ORIGINAL ARTICLE

OSTEOPOROSIS IN CHRONIC KIDNEY DISEASE

Kronik Böbrek Hastalığında Osteoporoz

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ABSTRACT

Objective: When determining the treatment modality for bone mineral disorder in hemodialysis patients, the aim is to create an appropriate treatment approach by considering vascular complications.

Material and Methods: Thirty-three individuals (mean age 72.36±6.55 years; 20 females, 13 males) on hemodialysis for chronic kidney disease were included in the study. Body mass index, calcium, phosphorus, parathormone, bone densitometry results were recorded. In addition, the presence of intravascular calcification in the aorta on radiographs taken within the last 6 months was recorded. The relationships between these parameters were analyzed. Data were analyzed in SPSS. $p< 0.05$ was considered statistically significant.

Results: When the Dual-X-ray Absorptiometry (DEXA) scores of 33 individuals with stage 5 Chronic Kidney Disease (CKD) on hemodialysis were analyzed, the difference between T scores and Parathyroid hormone (PTH) values was found to be significant (p=0.020). As PTH increases, the risk of osteoporosis also increases. Osteopenia and osteoporosis were observed less in individuals with high calcium-phosphorus product. However, the difference between intravascular calcification and calcium-phosphorus product was significant (p=0.004). The calcium-phosphorus product was significantly higher in the group with extensive aortic calcification compared to the other groups. Calcium-containing agents given with osteoporosis treatment increase cardiovascular mortality in stage-5 chronic kidney disease.

Conclusion: Bone mineral density disorders should be treated in hemodialysis patients without increasing vascular calcification. In hemodialysis patients with high risk of cardiovascular disease, osteopenic follow-up can be performed by considering the benefit-harm relationship.

Keywords: *Bone Mineral Density Disorder; Osteoporosis; Hemodialysis; Cardiovascular Mortality*

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ÖZET

Amaç: Hemodiyaliz hastalarında kemik mineral yoğunluğunun azalması nedeniyle tedavi modalitesini belirlerken, vasküler komplikasyonları da göz önünde bulundurarak uygun tedavi yaklaşımını oluşturmak amaçlanmaktadır.

Gereç ve Yöntemler: Çalışmaya kronik böbrek hastalığına bağlı hemodiyaliz ile takipli 33 birey (ortalama yaş 72,36±6,55 olup; 20 kadın, 13 erkek) dahil edilmiştir. Hastaların beden kitle indeksleri, kalsiyum, fosfor, parathormon, kemik dansitometri sonuçları kaydedildi. Ayrıca bireylerin son 6 ay içerisinde çekilmiş grafilerinde aortada damar içi kalsifikasyon varlığı kaydedildi. Bu parametreler arasındaki ilişkiler incelendi. Veriler SPSS de analiz edildi. $p< 0,05$ istatistiksel açıdan anlamlı kabul edildi.

Bulgular: Evre 5 Kronik Böbrek Hastalığı (KBH) hemodiyalize giren 33 bireyin kemik dansitometri (DEXA) skorları incelendiğinde T skorları ile Parathormon (PTH) değerleri arasındaki farklılık önemli bulundu (p=0,020). PTH arttıkça osteoporoz riski de artmaktadır. Kalsiyum-fosfor çarpımı yüksek olan bireylerde osteopeni ve osteoporoz daha az gözlendi. Ancak damar içi kalsifikasyon ile kalsiyum-fosfor çarpımı karşılaştırıldığında aralarındaki fark anlamlı bulundu (p=0,004). Aortada kalsifikasyonun yaygın olduğu grupta kalsiyum-fosfor çarpımının diğer gruplarla karşılaştırıldığında daha anlamlı olarak daha yüksek olduğu gözlendi. Osteoporoz tedavisi ile verilen kalsiyum içerikli ajanlar Evre-5 kronik böbrek hastalığında kardiyovasküler mortaliteyi artırmaktadır.

Sonuç: Hemodiyaliz hastalarında vasküler kalsifikasyonu artırmadan kemik mineral dansite bozuklukları tedavi edilmelidir. Kardiyovasküler hastalık riski yüksek olan hemodiyaliz hastalarında fayda zarar ilişkisi gözetilerek osteopenik takip yapılabilir.

