by Sex

Laboratory Marker	Men	Women
25-hydroxyvitamin D, ng/dL		
Hemodialysis	14.41 $\pm$ 12.23	13.05 $\pm$ 10.17
Peritoneal dialysis	9.55 $\pm$ 9.33	5.79 $\pm$ 5.18
High-sensitivity C-reactive protein, mg/dL		
Hemodialysis	10.82 $\pm$ 9.16	13.12 $\pm$ 18.10
Peritoneal dialysis	12.52 $\pm$ 19.27	5.87 $\pm$ 5.06
Neutrophil-lymphocyte ratio		
Hemodialysis	3.23 $\pm$ 0.79	3.37 $\pm$ 1.14
Peritoneal dialysis	3.33 $\pm$ 1.14	2.66 $\pm$ 0.81

had significant vitamin D deficiency ( $< 10$  ng/dL), respectively.

In the hemodialysis group, the association of 25-hydroxyvitamin D with age, BMI, calcium, phosphorus, PTH, albumin, dialysis quality, and duration of dialysis were not significant; however, NLR and HSCRPs levels were significantly associated with 25-hydroxyvitamin D ( $P < .001$  and  $P = .001$ , respectively). In the PD group, none of the mentioned variables were associated with 25-hydroxyvitamin D.

Comparing the dialysis patients based on 25-hydroxyvitamin D low and normal levels (Table 3), NLR and HSCRPs were significantly higher in hemodialysis groups with severe deficiency in comparison with other groups ( $P < .001$  and  $P = .02$ , respectively). Another division of the groups based on 25-hydroxyvitamin D levels of 10 ng/dL and greater versus less than 10 ng/dL showed that NLR and HSCRPs were significantly higher in the hemodialysis patients with low 25-hydroxyvitamin D ( $P < .001$  and  $P = .006$ , respectively); however, in the PD patients, the difference was not significant. Overall, BMI in the group with low 25-hydroxyvitamin D was higher and albumin was lower than the group with a

**Table 1.** Baseline Characteristics of Participants

Characteristic	Hemodialysis (n = 176)	Peritoneal Dialysis (n = 32)	<i>P</i>
Age, y	52.4 $\pm$ 15.9	61.6 $\pm$ 15.8	.003
Body mass index, kg/m <sup>2</sup>	21.4 $\pm$ 3.6	24.6 $\pm$ 5.1	.001
Serum calcium, mg/dL	8.1 $\pm$ 1.4	8.7 $\pm$ 0.5	$< .001$
Serum phosphorus, mg/dL	6.6 $\pm$ 13.2	4.6 $\pm$ 0.7	.39
Parathyroid hormone, pg/mL	258.8 $\pm$ 241.2	161.5 $\pm$ 137.0	.03
Serum albumin, g/dL	3.7 $\pm$ 1.2	3.2 $\pm$ 0.5	$< .001$
Neutrophil-lymphocyte ratio	3.3 $\pm$ 0.9	2.9 $\pm$ 1.0	.11
25-hydroxyvitamin D, mg/dL	13.7 $\pm$ 11.2	7.6 $\pm$ 7.6	.004
High-sensitivity C-reactive protein, mg/dL	11.9 $\pm$ 14.3	9.1 $\pm$ 14.2	.32
Dialysis quality (KT/V)	1.5 $\pm$ 4.15	2.5 $\pm$ 1.4	.19

**Table 3.** Laboratory Markers by Categories of Vitamin D Levels

Laboratory Marker	25-Hydroxyvitamin D, ng/dL			P
	< 10	10 to 30	> 30	
Body mass index, kg/m <sup>2</sup>				
Hemodialysis	21.38 ± 3.94	21.46 ± 3.55	21.8 ± 2.76	.93
Peritoneal dialysis	24.52 ± 5.03	25.51 ± 5.99	23.3	.89
Total	22.09 ± 4.38	21.77 ± 3.88	21.91 ± 2.68	.87
Serum albumin, g/dL				
Hemodialysis	3.26 ± 0.43	3.28 ± 0.84	3	.41
Peritoneal dialysis	3.26 ± 0.43	3.26 ± 0.43	3	.09
Total	3.61 ± 1.24	3.85 ± 1.02	3.45 ± 0.71	.25
Neutrophil-lymphocyte ratio				
Hemodialysis	3.65 ± 0.89	2.98 ± 0.78	2.65 ± 1.53	< .001
Peritoneal dialysis	2.91 ± 0.90	3.35 ± 0.57	2.9	.67
Total	3.49 ± 0.95	3.01 ± 0.86	2.67 ± 1.47	< .001
High-sensitivity C-reactive protein, mg/dL				
Hemodialysis	14.88 ± 15.72	8.99 ± 10.05	8.82 ± 20.66	.02
Peritoneal dialysis	9.06 ± 15.86	10.63 ± 6.73	3.8	.91
Total	13.60 ± 15.87	9.11 ± 9.82	8.46 ± 19.89	.07

25-hydroxyvitamin D level greater than 10 ng/dL, but the difference was not significant (Table 4).

