Risk Factor Analysis of Calcification in Aortic and Mitral Valves in Maintenance Peritoneal Dialysis Patients

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Key Words
Peritoneal dialysis • Valve calcification • Risk factors

Abstract
Background/Aims: This study aimed to investigate potential risk factors for calcification in aortic and mitral valves in maintenance peritoneal dialysis (MPD) patients. Methods: We enrolled MPD patients who had undergone over 18 months of dialysis in our dialysis center, examined their cardiac valve calcification status by echocardiography, and recorded their biochemical data and dialysis-related indicators. These results were compared by logistic regression analyses to identify the risk factors associated with calcification in aortic and mitral valves. Results: Among the 117 enrolled MPD patients, 41 exhibited calcification in aortic or mitral valves, including 38 with aortic valve calcification (AVC) and 17 with mitral valve calcification (MVC); 14 of them had calcification in both aortic and mitral valves. Multivariate logistic regression analysis revealed that age (OR=1.965, p=0.01), diabetes history (OR=4.693, p=0.029), calcium-phosphorus product (OR=2.373, p=0.001) and prealbumin (OR=0.908, p=0.012) were independently related to AVC, whereas age (OR=3.179, p=0.023), calcium-phosphorus product (OR=6.512, p=0.001), prealbumin (OR=0.885, p=0.033), high-density lipoprotein (OR=19.540, p=0.011) and diabetes history (OR=6.948, p=0.038) were independently related to MVC. Conclusions: The incidence of cardiac valve calcification in MPD patients is high, and the incidence of AVC is higher than MVC. Age, diabetes history, calcium-phosphorus product and hypo-prealbuminemia are independent risk factors for AVC, whereas age, calcium-phosphorus product and hypo-prealbuminemia are independent risk factors for MVC.
Introduction

Cardiovascular calcification is common in patients with chronic kidney disease and is an independent risk factor that affects cardiovascular and all-cause mortality [1, 2]. Due to the interdependent influences between malnutrition, inflammatory state, atherosclerosis and calcium-phosphorus metabolic disorders, the incidence of cardiac valve calcification is significantly higher in end-stage renal disease patients than the general population [3] and is also a key factor impacting their prognosis [4].

Although many factors, including age, hyperphosphatemia, microinflammatory state and β2-microglobulin elevation, are independent risk factors for cardiac valve calcification in hemodialysis patients [3, 5], there is controversy regarding the independent risk factors for cardiac valve calcification in peritoneal dialysis patients. Age, calcium-phosphorus metabolic disorders and microinflammation state are associated with valve calcification in peritoneal dialysis patients [6]. Nevertheless, a multi-center, prospective study indicated that total cholesterol (TC), triglyceride (TG) and low-density lipoprotein (LDL) levels are risk factors for valve calcification progression, but the report did not confirm the influences of calcium-phosphorus metabolic disorders on valve calcification in peritoneal dialysis patients [7]. Therefore, the risk factors for cardiac valve calcification among peritoneal dialysis patients remain to be further investigated.

This study attempts to examine the risk factors for cardiac valve calcification among peritoneal dialysis patients. We hope that our findings will provide a clinical basis for preventing cardiac valve calcification in peritoneal dialysis patients.

Materials and Methods

Subjects

We enrolled 117 patients undergoing regular peritoneal dialysis who were admitted to our peritoneal dialysis center since 2006. Among them, 98 underwent continuous ambulatory peritoneal dialysis (CAPD) treatment, and 19 received daytime ambulatory peritoneal dialysis (DAPD). The inclusion criteria were 1) age >18 years and 2) >18 months of dialysis. The exclusion criteria were congenital heart valve disease, rheumatic valve disease, hyperthyroid heart disease and acute inflammation. We collected clinical information such as age, gender, dialysis duration, primary kidney disease, diabetes history, course of hypertension (years), hypertension stage, hypertensive duration-stage product and medication.