Anahtar Kelimeler: *Kemik Minerak Dansite Bozukluğu; Osteoporoz; Hemodiyaliz; Kardiyovasküler Mortalite*

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Geliş tarihi/Received: 08.08.2024
Kabul tarihi/Accepted: 07.03.2025
DOI: 10.16919/bozoktip.1529626

Bozok Tıp Derg 2025;15(2):125-131
Bozok Med J 2025;15(2):125-131

INTRODUCTION

Chronic kidney disease refers to functional and structural abnormalities that may cause impairment in renal function for more than 3 months. According to the Kidney Disease: Improving Global Outcomes (KDIGO) classification, end-stage renal failure is defined as a glomerular filtration rate below 15 ml/min/1.73 m2. In addition to medical treatment, renal replacement therapies such as hemodialysis and peritoneal dialysis are applied (1,2).

In chronic kidney disease, damage to the skeletal system occurs due to bone mineral disorder. Factors that cause this can be listed as insufficient vitamin D, bone loss secondary to uremia, electrolyte disorders, acid-base imbalances, excessive use of phosphate binders, hyperparathyroidism, hypoparathyroidism, dialysis-related amyloidosis, heparin use during dialysis, anemia, inflammation (3).

Osteoporosis is one of the bone mineral disorders encountered in chronic kidney disease. Direct radiography, computer tomography, bone densitometry and bone biopsy can be used in the diagnosis of osteoporosis. Bone densitometry is the most commonly used in clinical practice (4). Bone mineral density screening is recommended in patients with Chronic Kidney Disease (CKD) at risk for osteoporosis. (5,6). Lumbar and vertebral bone density is assessed by T and Z scores. The T score compares expected bone mineral density values in young and healthy individuals of the same sex, whereas the Z score compares bone mineral density values in individuals of the same age and sex. The T score is preferred in postmenopausal women and older men (7).

In treatment, the patient should be informed about increasing physical activity. Vitamin D should be replaced so that it is above 30 ng/dl. However, vitamin D should be avoided in the presence of hyperphosphatemia and hypercalcemia with PTH below 150 pg/ml. Hypocalcemia should be prevented, phosphorus should be restricted in the diet and phosphate binders should be used if necessary. Parathyroid hormone (PTH) should be kept in the range of 150-300 pg/ml. Calcimimetics and parathyroidectomy should also be considered in treatment. If there is no bone fracture in stage 5 patients, bisphosphanate should not be used. In patients in whom bisphosphonate is indicated, the maximum duration of treatment at half dose should be planned not to exceed 3 years (8-10).

Impaired mineralization caused by chronic kidney disease can lead to calcium and phosphorus deposits in the blood vessels. This can lead to atherosclerosis. It is very difficult to demonstrate atherosclerosis in patients with chronic kidney disease. Because in most of the methods used, we are faced with nephrotoxicity due to radiopaque material. For this reason, various methods have been developed to demonstrate atherosclerosis in this patient group, and one of them is calcification of the calcification level in the abdominal center on direct radiography. Thus, it is possible to make predictions about cardiovascular risk (11,12).

MATERIALS AND METHODS

Our study was approved by the Yozgat Bozok University Clinical Research Ethics Committee on 24.11.2022 with the protocol code 2017-KAEK-189_2022.11.24_02. Consent was obtained from the individuals participating in the study.

Based on KDIGO chronic kidney disease staging, 75 patients who were grouped as Stage 5 with a Glomerular filtration rate (GFR) below 15 and had been on hemodialysis for at least 3 months and three times a week for renal replacement therapies were included in our study. However, 42 of the 75 patients included in the study did not have bone densitometry since the women were under 65 years of age and the men were under 70 years of age, and were therefore excluded from the study.

Personal information such as age, gender, race as well as medical history and medications were recorded. Height and weight values were measured. Body mass index was calculated as weight/height^2. Calcium (Ca), phosphorus (P), PTH, vitamin D levels were recorded from the dialysis input blood of the individuals. Bone mineral density was measured according to the standards and measurements from lumbar and vertebral bones were recorded as T and Z scores. The presence of intravascular calcification in the aorta on radiographs taken within the last 6 months was graded on the basis of deposition indices as absent, minimal, or extensive (if it covered more than half of the aorta in the long axis). Comparisons were made with available computed tomography (CT) images of the individuals

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to confirm that the observational examination matched. Calcification conditions in the aorta on previously taken thoracic-abdominal tomographies were recorded from the radiology reports.

