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Original research

STUDY OF BONE MINERAL DISORDERS IN HEMODIALYSIS PATIENTS AT HUE CENTRAL HOSPITAL

Dinh Thi Minh Hao[1,2], Ho Thi Hong Nhung[1], Bui Thi Minh Ngoc[1], Nguyen Thi Minh Phuong[1], Thai Doan Quang Hung[1]

[1]Hemodialysis Department, Hue Central Hospital, Hue, Viet Nam

[2]Hue University of Medicine and Pharmacy, Hue, Viet Nam

ABSTRACT

Aims: *Early detection and correction of calcium-phosphate imbalances to improve symptoms of hyperuremia, slow the progression of chronic kidney disease and reduce the risk of death from cardiovascular complications and renal osteodystrophy dues to secondary hyperparathyroidism.*

Methods: *Cross-sectional study on 101 patients with end-stage chronic kidney disease on hemodialysis at the Hemodialysis Department in Hue Central Hospital.*

Results: *The rate of bone mineral factor disorders was arranged in the order of phosphorus (86,1%), calcium x P (60,4%), PTH (49,5%) and calcium (19,8%). There were 12 patients (11,9%) with osteoporosis and 38 patients (37,6%) with osteopenia. There were 60 patients (59,4%) with abdominal aortic calcification. There were 11 patients (10,89%) acquire heart valve calcification. Age and BMI predicted the risk of decreased bone density at all 3 locations: lumbar spine, total femur and femoral neck with p < 0,0001. Age and time of dialysis predicted the risk of abdominal aortic calcification, in which age had the highest predictive value (OR = 1,07, p < 0,0001).*

Conclusion: *The rate of patients with bone mineral disorders in the study group is still high. More attention should be paid to the detection and correction of bone mineral disorders according to KDIGO 2017 recommendations in patients on hemodialysis.*

Keywords: *Chronic kidney disease, hemodialysis, bone density, osteoporosis, abdominal aortic calcification, heart valve calcification.*

I. INTRODUCTION

An important issue related to mortality in patients with chronic kidney disease (CKD) is osteoporosis-related fractures and cardiovascular events caused by vascular calcification [10]. In 2017, KDIGO continued to update and adjust 15 out of 39 recommendations from 2009 with the aim of early and active detection and treatment of bone and bone mineral abnormalities in patients with CKD and hemodialysis (HD) [8,9].

Therefore, we conducted study: "Study of bone mineral disorders in patients with end stage chronic kidney disease on hemodialysis at Hue Central Hospital" in order to deal with objectives: Evaluate bone mineral disorders in CKD patients on hemodialysis at Hue Central Hospital; and survey some factors related to bone mineral disorders in CKD patients on hemodialysis at Hue Central Hospital.

II. MATERIALS AND METHODS

Subjects: 101 patients with end-stage chronic kidney disease (ESKD) on hemodialysis at the Hemodialysis Department.

Selection criteria: Age: ≥ 18; Agree to participate in the study. CKD without kidney transplant

Exclusion criteria: Patients diagnosed with acute kidney injury (AKI); Patients who are in

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Corresponding author: Dinh Thi Minh Hao. Email: minhhaodinh@gmail.com. Phone: +84 905336951

life-threatening critical circumstance; Use of any medicines that affect bone turnover; History of pathological conditions that affect bone turnover; Women with uterine-ovarian diseases; Patients with neuropsychiatric disorders that affect cognition.

Research design: Descriptive, cross-sectional study. Data collection started in April 2024.

Research process: Diagnosis of bone mineral disorders according to KDIGO 2017 criteria; Measurement of bone density by dual-energy X-ray absorptiometry, diagnosis of osteoporosis according to WHO 1994

Imaging techniques to examine vascular calcification: Lateral abdominal X-ray technique. Assessment of abdominal aortic calcification using the Kauppila score.

+ Echocardiography to examine calcification on cardiovalves.

III. RESULTS

The rate of bone mineral factor disorders was phosphorus (86,1%), calcium x P (60,4%), PTH (49,5%) and calcium (19,8%) (Table 1). The rate of patients meeting the bone mineral concentration standards according to KDIGO decreased as follows: Calcium (80,2%), PTH (50,5%), phosphorus (13,9%). The rate of patients meeting the 3 bone mineral standards (Ca, P, PTH) according to KDIGO was only 5,94% (Table 2).