Methods

Measurements. Blood was collected from all patients under the fasting state in the morning and was used to determine levels of hemoglobin, hematocrit, serum creatinine, urea nitrogen, albumin, prealbumin, parathyroid hormone (PTH), serum calcium, serum phosphorus, C-reactive protein (CRP), 25-hydroxyl vitamin D, TG, TC, high-density lipoprotein (HDL), low-density lipoprotein (LDL) and uric acid. In addition, we calculated total Kt/V (where K=dialyzer clearance of urea, t=dialysis time and V=patient’s body water volume) and conducted a peritoneal equilibration test (PET) for each patient each week under stable conditions.

Echocardiography. Echocardiography for all patients was performed in the ultrasonic laboratory (equipment model: GE Vivid E9) of this hospital. Valve calcification was defined as one or more hyperechoic foci of >1 mm being detected in aortic or mitral valves or rings.

Statistics. Based on the distribution type, data are expressed as either the mean (±s) or median (interquartile range). SPSS17.0 software was used for all statistical analyses. The t test was employed to compare two groups of normally distributed data. The Mann-Whitey U test was used for skewed data. The χ2 test was used for categorical data. For logistic regression analysis, univariate regression analysis was first performed, and the variables with p<0.1 were selected as the covariates for the logistic regression analysis; those variables with two-sided p<0.05 were considered statistically significant.
Results

Clinical data
The 117 patients included 71 males and 46 females with an average age of 56.9±15.0 years, a median dialysis duration of 31 (24, 40) months and an average dialysis of Kt/V of 1.62±0.36. Forty-two subjects had history of smoking, 99 had history of hypertension, 11 had history of coronary heart disease, 32 had history of type II diabetes, and 8 had history of cerebral infarction. One hundred five patients were taking antihypertensive drugs. Among them, 30 were taking one drug, including 21 taking calcium channel blockers (CCBs), 6 were taking angiotensin-converting enzyme inhibitors (ACEIs) or angiotensin II receptor blockers (ARBs) and 3 were taking β-receptor blockers; 75 patients were taking two or more drugs, predominantly the combination of CCB and ARB. Among patients with primary kidney disease, there were 51 cases of primary glomerular disease, 22 cases of diabetic nephropathy, 10 cases of hypertensive nephropathy, 2 cases of lupus nephritis, 8 cases of polycystic kidney disease, 1 case of obstructive nephropathy, 1 case of purpura nephritis and 22 cases with unknown causes.

State of cardiac valve calcification
A total of 41 patients exhibited cardiac valve calcification, including aortic (AVC) and mitral valve calcification (MVC). Specifically, 38 patients displayed AVC and 17 MVC, with 14 patients having both AVC and MVC. In comparison with the AVC-negative group, the AVC-positive group was older (p<0.001); CRP (p=0.034), LDL (p=0.018) and TC were higher (p=0.032); the course of hypertension was longer (p=0.001); the value of the hypertension duration-stage product was higher (p=0.014); and the level of prealbumin was lower (p=0.001) In contrast, there were no significant differences in albumin, hemoglobin, serum calcium, serum phosphorus, calcium-phosphorus product or PTH. The comparison of the MVC-negative and MVC-positive groups revealed that patients in the positive group were older (p=0.005); their dialysis duration was longer (p=0.019); their serum phosphorus (p=0.001), calcium-phosphorus product (p=0.001) and CRP (p=0.034) were higher; and their prealbumin (p=0.011) was lower (Table 1).

Valve calcification and the relevant risk factors
We first performed univariate regression analysis with valve calcification as the dependent variable. The results indicated that age, diabetes history, course of hypertension, hypertensive duration-stage product, calcium-phosphorus product, TC, CRP, albumin and prealbumin were significantly correlated with valve calcification (Table 2). Multivariate regression analysis revealed that age (in increments of 10 years) and calcium-phosphorus product were both independently and positively correlated with valve calcification, whereas prealbumin was independently and negatively correlated with valve calcification (Table 3). Next, we performed univariate regression analysis with AVC or MVC as the dependent variable, and variables with P<0.1 were used as the covariates of multivariate regression analysis (backward method). The results revealed that age (OR=1.965, p=0.01), diabetes history (OR=4.693, p=0.029), calcium-phosphorus product (OR=2.373, p=0.001) and prealbumin (OR=0.908, p=0.012) were independently correlated with AVC (Table 4). In addition, age (OR=3.179, p=0.023), calcium-phosphorus product (OR=6.512, p=0.001), prealbumin (OR=0.885, p=0.033), HDL (OR=19.540, p=0.011) and diabetes history (OR=6.948, p=0.038) were independently correlated with MVC (Table 5).