Individuals with acute renal failure, those who have been on hemodialysis for less than 3 months, individuals receiving treatment for bone mineral density disorders, individuals receiving lipid-lowering therapy, individuals receiving anticoagulant or antiaggregant therapy other than standard heparin used during hemodialysis, individuals with a body mass index of 35 kg/m² and above, and pregnant women were not included in the study.

Data were analyzed in statistical pacage for social sciences (SPSS version 20.0 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0 Armonk, NY: IBM Corp.)). Categorical measurements were summarized as number and percentage, continuous measurements were summarized as mean and standard deviation (median and min-max where necessary). Kruskal Wallis test was used to evaluate the significance of the difference between the group average in groups that did not show normal distribution. Analysis of variance and Tukey test were used to analyze the data. Statistically, $p<0.05$ was considered significant

RESULT

The study included 33 individuals who were followed up with hemodialysis due to chronic kidney disease. Of these individuals, 13 (39.4%) were male and 20 (60.6%) were female. Minimum age was 64 years and maximum age was 91 years, mean age was 72.36±6.55 years and median age was 71 years. Bone densitometry values performed within the indication were recorded (Table 1).

According to the recorded bone densitometry results, individuals were divided into three groups: a group with healthy bone densitometry results without osteoporosis, osteopenia, or both. When dexa scores of 33 individuals were analyzed, the difference between T scores and PTH values was found to be significant ($p<0.05$). The average parathormone level in individuals with osteoporosis was found to be more than 2 times higher than in individuals with osteoporosis. As the parathormone value increased, the risk of osteoporosis increased ($p = 0.02$). As a result, the relationship between parathormone level and bone mineral density is clearly observed. Osteoporosis was observed more in individuals with low vitamin D levels. The results show that the protective effect of vitamin D on bone is also important in this patient group. Osteopenia and osteoporosis were observed less in individuals with high calcium-phosphorus product. Data show the effect of calcium and phosphorus levels on bone and the necessity of CaxP monitoring for bone health. Body mass index (BMI) was calculated based on dry weight. No correlation was found between BMI and bone mineral density disorders in hemodialyzed individuals (Table 2).

Individuals were divided into 3 groups according to their calcification status in the aorta: non-existent, minimal and obvious. While the number of individuals without calcification was 14, minimal calcification was detected in 8 patients and overt calcification was detected in 11 patients. The product of the patients' serum calcium and phosphorus values taken before hemodialysis was calculated. It was observed that the calcium-phosphorus product was significantly higher in the group with extensive calcification in the aorta compared to the other groups ($p<0.05$). When the values were compared pairwise, the difference between non-calcification and diffuse, minimal and diffuse was found to be significant, while the difference between non-calcification and minimal group was found to be insignificant (Table 3).

Table 1. General data and mean values of the patients

Age (years)	72.36 ± 6.55 (64-91)
Gender (male/female)	20 (%60.6) / 13 (%39.4)
Weight –kilogram (kg)	75.71 ± 14.48
Length—metre (m)	1.64 ± 0.94
Body mass index - kg/m2	28.07 ± 4.89
T score (lumbar/femur)	-0.29 / -2.15

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Table 2. The Relationship of Bone Densitometry Results with Biochemical Markers and Body Mass Indexes in Hemodialysis Patients

	Non osteoporotic and Non osteoporosis	Osteopenia	Osteoporosis	Result
N (number of individuals)	3	21	9	33
Parathormon	209.00± 93.95	355.97± 31.72	713.86± 40.84	F=4.47 p=0,020
Vitamin D	17.46±7.16	14.95±10.33	10.07±3.84	F=1.29 p=0.307
Calcium-phosphorus product	20.95±3.49	17.43±5.66	18.05±4.89	F=0.57 p=0.569
Body mass index-kg/m²	27.41±3.31	27.71±4.55	29.14±6.28	F=0.28 p=0.755

*p <0.05 significant, (Bone mineral density measurement sites are lumbar vertebrae (1-4) and femur total and femoral neck. The T score was based on comparison with the younger population, while the Z score was based on comparison with the same age group. T score is more appropriate for postmenopausal women and both sexes over 65 years of age. T score > -1 is normal; T score -1 to -2.5 osteopenia; T score < -2.5 is considered osteoporosis)