Table 1: Disorders of bone mineral indices according to KDIGO

Type of disorder		Normal	Disorder	Total
Calcium	n	81	20	101
	%	80.2	19.8	100
Phosphorus	n	14	87	101
	%	13.9	86.1	100
Ca x P	n	40	61	101
	%	39.6	60.4	100
PTH	n	51	50	101
	%	50.5	49.5	100

Table 2: Percentage of patients meeting bone mineral index standards according to KDIGO

Bone Minerals (n = 101)	Meet the standards		Substandard	
	n	%	n	%
Calcium	81	80.2	20	19.8
Phosphorus	14	13.9	87	86.1
PTH	51	50.5	50	49.5
Meet all 3 factors	6	5.94	95	94.06

Bone density decreased in the following order: lumbar spine (1,080 ± 0,186g/cm2), total femur (0,891 ± 0,164g/cm2), femoral neck (0,862 ± 0,190g/cm2). The average bone density at the 3 measurement locations was statistically significantly different (p < 0,0001) (Table 3). According to WHO 1994 standards, the study group had 12 patients with osteoporosis (11,9%) and 38 patients with osteopenia (37,6%) (Table 4).

Table 3: Average bone density measured at the lumbar spine, total femur, femoral neck

Bone density	n	Average ± SD (g/cm²)	Min-Max
Lumbar spine	101	1.080 ± 0.186	0.522 - 1.504
Total femur	101	0.891 ± 0.164	0.360 - 1.333
Femoral neck	101	0.862 ± 0.190	0.316 - 1.420
p = 0.0001			

Table 4: Osteoporosis rate according to WHO 1994

Bone Status	Quantity	Ratio
Normal	51	50.5
Osteopenia	38	37.6
Osteoporosis	12	11.9
Total	101	100

Up to 49,5% of patients in the study group had moderate and severe abdominal aortic calcification (Table 5). There were 10,89% of patients in the study group with heart valve calcification (Table 6).

Table 5: Abdominal aortic calcification

Level	Quantity	Ratio
No	41	40.6
Mild	10	9.9
Moderate-Severe	50	49.5
Total	101	100

Table 6: Calcification of heart valves

Calcification of heart valves	Quantity	Ratio
Yes	11	10.89
No	90	89.11
Total	101	100

In the study group, age and BMI predicted the risk of reduced bone density at the lumbar spine. Of these, BMI had the most predictive value (p < 0,0001) (Table 7). Bone density at the lumbar spine = 1,415 - 0,004 x Age + 0,022 x BMI. In the study group, age and BMI predicted the risk of decreased bone mineral density at the total femur. (Table 8). Bone mineral density at the total femur = 0,799 - 0,007 x Age + 0,022 x BMI. In the study group, age and BMI predicted the risk of decreased bone density at the femoral neck (Table 9). Bone density at the femoral neck = 1,087 - 0,006 x Age + 0,02 x BMI. In the study group, age and dialysis time predicted the risk of abdominal aortic calcification, with age having the highest predictive value (p < 0,0001) (Table 10).

Table 7: Multivariate regression of bone density at the lumbar spine with covariates

Variables	B	p
Age	-0.004	0.003
BMI	0.022	0.0001
Dialysis time	0.001	0.110
Albumin	0.006	0.397
Calcium	-0.313	0.143
Phosphorus	-0.226	0.451
Ca x P	0.104	0.392
PTH	0.000	0.058
Constant	1.415	

Table 8: Multivariate regression of bone density at the total femur with covariates

Variables	B	p
Age	-0.007	0.0001
BMI	0.022	0.0001
Dialysis time	0.0001	0.711
Albumin	-0.002	0.757
Calcium	0.017	0.924
Phosphorus	0.192	0.435
Ca x P	-0.072	0.473
PTH	0.000	0.927
Constant	0.799	

Table 9: Multivariate regression of bone density at the femoral neck with covariates

Variables	B	p
Age	-0.006	0.0001
BMI	0.02	0.0001
Dialysis time	0.000	0.963
Albumin	0.003	0.661
Calcium	-0.198	0.328
Phosphorus	-0.169	0.553
Ca x P	0.089	0.443
PTH	0.000	0.097
Constant	1.087	

Table 10: Multivariate regression of abdominal aortic calcification with covariates