Discussion
The results of this study show that the incidences of cardiac valve calcification, AVC and MVC among the peritoneal dialysis patients were 35.04%, 32.5% and 14.5%, respectively. Age, calcium-phosphorus product, hypoprealbuminemia and diabetes history were the risk factors for valve calcification.
factors for both MVC and AVC. A previous study observed that the incidence of cardiac valve calcification in dialysis patients was five times that in the general population [8]. Another study showed that in dialysis patients, the incidence of AVC was higher than that of MVC and that the aortic valve was a common location of valve abnormalities in both the general population and hemodialysis patients [9].

In hemodialysis patients, age is an independent risk factor for cardiac valve calcification [5]. Sayarlioglu also reported that the incidence of valve calcification rapidly increased with age [10]. Consistent with these previous studies, our results show that age is an independent risk factor for cardiac valve calcification. Serum calcium and phosphorus levels both play crucial roles in valve calcification of hemodialysis patients [3, 11]. Several cross-sectional clinical studies [12, 13] demonstrated that hyperphosphatemia is closely associated with vascular and valve calcification in end-stage renal disease patients. High phosphorus is also a significant predictor of death in peritoneal dialysis patients [13]. Calcium-phosphorus product has been significantly correlated with valve calcification in peritoneal dialysis

| Item                        | All patients | Aortic valve calcification | Mitral valve calcification |
|-----------------------------|--------------|----------------------------|----------------------------|
|                            | Positive     | Negative                   | Positive                   | Negative                   |
| General data                |              |                            |                            |                            |
| Age (year)                  | 56.9±15.0    | 65.4±11.8                  | 52.9±14.7                  | 66.0±13.8                  | 55.4±14.7                  |
| Gender (male/female)        | 71/46        | 20/18                      | 51/28                      | 8/9                        | 63/37                      |
| Diabetes history (n)        | 32           | 17                         | 15                         | 9                          | 23                         |
| Dialysis duration (month)   | 31(24, 40)   | 31(24, 58)                 | 31(24, 38)                 | 38(29, 60)                 | 30(24, 39)                 |
| Course of Hypertension (years) | 6.0(3.5, 12.0) | 9.0(5.0, 12.25) | 6.0(3.5, 12.0) | 12.0(6.5, 15.0) | 5.0(3.9, 7.5) |
| Hypertension duration-stage product | 8.0(4.0, 12.0) | 12.0(5.0, 18.5) | 8.0(4.0, 12.0) | 15.0(10.5, 19.0) | 6.0(4.0, 12.0) |
| Systolic pressure (mmHg)    | 140±27.4     | 137±25.3                   | 141±28.5                   | 150±23.4                   | 138±25.8                   |
| Diastolic pressure (mmHg)   | 82±15.0      | 78±12.1                    | 84±16.0                    | 81±14.5                    | 82±15.2                    |

Dialysis data

| Item                        | SpKt/V       | PET (Creatinine transport) | Creatinine (μmol/L) | Urea nitrogen (mmol/L) |
|-----------------------------|--------------|-----------------------------|----------------------|-------------------------|
|                            | 1.62±0.36    | 0.59±0.13                   | 957.6±329.1          | 17.4(13.8, 20.8)        |
|                            | 1.63±0.32    | 0.59±0.14                   | 885.3±317.3          | 17.4(12.7, 20.6)        |
|                            | 1.60±0.38    | 0.59±0.14                   | 992.4±330.8          | 17.2(14.0, 21.5)        |
|                            | 1.49±0.28    | 0.57±0.10                   | 950.2±325.0          | 17.2(12.1, 21.1)        |
|                            | 1.63±0.37    | 0.59±0.14                   | 958.9±331.4          | 17.5(13.9, 20.8)        |