Table 3. The relationship between intravascular calcification levels and serum Ca X P product in hemodialysis patients

Calcification in the aorta	N	Calcium-phosphorus product (mg/dl)	Result
Non-	14	15.31 ± 5.00	F=6.70 p =0.004*
Minimal	8	16.49 ±1.63	
Widespread	11	21.47 ± 4.58	
Total	33	17.65 ± 5.00	

(p<0.05 significant), mg: milligram, dl: deciliter

DISCUSSION

Bone mineral disorders are a common condition that increases with age and cause serious deterioration in quality of life when left untreated. Some chronic diseases have a higher risk of developing bone mineral disorders. Chronic kidney disease is one of them. Compared to the normal population, the risk of fracture, which is both itself and one of the complications of bone mineral density disorders, was found to be quite high in stage 5 chronic kidney disease patients (13). In our study, there were 33 individuals who underwent bone densitometry in hemodialysis patients with end-stage renal failure, especially within the indication due to age. In our study, bone mineral disorder was found in 90% of hemodialysis patients. This result shows that chronic kidney disease, especially hemodialysis, should be considered as a major risk factor for bone mineral disorders and screening criteria can be established for individuals undergoing hemodialysis at an early age.

The incidence of osteoporosis may vary in renal replacement therapy methods. In a study by Aslan et al. comparing the risk of osteoporosis in hemodialysis and peritoneal dialysis patients, peritoneal dialysis was found to be less risky. When deciding on renal replacement therapy in individuals with additional risk factors for osteoporosis, peritoneal dialysis may be considered as an alternative to hemodialysis (14). Although the risk of osteoporosis increases in the first period after renal transplantation, transplantation has been shown to be protective for bone mineral disease in the long term. In appropriate patients, early transplantation may be recommended in all aspects (15,16).

Obesity is known to be protective in osteoporosis (17). In our study, the mean body mass index of 33 individuals undergoing hemodialysis was found to be 28.07 ± 4.89 kg/m². Although the mean body mass index was within the range considered overweight; bone mineral density disorder was found in 90% of our patients. Our study shows that the ideal weight in these individuals is not the same as in individuals with normal renal function; the protective effect of obesity on osteoporosis is not

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valid in hemodialysis patients.

Limited methods are used to demonstrate coronary artery calcification in individuals with renal failure. Because nephrotoxicity develops with the use of radiopaque material in standard examinations (such as interventional angiography, CT angiography) and progression of existing renal impairment is facilitated (18). For this reason, new noninvasive methods that would be the least nephrotoxic have been tried to be developed in patients for many years. In similar studies by Nallamothu et al. and Raggi et al. the correlation of angiography results with electron-beam computed tomography to demonstrate vascular calcification was examined. They found a statistically significant correlation between imaging and angiography results (19,20). In the study conducted by Wilson et al. on 2515 individuals, direct radiography was shown to be a method that can be used to show vascular calcification in almost most centers. In the study by Toussaint et al. it was concluded that abdominal aorta could be evaluated with lumbar radiography to show calcification. Calcific deposits in the aorta were classified and graded on abdominal radiographs (21,22). In our study, the presence of calcification was graded from the available radiographs of the patients and its accuracy was confirmed with the available computed tomography of the individuals.

Combating hyperphosphatemia in renal failure is very important. In cases where phosphorus levels exceed 6.5 mg/dl, mortality has been reported to increase with an increase in calcium. When the calcium phosphorus product exceeded 70 mg/dl, the risk of death increased by 34%. The reason for this increase in mortality is that when the calcium phosphorus product is 55 mg/dl, calcium phosphorus accumulation in tissues and vascular structures increases and causes intravascular calcifications (23,24). Agents used to prevent hyperphosphatemia may cause hypercalcemia and increase intravascular calcifications. Similarly, the aim of treatments used for osteoporosis is to increase bone mineralization. While osteoporosis is treated as a result of increased blood calcium with the treatment given, calcium and phosphorus levels should be closely monitored in patients with chronic kidney disease in order not to cause intravascular calcification. Especially in stage 5 hemodialysis patients, the use of high calcium-containing treatments should be avoided unless necessary (25). In the study by Okuno et al. it was aimed to evaluate whether abdominal aortic calcification is a reliable method in hemodialysis patients as well as being reported as a marker of cardiovascular mortality in the community. A total of 515 hemodialysis patients with stage 5 renal disease were included in the study. Abdominal lateral radiography has been found to have prognostic significance as a cardiovascular indicator in hemodialysis patients (26).