Variables	B	p
Age	0.252	0.0001
Dialysis time	0.037	0.008
Albumin	-0.025	0.916
Calcium	-8.93	0.25
Phosphorus	-13.261	0.231
Ca x P	6.809	0.134
PTH	-0.001	0.513
Constant	14.953	

Multivariate regression equation: Abdominal aortic calcification (AAC score) = 14,953 + 0,252 x Age + 0,037 x dialysis time. In the univariate logistic regression analysis in the study group, there was 1 factor contributing to predicting the risk of abdominal aortic calcification: age ($p < 0,05$). The univariate logistic regression equation was: Log (p/ (1−p)) = -2,646+ 0,065 x Age. With OR = 1,07, $p < 0,0001$, it means that if the patient is 1 year older, the risk of abdominal aortic calcification increases by 1,07 times (Table 11).

Table 11: Univariate logistic regression analysis of abdominal aortic calcification and factors

Factor	B	S.E.	Wald	df	p	Exp (B) (OR)	95% CL
Age	0.065	0.018	13.197	1	0.000	1.068	1.031 - 1.106
Constant	-2.646	0.844	9.820	1	0.002	0.071	

IV. DISCUSSION

4.1. The prevalence of bone mineral disorders according to KDIGO

Our research results show that the rate of bone mineral factor disorders is arranged in the order of phosphorus (86.1%), calcium x P (60.4%), PTH (49.5%) and calcium (19.8%). The rate of patients meeting the bone mineral concentration standards decreased as follows: Calcium (80.2%), PTH (50.5%), phosphorus (13.9%). The rate of patients meeting the 3 bone mineral standards (Ca, P, PTH) was only 5.94%.

The results of our study are almost similar to other studies: Nguyen Hoang Thanh Van's study (2015), the rate of patients on hemodialysis with hypocalcemia and normal blood calcium was 69.7%, hyperphosphatemia was 81.82% [5].

According to Samaké M et al (2019), the rate of achievement according to KDIGO standards: 57.8% with calcium, 29.4% with phosphorus, 29.4% with PTH and 6.9% achieved according to 2 or 3 criteria [11].

Thus, the rate of achievement of calcium, phosphorus, PTH targets is low, similar to other studies. From this research data, it is possible to make recommendations to pay more attention to the detection and adjustment of bone mineral disorders.

Bone density: Bone density decreased in the following order: lumbar spine (1.080 ± 0.186g/cm^2), total femur (0.891 ± 0.164g/cm^2), femoral neck (0.862 ± 0.190g/cm^2).

Based on the 1994 WHO osteoporosis diagnostic criteria, there were 12 patients (11.9%) with osteoporosis and 38 patients (37.6%) with

osteopenia. The results of our study are almost similar to other studies:

According to the authors Nguyen Thi Dung, Vo Tam (2015), the average bone density at the femoral neck, trochanter, intertrochanteric, Ward's area and the total femur respectively as 0.603 ± 0.105; 0.583 ± 0.121; 0.811 ± 0.166; 0.489 ± 0.146; 0.723 ± 0.138 g/cm^2 [1].

Ludmila Brunerová et al., Czech Republic (2016) studied 59 patients on hemodialysis, recorded the rate of osteopenia was 36%, osteoporosis was 34% [7].

Thus, the results of our study are similar to those of previously published. However, the rate of osteoporosis in our study was lower. This may be due to differences in factors such as age, sex ratio, race, hemodialysis time, anthropometric indices and different treatment regimens.

4.2. Abdominal aortic calcification

Our study had 60 patients (59.4%) with abdominal aortic calcification, of which 49.5% of patients in the study group had moderate and severe abdominal aortic calcification, 9.9% of patients had mild abdominal aortic calcification.

In our country, there are not many studies on the status of vascular calcification, including the study of Vu Thanh Do on end-stage patients and CT scan [2], the study of Nguyen Thanh Minh on patients with hemodialysis and abdominal X-ray examination showed that 56 patients (34.4%) had abdominal aortic calcification AAC ≥ 4 [3].

According to the author Nigel D Toussaint et al, published in 2011, AAC was present in 94.4% of patients, the average AAC score was 11.0 ± 6.4, independent predictors for the presence and severity of calcification were age (p = 0.03), dialysis time (p = 0.04) and history of cardiovascular disease (p = 0.009) [12]. Compared with the publications of authors around the world, the rate of abdominal aortic calcification in our study was lower, which may be due to differences in age, dialysis time and previous underlying diseases.