Nutrition data

| Item                        | Hemoglobin (g/L) | Prealbumin (mg/mL) | Albumin (g/L) | low-density lipoprotein (mmol/L) | high-density lipoprotein (mmol/L) | Triglycerides (mmol/L) | Total cholesterol (mmol/L) | Alkaline phosphatase (U/L) | C-reactive protein (mg/L) | Calcium (mmol/L) | Phosphorus (mmol/L) | CaP (mmol²/L) | PTH (ng/L) | 25-OH-vitamin D |
|-----------------------------|------------------|--------------------|---------------|---------------------------------|---------------------------------|------------------------|----------------------------|--------------------------|------------------------|-----------------|-----------------|-------------|-----------|-----------------|
|                            | 97.8±23.6        | 29.48±11.06        | 31.5±6.3      | 2.41±0.85                       | 0.98±0.34                       | 1.56(0.98, 2.24)        | 4.33±1.10                  | 76(60, 100)               | 5.6(4.8, 24.5)        | 2.22±0.23       | 1.74±0.53       | 3.86±1.29    | 172(68, 339) | 34(26, 45)      |
|                            | 98.7±24.4        | 24.80±8.53         | 30.1±5.3      | 2.71±0.99                       | 1.01±0.34                       | 1.53(1.00, 2.17)        | 4.65±1.20                  | 78(60, 107)               | 7.1(5.13, 24.5)        | 2.25±0.19       | 1.83±0.59       | 4.14±1.46    | 173(51, 363) | 31(23, 31)      |
|                            | 97.3±23.4        | 31.72±11.52        | 32.1±6.7      | 2.27±0.73                       | 0.97±0.34                       | 1.56(0.93, 2.36)        | 4.17±1.02                  | 76(60, 94)                | 5.2(4.7, 24.5)        | 2.21±0.25       | 1.69±0.50       | 3.72±1.18    | 172(85, 322) | 36(26, 47)      |
|                            | 97.1±17.8        | 23.17±6.72         | 30.6±4.6      | 2.49±0.75                       | 1.11±0.34                       | 1.39(0.97, 1.90)        | 4.25±0.90                  | 85(62, 131)               | 11.2(5.7, 38.4)        | 2.21±0.18       | 2.17±0.54       | 4.84±1.41    | 281(102, 566) | 31(22, 40)      |
|                            | 97.9±24.6        | 30.54±11.35        | 31.6±6.6      | 2.40±0.86                       | 0.95±0.34                       | 1.59(0.98, 2.39)        | 4.33±1.13                  | 74(60, 96)                | 5.4(4.7, 24.4)        | 2.22±0.24       | 1.66±0.50       | 3.69±0.12    | 153(65, 318) | 35(27, 47)      |

Data are expressed as the mean (X±s) when normally distributed or median (interquartile range) for abnormally distributed. a: Comparison of positive group and negative group, p<0.01; b: Comparison of positive group and negative group, p<0.05.

SpKt/V, K=diayzer clearance of urea, t=dialysis time and V=paitent's body water volume
PET, peritoneal equilibration test; CaP, calcium-phosphorus product; PTH, parathyroid hormone
Table 2. Univariate regression analysis for aortic valve calcification and/or mitral valve calcification

| Variable                      | AVC or MVC | AVC | MVC |
|-------------------------------|------------|-----|-----|
| Age (in increments of 10 years)| 0.708      | 0.719| 0.592| 0.010|
| CaP                           | 0.246      | 0.25 | 0.10 | 0.664| 0.002|
| Prealbumin                    | -0.102     | -0.083| 0.001| -0.065| 0.025|
| Diabetes history              | 1.432      | 1.24 | 0.004| 1.326| 0.014|
| Dialysis duration             | ----       | ---- | ---- | 0.025| 0.093| 0.042| 0.022|
| Course of hypertension (years)| 0.088      | 0.086| 0.003| 0.079| 0.01 |
| Hypertensive duration-stage product | 0.023    | 0.021| 0.102| 0.028| 0.04 |
| Total cholesterol             | 0.38       | 0.036| --   | --   |
| C-reactive protein            | 0.01       | 0.052|      |      |
| Albumin                       | -0.071     | 0.039|      |      |
| Hypertension                  | 1.52       | 0.05 |      |      |
| Diastolic pressure            | 0.014      | 0.064|      |      |
| Phosphorus                    |            |      | 1.716| 0.001|
| PTH                           |            |      | 0.001| 0.078|
| High-density lipoprotein      |            |      | 1.225| 0.095|