Similarly, in our study, as the calcium phosphorus product increased, the presence of intravascular calcification increased correlatively. The patients with chronic kidney disease included in the study were in the risk group who had never received osteoporosis treatment. Although the majority of the patients were in the osteopenic group, no correlation was found between intravascular calcification and bone mineral density in individuals with osteoporosis. The reason was thought to be that the deficient mineralization in the bones was obtained from the blood and was not present at the level to accumulate in the vein for a long time. When the bones reach sufficient saturation with minerals, accumulation occurs in the vessels. Therefore, it is necessary to compare the intravascular calcifications of these patients after osteoporosis treatment with those before.

There are some limitations in our study. The first of these is that calcifications cannot be shown more clearly with angiographic CT or interventional CT, the second is that the patients in our study are not available for comparison before and after osteoporosis treatment and the calcifications cannot be followed, and the third is that individuals do not have bone densitometric measurements before the development of osteoporosis.

CONCLUSION

It is very difficult and important to diagnose osteoporosis and manage the treatment process in chronic kidney disease, especially in hemodialysis patients. Bone mineral density disorders should be identified before the development of complications that will affect the comfort of life of the individual. Establishing a protocol that takes into account cardiovascular mortality both during the selection of renal replacement therapy,

when choosing a more appropriate treatment than hemodialysis, and when providing post-diagnostic treatment is a very demanding process. The need for appropriate treatment protocols for these individuals is obvious. Bone mineral density disorders should be treated without affecting cardiovascular mortality in hemodialysis patients. In order not to increase cardiovascular mortality, hemodialysis can be followed by osteopenic patients, taking into account the profit-loss relationship.

Acknowledgment

The authors declare that they have no conflict of interest to disclose.

REFERENCES

1. De Boer I. H, Caramori M. L, Chan J. C, Heerspink H. J, Hurst C, Khunti K. et al. Executive summary of the 2020 KDIGO Diabetes Management in CKD Guideline: evidence-based advances in monitoring and treatment. Kidney Int. 2020;98(4):839-48

2. Bıçakçı Ş, Sezer M. 2014-2018 Yılları Arasında Ülkemizde Uygulanan Renal Replasman Tedavilerinin Genel Değerlendirmesi. Aydın Sağlık Dergisi. 2020; 6(2): 79-89.

3. Zheng CM, Zheng JQ, Wu CC, Lu CL, Shyu JF, Yung-Ho H, et al. Bone loss in chronic kidney disease: Quantity or quality? Bone. 2016; 87: 57-70.

4. Nazia Fathima SM, Tamilselvi R, Parisa Beham M, Sabarinathan D. Diagnosis of Osteoporosis using modified U-net architecture with attention unit in DEXA and X-ray images. J Xray Sci Technol. 2020;28(5):953-73.

5. Haarhaus M, Aaltonen L, Cejka D, Cozzolino M, de Jong RT, D'Haese P,et al. Management of fracture risk in CKD-traditional and novel approaches. Clin Kidney J. 2022:22;16(3):456-72.

6. Kültür T, Çifci A, İnanır A. Kronik böbrek hastalığında kemik-mineral metabolizması bozuklukları (renal osteodistrofi) ve tedavi yaklaşımı. Ortadoğu Tıp Dergisi 2016;8(4):214-7.

7. Yıldırım M.A. Osteoporoz Tanısı ve İzlem Parametreleri. Aile Hekimliği. 2019;11:119-21.

8. Kışlak P, Genç F. Osteoporoz ve Tedavisi. Lectio Scientific. 2019; 3(1): 1-18.

9. Taş N. Osteoporoz için Çeşitli İlaçlı Tedavi Seçeneklerinin Etkinliği Üzerine Bir Meta-analiz. Gümüşhane Üniversitesi Sağlık Bilimleri Dergisi. 2023;12.(3):1131-40.