Heart valve calcification: There were 11 patients (10.89%) in the study group with valvular calcification. This result is significantly lower than that of foreign studies such as Uhlinova J. showed that 42 out of 90 patients (46.7%) were found to have valvular calcification [13]. The difference compared to foreign studies can be explained by the fact that the detection of calcification on echocardiography depends a lot on the sonographer, the quality of the ultrasound machine or the degree of calcification depends on the time of dialysis.

Factors associated with bone mineral disorders: Our study is also similar to the author Adrian R Levy et al (2019): Blood PTH is related to blood phosphorus concentration (p < 0.001) [6].

Bone density: In the study group, age and BMI predicted the risk of reduced bone density at the lumbar spine. Of which, BMI had the highest predictive value (p < 0.0001).

Multivariate regression equation: Bone density at the lumbar spine = 1.415 - 0.004 x Age + 0.022 x BMI. In the study group, age and BMI predicted the risk of reduced bone density at the total femur. Multivariate regression equation: Bone density at the total femur = 0.799 - 0.007 x Age + 0.022 x BMI. In the study group, age and BMI predicted the risk of reduced bone density at the femoral neck. Multivariate regression equation: Bone density at the femoral neck = 1.087 - 0.006 x Age + 0.02 x BMI

Our study is similar to the study of author Bach Thi Nho and colleagues. The rate of osteoporosis was closely correlated with the factors of gender, height, weight and BMI [4].

Abdominal aortic calcification: In the study group, age and dialysis time predicted the risk of abdominal aortic calcification, in which age had the highest predictive value (p < 0.0001).

Multivariate regression equation: Abdominal aortic calcification (AAC score) = 14.953 + 0.252 x Age + 0.037 x dialysis time. In the univariate logistic regression analysis in the study group, there was 1 factor contributing to predicting the risk of abdominal aortic calcification: age (p < 0.05).

With OR = 1.07, p < 0.0001, it means that if the patient increases by 1 year, the risk of abdominal aortic calcification increases by 1.07 times.

According to Nguyen Thanh Minh, it was found that the presence or absence of abdominal aortic calcification was significantly related to gender, age group, blood pressure and dialysis time ($p < 0.05$) [3].

According to Nigel D Toussaint (2011), 94.4% of patients had AAC, on univariate logistic regression, AAC was significantly related to age ($p = 0.002$) [12].

Our study is also similar to the above studies.

V. CONCLUSION

Bone mineral disorders. Bone minerals indices: The rate of bone mineral factor disorders is arranged in the order of phosphorus (86.1%), Calcium x P (60.4%), PTH (49.5%) and calcium (19.8%). The rate of patients meeting the bone mineral concentration standards decreased as follows: Calcium (80.2%), PTH (50.5%), phosphorus (13.9%). The rate of patients meeting the 3 bone mineral standards (Ca, P, PTH) was only 5.94%.

Bone density, osteoporosis: Bone density decreased in the following order: lumbar spine ($1.080 \pm 0.186 g/cm^2$), total femur ($0.891 \pm 0.164 g/cm^2$), femoral neck ($0.862 \pm 0.190 g/cm^2$). There were 12 patients (11.9%) with osteoporosis and 38 patients (37.6%) with osteopenia.

Abdominal aortic calcification: There were 60 patients (59.4%) with abdominal aortic calcification, of which 49.5% of patients in the study group had moderate and severe abdominal aortic calcification and 9.9% of patients had mild abdominal aortic calcification.

Calcification of heart valves: There were 11 patients (10.89%) in the study group with heart valve calcification.

Factors associated with bone mineral disorders. Bone minerals indices: Protein, phosphorus and CaxP index had a statistically significant effect on adjusted blood calcium concentration ($p = 0.0001$). Calcium and CaxP had a statistically significant effect on blood phosphorus concentration ($p = 0.0001$). Age, dialysis time and CaxP and Phosphorus had a statistically significant effect on blood PTH concentration ($p= 0.0001$).

Bone density: Age and BMI predicted the risk of reduced bone mineral density at all three sites: lumbar spine, total femur, and femoral neck with $p < 0.0001$.

Abdominal aortic calcification: Age and dialysis time predicted the risk of abdominal aortic calcification, with age having the highest predictive value ($OR = 1.07$, $p < 0.0001$).

Disclosure

The authors report no other conflicts of interest in this work.

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