AVC, Aortic valve calcification; MVC, Mitral valve calcification
CaP, calcium-phosphorus product; PTH, parathyroid hormone

Table 3. Multivariate regression analysis for the risk factors for cardiac valve calcification

| Variable                      | AVC or MVC | \( \beta \) | P   | OR   | 95% CI       |
|-------------------------------|------------|------------|-----|------|--------------|
| Age (in increments of 10 years)| 0.747      | 0.001      | 2.111| 1.377-3.235|
| CaP                           | 0.769      | 0.001      | 2.157| 1.397-3.331|
| Prealbumin                    | -0.111     | 0.002      | 0.895| 0.835-0.959|

AVC, Aortic valve calcification; MVC, Mitral valve calcification
CaP, calcium-phosphorus product

Table 4. Multivariate analysis for the risk factors for aortic valve calcification

| Variable                      | AVC | \( \beta \) | P   | OR   | 95% CI       |
|-------------------------------|-----|------------|-----|------|--------------|
| Age (in increments of 10 years)| 0.676| 0.010     | 1.965| 1.172-3.295|
| CaP                           | 0.864| 0.001     | 2.373| 1.424-3.954|
| Prealbumin                    | -0.096| 0.012    | 0.908| 0.842-0.979|
| Diabetes history              | 1.546| 0.029     | 4.693| 1.173-18.780|

AVC, Aortic valve calcification; CaP, calcium-phosphorus product

Table 5. Multivariate analysis for the risk factors for mitral valve calcification

| Variable                      | MVC | \( \beta \) | P   | OR   | 95% CI       |
|-------------------------------|-----|------------|-----|------|--------------|
| Age (in increments of 10 years)| 1.157| 0.023    | 3.179| 1.176-8.592|
| CaP                           | 1.874| 0.001    | 6.512| 2.389-17.752|
| Prealbumin                    | -0.122| 0.033  | 0.885| 0.791-0.990|
| Diabetes history              | 1.938| 0.038    | 6.948| 1.108-43.552|
| High-density lipoprotein      | 2.972| 0.011    | 19.540| 1.964-194.418|

MVC, Mitral valve calcification; CaP, calcium-phosphorus product

patients [6]. Although this study did not identify a correlation between serum calcium or serum phosphorus level and valve calcification, serum phosphorus in the MVC-positive group was significantly higher than in the MVC-negative group. In addition, calcium-phosphorus product was independently correlated with AVC and MVC, indicating that calcium-phosphorus product is an independent risk factor for AVC and MVC.
This study revealed that hypoprealbuminemia was independently correlated with AVC and MVC, suggesting that nutritional status has important implications for valve calcification in dialysis patients. Peritoneal dialysis patients have higher serum prealbumin than their hemodialysis counterparts [14]. In addition, peritoneal dialysis patients generally have lower incidence of valve calcification than hemodialysis patients [15-18]. Hypoalbuminemia may be one cause of this phenomenon, but the underlying mechanisms of the impact of hypoalbuminemia on valve calcification remain to be further investigated.

Malnutrition, inflammation and oxidative stress are widely present in dialysis patients and are collectively referred to as malnutrition-inflammation syndrome, which is a strong predictor of death of dialysis patients [19]. Sayarlioglu discovered that AVC patients exhibit markedly low levels of serum albumin [10]. Wang Ay et al. found that malnutrition and inflammation are closely associated with valve calcification in peritoneal dialysis patients [6]. Our data show that CRP was higher in the MVC-positive group than in the MVC-negative group, indicating that an inflammatory state is more common in MVC-positive patients than in MVC-negative patients. Oxidative stress is a pivotal common factor for endothelial dysfunction and atherosclerosis. Oxidative stress is enhanced in dialysis patients [20], and malnutrition and inflammation might promote atherosclerosis by boosting oxidative stress [21].