The mean rank of phosphorus, PTH, albumin, and HSCRCP in the hemodialysis patients were significantly higher than in the PD patients ( $P < .001$ ,  $P = .018$ ,  $P < .001$ , and  $P = .048$ , respectively), but the mean rank of calcium was lower in this group ( $P = .014$ ).

A weak inverse correlation was found between PTH and calcium and 25-hydroxyvitamin D and HSCRCP ( $P = .035$ ,  $r = -0.161$ ;  $P < .001$ ,  $r = -0.280$ , respectively) and albumin was weakly correlated with PTH and 25-hydroxyvitamin D ( $P = .005$ ,  $r = 0.216$ ;  $P = .012$ ,  $r = 0.173$ , respectively). In

addition, a strong correlation was found between NLR and HSCRCP ( $P < .001$ ,  $r = 0.817$ ) and NLR was inversely correlated with 25-hydroxyvitamin D ( $P < .001$ ,  $r = -0.408$ ). No significant association was found between 25-hydroxyvitamin D and calcium-phosphorus production ( $P = .084$ ). In both of the hemodialysis and PD patients, NLR was positively associated with HSCRCP. A positive HSCRCP ( $> 3$ ) was associated with an NLR greater than 3. An NLR greater than 3 had a 76.38% sensitivity and a 95.92% specificity in the hemodialysis group and a 72.22% sensitivity and a 92.86% specificity in the PD group, to estimate inflammation documented by HSCRCP (Table 5).

**Table 4.** Laboratory Markers by Vitamin D Deficiency

Laboratory Marker	25-Hydroxyvitamin D, ng/dL		P
	< 10	> 10	
Body mass index, kg/m <sup>2</sup>			
Hemodialysis	21.38 ± 3.94	21.51 ± 3.43	.82
Peritoneal dialysis	24.52 ± 5.03	25.21 ± 5.52	.76
Total	22.09 ± 4.38	21.79 ± 3.71	.61
Serum albumin, g/dL			
Hemodialysis	3.71 ± 1.34	3.84 ± 0.99	.47
Peritoneal dialysis	3.26 ± 0.43	3.24 ± 0.78	.94
Total	3.61 ± 1.24	3.79 ± 0.98	.25
Neutrophil-lymphocyte ratio			
Hemodialysis	3.65 ± 0.89	2.93 ± 0.93	< .001
Peritoneal dialysis	2.91 ± 0.90	3.28 ± 1.44	.41
Total	3.49 ± 0.94	2.96 ± 0.97	< .001
High-sensitivity C-reactive protein, mg/dL			
Hemodialysis	14.88 ± 15.70	8.97 ± 12.00	.006
Peritoneal dialysis	9.06 ± 15.86	9.66 ± 6.66	.93
Total	13.60 ± 15.87	9.02 ± 11.71	.02

**Table 5.** Diagnostic Accuracy of Neutrophil-Lymphocyte Ratio Against High-Sensitivity C-Reactive Protein

Parameter	Value (95% Confidence Interval)		
	Hemodialysis	Peritoneal Dialysis	Total
Sensitivity	76.38 (68.03 to 83.46)	72.22 (46.52 to 90.31)	75.86 (68.06 to 82.57)
Specificity	95.92 (86.02 to 99.50)	92.86 (66.13 to 99.82)	95.24 (86.69 to 98.95)
Positive likelihood ratio	18.71 (4.80 to 72.97)	10.11 (1.50 to 68.30)	15.93 (5.26 to 48.25)
Negative likelihood ratio	0.25 (0.18 to 0.34)	0.3 (0.14 to 0.64)	0.25 (0.19 to 0.34)
Positive predictive value	97.98 (92.89 to 99.75)	92.86 (66.13 to 99.82)	97.35 (92.43 to 99.42)
Negative predictive value	61.04 (49.25 to 71.95)	72.22 (46.52 to 90.31)	63.16 (52.64 to 72.83)