10. Akalın A. Osteoporoz ve Metabolik Kemik Hastalıkları Tanı ve Tedavi Kılavuzu. 15. Baskı Ankara Türkiye Endokrinoloji Metabolizma Derneği. 2022: 89-114.

11. Benjamens S, Pol RA, Glaudemans AWJM, Wieringa I, Berger SP, Bakker SJL, et al. A high abdominal aortic calcification score by dual X-ray absorptiometry is associated with cardiovascular events after kidney transplantation. Nephrol Dial Transplant. 2018; 33(12):2253-9.

12. Sethi A, Taylor DL, Ruby JG, Venkataraman J, Sorokin E, Cule M, et al. Calcification of the abdominal aorta is an under-appreciated cardiovascular disease risk factor in the general population. Front Cardiovasc Med. 2022;6(9):1003246.

13. Festuccia F, Jafari MT, Moioli A, Fofi C, Barberi S, Amendola S, et al. Safety and efficacy of denosumab in osteoporotic hemodialysed patients, J Nephrol. 2017; 30(2): 271-9.

14. Aslan B, Sarı F. Hemodiyaliz ve Periton Diyalizi Yapan Hastalarda Osteoporoz Sıklığı ve Osteoporoz Gelişmesini Etkileyen Faktörler. Akdeniz Tıp Dergisi.2021; 7(2): 277-82.

15. Bloemendal N. T, Hertsig R, Benjamens S, van de Kuit A, Swaab T, Yakar D, et al. Atherosclerosis and Intrarenal Resistance Index in Kidney Transplant Recipients. Transplant Direct. 2023: 12;9(2):e1435.

16. Mercantepe F. Solid Organ Nakilli Hastalarda Osteoporoz: Yönetim Ve Tedavi. Aegean. 2021:67-76.

17. Koçak B, Yüksel A. Kemik-eklem hastalıklarının obezite ile ilişkisi. Sağlık ve Yaşam Bilimleri Dergisi. 2021; 3(1): 97-100.

18. Acartürk G, Kazancıoğlu R, Memişoğlu E, Tepe S, Çalışkan Y, Türkmen A ve ark. Renal Replasman Tedavisi Gören Hastalarda Koroner Arter Kalsifikasyonu. İst Tıp Fak Derg. 2011;70(1):1-5.

19. Nallamothu BK, Saint S, Bielak LF, Sonnad SS, Peyser PA, Rubenfire M, et al. Electron-beam computed tomography in the diagnosis of coronary artery disease. Arch Intern Med. 2001; 161:833-8.

20. Raggi P, Cooil B, Hadi A, Friede G. Predictors of aortic and coronary artery calcium on a screening electron beam tomographic scan. Am J Cardiol. 2003; 1:744-6.

21. Wilson PW, Kauppila LI, O'Donnell CJ, Kiel DP, Hannan M, Polak JM, et al. Abdominal aortic calcific deposits are an important predictor of vascular morbidity and mortality. Circulation. 2001;103(11):1529-34.

22. Toussaint ND, Lau KK, Strauss BJ, Polkinghorne KR, Kerr PG. Determination and validation of aortic calcification measurement from lateral bone densitometry in dialysis patients. Clin J Am Soc Nephrol. 2009;4(1):119-27.

23. Doğukan A, Utaş C. Kronik böbrek yetersizliğinde hiperfosfatemi tedavisi: Yeni Ajanlar. Türk Nefroloji Diyaliz ve Transplantasyon Dergisi.2000; 3:130-4.

24. Copland M, Komenda P, Weinhandl ED, McCullough PA, Morfin JA. Intensive Hemodialysis, Mineral and Bone Disorder, and Phosphate Binder Use. Am J Kidney Dis. 2016;68(5S1):24-32.

25. Ferraresi M, Pia A, Guzzo G, Vigotti FN, Mongilardi E, Nazha M, et al. Calcium-phosphate and parathyroid intradialytic profiles: A

potential aid for tailoring the dialysate calcium content of patients on different hemodialysis schedules. Hemodial Int. 2015;19(4):572-82.

26. Okuno S, Ishimura E, Kitatani K, Fujino Y, Kohno K, Maeno Y, et al. Presence of abdominal aortic calcification is significantly associated with all-cause and cardiovascular mortality in maintenance hemodialysis patients. Am J Kidney Dis. 2007;49(3):417-25.