This study revealed that diabetes history was independently correlated with valve calcification. In the general population, diabetes history is a risk factor for cardiac valve calcification[22, 23]. Sayarlioglu proposed that diabetes history might be considered a risk factor for cardiac valve calcification [10]. Nair et al. found that among people younger than 60 years, the valve calcification-positive group had a higher incidence of diabetes than the valve calcification-negative group [24]. In addition, Aronow reported that among people aged over 62 years, those with diabetes were more likely to develop cardiac valve calcification [25]. In another study, peritoneal dialysis patients with cardiac valve calcification had higher systolic blood pressure [26]. In this study, nonetheless, we only found that the course of hypertension was longer and hypertension duration-stage product was higher in the AVC-positive group compared to the AVC-negative group, although multivariate regression analysis revealed no significant difference in these two parameters.

This study was a single-center, observational study with a small sample. A prospective study with a large sample is needed to validate the risk factors for valve calcification. Moreover, we were unable to investigate the influence of fibroblast growth factor 23 on cardiac valve calcification, which is also a shortcoming of this study. Finally, the mechanisms of the effect of hypo-prealbuminemia on valve calcification remain to be determined.

Conclusion

Our study found that the incidence of AVC is higher than MVC in elderly dialysis patients. Age, diabetes history, calcium-phosphorus product and hypo-prealbuminemia are independently both AVC with MVCHDL cholesterol is also independently MVC. It is maybe helpful that we improve nutritional status and rectify mineral metabolism.

Conflict of Interest

Chunyuan Wang and Linsen Jiang contribute equally to this paper. We certify that all authors have no financial or other conflict of interests in connection with the submitted article.
Wang/Jiang/Feng/Shi/Shen/Shi/Wang/Zeng: Risk Factor of CVC in PD Patients

Reference

1. Raggi P, Bellasi A, Gamboa C, Ferramosca E, Ratti C, Block GA, Muntner P: All-cause mortality in hemodialysis patients with heart valve calcification. Clin J Am Soc Nephrol 2011;6:1990-1995.

2. Sharma R, Pellerin D, Gaze DC, Mehta RL, Gregson H, Streather CP, Collinson PO, Brecker SJ: Mitral annular calcification predicts mortality and coronary artery disease in end stage renal disease. Atherosclerosis 2007;191:348-354.

3. Tarrass F, Benjelloun M, Zamd M, Medkouri G, Hachim K, Benghanem MG, Ramdani B: Heart valve calcifications in patients with end-stage renal disease: Analysis for risk factors. Nephrology (Carlton) 2006;11:494-496.

4. Wang AY, Wang M, Woo J, Lam CW, Li PK, Lui SF, Sanderson JE: Cardiac valve calcification as an important predictor for all-cause mortality and cardiovascular mortality in long-term peritoneal dialysis patients: A prospective study. J Am Soc Nephrol 2003;14:159-168.

5. Ikeee R, Honda K, Oka M, Maesato K, Mano T, Moriya H, Ohtake T, Kobayashi S: Association of heart valve calcification with malnutrition-inflammation complex syndrome, beta-microglobulin, and carotid intima media thickness in patients on hemodialysis. Ther Apher Dial 2008;12:464-468.

6. Wang AY, Woo J, Wang M, Sea MM, Ip R, Li PK, Lui SF, Sanderson JE: Association of inflammation and malnutrition with cardiac valve calcification in continuous ambulatory peritoneal dialysis patients. J Am Soc Nephrol 2001;12:1927-1936.

7. Gallieni M, Caputo F, Filippini A, Gabella P, Giannattasio M, Stingone A, Farina M: Prevalence and progression of cardiovascular calcifications in peritoneal dialysis patients: A prospective study. Bone 2012;51:332-337.

8. Herzog CA: Kidney disease in cardiology. Nephrol Dial Transplant 2011;26:46-50.

9. Boon A, Cheriex E, Lodder J, Kessels F: Cardiac valve calcification: Characteristics of patients with calcification of the mitral annulus or aortic valve. Heart 1997;78:472-474.

10. Sayarioglu H, Acar G, Sahin M, Altunoren O, Cosluan Yavuz Y, Nacar AB, Dogan E: Prevalence and risk factors of valvular calcification in hemodialysis patients. Iran J Kidney Dis 2013;7:129-134.