## DISCUSSION

Inadequate Vitamin D level is prevalent in ESRD patients receiving hemodialysis and PD and increases mortality and morbidity in these groups of patients.<sup>12</sup> The deficiency in 25-hydroxyvitamin D in ESRD patients is multifactorial: inactivity of patients undergoing replacement therapy, limited exposure to sunlight, a minimal dietary intake of foods containing vitamin D, and the altered skin synthesis of vitamin D related to uremia has been proposed.<sup>16</sup> In this study, The mean 25-hydroxyvitamin D level was  $13.74 \pm 11.25$  ng/dL and  $7.67 \pm 7.67$  ng/dL in the hemodialysis and PD patients and the PD group had a significantly lower level of 25-hydroxyvitamin D in comparison with hemodialysis ones. Studies by Aloni and colleagues and Hanna and colleagues also showed the significant lower level of vitamin D in the PD group,<sup>17,18</sup> which could be due to high losses of both 25-hydroxyvitamin D and vitamin D-binding protein from the peritoneal fluid.<sup>17</sup> In addition, older age of our PD group could have roles in changing absorption and metabolism of vitamin D and could participate in making differences.

In the hemodialysis and PD groups, 7.4% and 3.1% had normal levels of 25-hydroxyvitamin D ( $> 30$  ng/dL), 26.7% and 9.3% had vitamin D insufficiency (15 ng/dL to 30 ng/dL), 65.8% and 87.6% had vitamin D deficiency ( $< 15$  ng/dL), 17.6% and 50% had severe vitamin D deficiency ( $< 5$  ng/dL), and 50.6% and 78.1% had significant vitamin D deficiency (25-hydroxyvitamin D  $< 10$  ng/dL), respectively. Thus, vitamin D deficiency was very prevalent in our both hemodialysis and PD patients. In Ahmadi coworkers' study,<sup>9</sup> severe vitamin D deficiency was 3.4%, mild vitamin D deficiency was 31.0%, vitamin D insufficiency was 36.6%, and vitamin D sufficiency was 29.0%,<sup>9</sup> which were better results than ours. In Marquard colleagues' study,<sup>19</sup> 21.3% of German hemodialysis

patients were found to be vitamin D sufficient and 32.7% were severely deficient ( $< 12.5$  ng/dL); however, Wolf and coworkers<sup>20</sup> found 22% of the United States hemodialysis patients to be vitamin D sufficient but only 18% classified as severely deficient ( $< 10$  ng/dL). The differences may be due to using fortified food with vitamin D in the United States populations. The different amount of vitamin D levels in different studies could be due to different race, nutritional behavior, sun exposure, and different cultural and religion costumes.

In our study, no significant association was found between 25-hydroxyvitamin D levels and sex, BMI, serum calcium, PTH, diabetes mellitus, serum phosphorus, serum albumin, and duration of dialysis in neither of the hemodialysis and PD groups; however, only in the hemodialysis group, NLR, and HSCRPs were significantly associated to 25-hydroxyvitamin D level. Furthermore albumin was weakly and directly correlated with PTH and 25-hydroxyvitamin D. In Bansal and colleagues' study, a weak correlation was found between 25-hydroxyvitamin D levels and BMI, sex, and albumin in the hemodialysis patients.<sup>21</sup> In Satirapoj and colleagues' study, male sex was less frequent and serum albumin and calcium levels were significantly less among patients with a 25-hydroxyvitamin D level of 30 ng/dL and less. In contrast, patients with a 25-hydroxyvitamin D level greater than 30 ng/dL presented significantly increased serum phosphorus levels and PTH levels.<sup>22</sup> Marinelli and coworkers did not find a correlation between 25-hydroxyvitamin D levels and phosphorus and PTH, but there was an association between low vitamin D levels and hypocalcemia.<sup>23</sup>

In Ahmadi and coworkers' study,<sup>9</sup> vitamin D deficiency was significantly associated with central obesity; however, our patient with lower vitamin D levels had higher BMI but the differences were not significant. In Bhan and colleagues' study, 79%

of hemodialysis patients had 25-hydroxyvitamin D levels less than 30 ng/dL, whereas 57% and 20% had levels less than 20 ng/dL and 10 ng/dL, respectively, and low serum albumin levels, black race, female sex, and winter season were associated with an increased risk of vitamin D deficiency.<sup>8</sup> In our study 25-hydroxyvitamin D level in hemodialysis group was associated with high inflammatory levels of factors like HSCRP and NLR; however, we did not find any association with nutritional factors such as albumin and BMI, particularly mainly because of the small number of the PD patients. In contrast to our findings another study<sup>24</sup> showed a strong inverse correlation between HSCRP and 1,25-dihydroxyvitamin D<sub>3</sub> levels in pediatric hemodialysis patients, which was associated with vascular calcification; however, they did not find any association between 25-hydroxyvitamin D and HSCRP.