11. Goodman WG, Goldin J, Kuizon BD, Yoon C, Gales B, Sider D, Wang Y, Chung J, Emerick A, Greaser L, Elashoff RM, Salusky IB: Coronary-artery calcification in young adults with end-stage renal disease who are undergoing dialysis. N Engl J Med 2000;342:1478-1483.

12. Ob J, Wunsch R, Turlzer M, Bahmer M, Raggi P, Querfeld U, Mehlis O, Schaefer F: Advanced coronary and carotid arteriopathy in young adults with childhood-onset chronic renal failure. Circulation 2002;106:100-105.

13. Noordzij M, Korevaar JC, Boeschoten EW, Dekker FW, Bos WJ, Krediet RT: The kidney disease outcomes quality initiative (K/DOQI) guideline for bone metabolism and disease in ckd: Association with mortality in dialysis patients. Am J Kidney Dis 2005;46:925-932.

14. Goldwasser P, Feldman JG, Barth RH: Serum prealbumin is higher in peritoneal dialysis than in hemodialysis: A meta-analysis. Kidney Int 2002;62:276-281.

15. Huting J: Mitral valve calcification as an index of left ventricular dysfunction in patients with end-stage renal disease on peritoneal dialysis. Chest 1994;105:383-388.

16. Braun J, Oldendorf M, Moshage W, Heidler R, Zeitler E, Luft FC: Electron beam computed tomography in the evaluation of cardiac calcification in chronic dialysis patients. Am J Kidney Dis 1996;27:394-401.

17. Ribeiro S, Ramos A, Brandao A, Rebelo JR, Guerra A, Resina C, Vila-Lobos A, Carvalho F, Remedio F, Ribeiro F: Cardiac valve calcification in haemodialysis patients: Role of calcium-phosphate metabolism. Nephrol Dial Transplant 1998;13:2037-2040.

18. Ventura JE, Tavella N, Romero C, Petraglia A, Baez A, Munoz L: Aortic valve calcification is an independent factor of left ventricular hypertrophy in patients on maintenance haemodialysis. Nephrol Dial Transplant 2002;17:1795-1801.

19. Kalantar-Zadeh K, Kopple JD, Kamranpour N, Fogelman AM, Navab M: HDL-inflammatory index correlates with poor outcome in hemodialysis patients. Kidney Int 2007;72:1149-1156.

20. Maggi E, Bellazzi R, Falaschi F, Frattoni A, Perani G, Finardi G, Gazo A, Nai M, Romanini D, Bellomo G: Enhanced ldl oxidation in uremic patients: An additional mechanism for accelerated atherosclerosis? Kidney Int 1994;45:876-883.
21 Stenvinkel P, Heimburger O, Lindholm B, Kaysen GA, Bergstrom J: Are there two types of malnutrition in chronic renal failure? Evidence for relationships between malnutrition, inflammation and atherosclerosis (mia syndrome). Nephrol Dial Transplant 2000;15:953-960.

22 Adler Y, Fink N, Spector D, Wiser I, Sagie A: Mitral annulus calcification—a window to diffuse atherosclerosis of the vascular system. Atherosclerosis 2001;155:1-8.

23 Mohler ER, 3rd: Mechanisms of aortic valve calcification. Am J Cardiol 2004;94:1396-1402, A1396.

24 Nair CK, Sudhakaran C, Aronow WS, Thomson W, Woodruff MP, Sketch MH: Clinical characteristics of patients younger than 60 years with mitral anular calcium: Comparison with age- and sex-matched control subjects. Am J Cardiol 1984;54:1286-1287.

25 Aronow WS, Schwartz KS, Koenigsberg M: Correlation of serum lipids, calcium and phosphorus, diabetes mellitus, aortic valve stenosis and history of systemic hypertension with presence or absence of mitral anular calcium in persons older than 62 years in a long-term health care facility. Am J Cardiol 1987;59:381-382.

26 Yilmaz M, Unsal A, Oztekin E, Kesmezacar O, Kaptanogullari OH, Eren N: The prevalence of hypertension, valve calcification and left ventricular hypertrophy and geometry in peritoneal dialysis patients. Kidney Blood Press Res 2012;35:431-437.