Wasse and coworkers showed that hemodialysis patients with low 25-hydroxyvitamin D levels had lower calcium and higher phosphorus levels, and 25-hydroxyvitamin D level was positively associated with interleukin-10 levels ( $P = .04$ ) and negatively with matrix metalloproteinase-9 ( $P = .03$ ).<sup>25</sup> Presence of an inflammatory environment with high matrix metalloproteinase-9 and lower interleukin-10 anti-inflammatory factor in vitamin D hypovitaminosis could be consistent with our finding about HSCRP and NLR. In Zhang and associates' study in both hemodialysis and PD patients, depression was associated with higher serum HSCRP levels and lower 25-hydroxyvitamin D levels. They also found that vitamin D supplementation could decrease serum HSCRP level and increase serum vitamin D level, but could not significantly change depressive symptoms.<sup>26</sup> Presence of an inverse relationship between HSCRP and vitamin D was consistent with our study. Matias and coworkers showed vitamin D supplementation in hemodialysis patients could improve vitamin D deficiency and reduce erythropoietin doses and ameliorate cardiac function.<sup>27</sup>

Wang and colleagues found that a low serum 25-hydroxyvitamin D concentration was associated with an increased risk of cardiovascular disease in PD patients.<sup>5</sup> It was also shown that hemodialysis patients with severe vitamin D deficiency (< 10 ng/dL) had significantly increased risk of all-cause mortality compared to patients with normal

25-hydroxyvitamin D levels (> 30 ng/dL).<sup>20</sup> We found that patients with a 25-hydroxyvitamin D level less than 10 ng/dL had higher BMI and lower albumin level in comparison with patients with higher levels of vitamin D, but the difference was not significant; however, the high level of inflammatory factors like HSCRP and NLR in the group with a 25-hydroxyvitamin D less than 10 ng/dL group was significant but the finding the fact that treating vitamin D deficiency could reverse the inflammation and improve survival needs more studies.<sup>20</sup>

On the other hand, in our both hemodialysis and PD patients, NLR was positively correlated with HSCRP. A positive HSCRP (HSCRP > 3) correlated with an NLR greater than 3. In Fu and coworkers' study, NLR was significantly and positively correlated with CRP in rheumatoid arthritis patients.<sup>28</sup> In Forget and coworkers' study, more complications was associated with higher levels of NLR, whereas none of the other factors, including CRP, showed any correlation.<sup>29</sup> Hence, they suggested the inflammatory status of a patient could be assessed easily with the NLR which could be considered as an independent marker of poor prognosis. This simple parameter, associated with systemic inflammation, was initially validated by cardiologists to stratify the risk of mortality after a major cardiac event.<sup>30</sup> The NLR has been shown to be associated with morbidity and mortality of patients with malignancy, cardiovascular disease, chronic kidney disease, and postsurgical complications.<sup>31</sup>

There are limits to this study. Association does not imply causality, and our sample size was small. Further studies are needed to evaluate the consequences of vitamin D deficiency and the impact of therapeutic interventions in ESRD patients. We found that most of our PD and hemodialysis patients were suffering from vitamin D deficiency. Evidence-based clinical guidelines are needed for optimal management, including vitamin D supplements and oral vitamin D receptor agonists in dialysis patients. Another problem with vitamin D supplementation could be hypercalcemia and hyperphosphatemia, which might facilitate metastatic calcification that increase mortality and morbidity; thus, more studies are needed to find the best strategy for vitamin D deficiency management in ESRD patients.<sup>15</sup>

In addition to vitamin D deficiency and its

associations, our results showed a 76.38% sensitivity and a 95.92% specificity for NLR in hemodialysis group and a 72.22% sensitivity and a 92.86% specificity for NLR in the PD group could be used instead of HSCRП as a marker of inflammation, which is a very simple and efficient test and it is available everywhere.

## CONCLUSIONS

Most of our patients undergoing hemodialysis and PD suffer from vitamin D deficiency and inadequate levels of vitamin D was associated with higher levels of inflammatory factors like HSCRП and NLR in both hemodialysis and PD patients. Given the association between low vitamin D levels and increased inflammatory factors, which increase mortality, vitamin D levels should be assayed at least once a year, especially in the winter time in everyday clinical practice. Decision to treat low levels of vitamin D depends on the PTH level, calcium, phosphorus, and other factors. More clinical trials are needed to assess the beneficial effects of vitamin D supplementation and survival benefit in these groups of patients. Also, our study reveals that an easy and inexpensive test of an NLR greater than 3 with good sensitivity and specificity could be used as a measure of inflammation instead of HSCRП in hemodialysis patients to monitor the inflammation, and it is potentially able to help the clinician to perform early diagnoses of dialysis complications.

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## CONFLICT OF INTEREST

None declared.

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