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Original Article

Hylonome

Longitudinal measurement of bone mineral density at the radius in hemodialysis patients using dual-energy X-ray absorptiometry

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Abstract

The object of our study was to document the changes in bone mineral density (BMD) at the 1/3 distal radius in patients undergoing maintenance hemodialysis (HD). Forty nine male and 24 female patients were enrolled in this study. The mean age was 55.9±13.1 (mean ± SD) years, and the duration of HD was 89.2 ± 81.0 months at the beginning of the investigation. BMD was measured by dual-energy X-ray absorptiometry at 1-year intervals for a period in excess of 3 years. No significant relationship was observed between BMD and age in both sexes. In male patients, BMD was positively correlated with body mass index (BMI) ($r=0.47$, $p<0.01$) and negatively with the duration of HD ($r=0.61$, $p<0.01$). In contrast, BMD was not correlated with either BMI or with the duration of HD in female patients. Eleven of the 14 patients on HD for more than 15 years showed marked bone loss (male; 0.460, female; 0.394g/cm^2), although they were relatively young (mean age: 43.4 years). Prolonged HD could be one of the risk factors responsible for bone loss.

Keywords: Hemodialysis (HD), Bone Mineral Density (BMD), Dual-Energy X-ray Absorptiometry (DXA), Renal Osteodystrophy

Introduction

Marked progress has been achieved in the management of hemodialysis (HD) in recent years, resulting in eliciting a new issue that renal osteodystrophy has become one of the most serious complications in these patients[1]. Recently, non-invasive techniques to measure bone mineral density (BMD), such as dual photon absorptiometry, dual-energy X-ray absorptiometry (DXA) and quantitative computed tomography have been increasingly utilized in the assessment of renal osteodystrophy. There are several reports referring to the cross sectional study on BMD in HD patients[2-5]. However, little information about the longitudinal assessment of BMD in these patients is available[6,7]. We performed a time course study for three years at 1-year intervals using DXA in order to elucidate whether or not prolonged HD patients suffer from significant bone loss.

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Materials and methods

Patients

Forty-nine male and 24 female patients under HD due to chronic renal failure were monitored for a period in excess of three years. The mean age was 53.8 ± 13.4 (mean ± SD) years for male (range, 23-78 years) and 58.6 ± 12.4 for female patients (range, 42-81 years), while the mean duration of HD was 85.1 ± 80.1 months for male (range, 4-292 months) and 97.0 ± 86.8 months for female patients (range, 5-296 months) at the beginning of the present investigation.

Hemodialysis treatment

HD treatment was performed three times weekly, 3-5 hours per session. Dialysis fluid contained 2.5 mEq/L calcium and 1.5 mEq/L magnesium, without aluminium contamination; however, heparin (2,500-6,500 units) was routinely administered during dialysis. In addition to cardiac and anti-hypertensive therapy, patients received oral calcitriol and $CaCO_3$ adjusted to keep serum calcium concentration between 8.5 and 10.5 mg/dl and serum phosphorus concentration lower than 7.0

	Male	Female	*p* value
Number of patients	49	24	
Age (year)	53.8±13.4	58.6±12.4	0.29
Duration of HD (month)	85.1±80.1	97.0±86.8	0.55
Body weight (kg)	57.5±9.1	48.7±5.9	p<0.01
Height (m)	1.64±0.06	1.52±0.06	p<0.01
BMI (kg/m^2)	21.4±3.1	20.9±2.8	0.56
Values are mean±SD			

Table 1. Clinical characteristics and bone mineral density of male and female hemodialysis patients.

mg/dl. All patients suffering from renal anemia were given erythropoietin intravenously (1,500-3,000 units) at every dialysis session to maintain hematocrit values at about 30%.

Bone mineral density

BMD at the 1/3 distal of the radius was measured by technicians at 1-year intervals using DXA (DCS 600 EX, ALOKA) (Osaka, Japan). It was calculated from the bone area (cm^2) and bone mineral content (g), thereby being expressed absolutely in g/cm^2.

Other variables

Height (m) and weight (kg) were measured using a stadiometer and a digital scale, respectively. Body mass index (BMI) was calculated as the ratio of weight (kg)/height (m)^2.

Statistical methods

BMD values and demographic parameters were expressed as mean ± SD for each group. Demographic parameters included age at the time of the study, duration of HD, height, weight and BMI. Comparisons between the male and female groups were made with the Mann-Whitney U-test. BMD alterations at each year were calculated for significance using Wilcoxon's signed rank sum test. The relationships between demographic parameters versus BMD were assessed by Pearson correlation coefficients.

Results

Baseline data in the study are presented in Table 1. BMD values were significantly lower in female than in male patients at each time point (p<0.01). No significant difference was found with respect to patient age and the duration of HD between both sexes. Because of the significant differences in absolute BMD values between the sexes, most of the subsequent analyses were done separately for male and female subjects. In male patients, BMD was positively correlated with BMI (r=0.47, p<0.01) and negatively correlated with the duration of HD (r=0.61, p<0.01). Regarding longitudinal changes of BMD, a significant decrease was found at the 2nd year (p<0.05) and at the 3rd year (p<0.01) compared with BMD at the beginning. In female patients, there was no significant relationship between BMD and BMI (r=0.22, p=0.32), and between BMD and the duration of HD (r=0.37, p=0.07). With regard to time course changes of BMD, a significant decrease was demonstrated at the 2nd year (p<0.05) and at the 3rd year (p<0.01) compared with BMD at the beginning.

Of the 49 male and 24 female patients, 10 male and 4 female patients had been on HD for more than 15 years. Marked bone loss was observed in 11 out of the 14 (7 males, 4 females) patients. Mean BMD values were 0.460 g/cm^2 for male and 0.394 g/cm^2 for female patients (Table 2).

Discussion

Renal osteodystrophy is a common and incapacitating disorder in HD patients and, therefore, early and precise evaluation of bone loss is definitely required, especially for those on prolonged HD. There are many reports about the cross sectional evaluation of HD patients on BMD by various methods, including dual photon absorptiometry, DXA and quantitative computed tomography. Our finding that BMD at each time point was significantly lower in female than in male patients was in agreement with previous studies[4,6]. The reason for this difference is still unknown but may be explained by the significant abnormalities associated with hypophysis/gonad function in uremic women. There is little information about the longitudinal assessment of BMD in HD patients. In Denmark, 42% of HD patients have been reported to lose bone mass in the forearm of more than 10% over 3 years, in the absence of vitamin D treatment[7]. In Japan, a 4-year follow-up study revealed an annual change in BMD at the 1/3 distal of the radius of +0.21% in males and –0.84% in females[6]. By means of monitoring time course changes in BMD, we confirmed bone loss over 2 years, and more obviously over 3 years, in male and female patients.

		Male	Female
Hemodialyzed patients for more than 15 years	Age (year)	44.8	53.8
	BMD (g/cm^2)	0.460	0.394
All cases	Age (year)	53.8	58.6
	BMD (g/cm^2)	0.665	0.457

Table 2. Marked bone loss in prolonged hemodialyzed patients.

The difference in these results may be due to heterogeneity in the race and the etiology of renal failure and/or differences in treatment. Previous studies reported two controversial opposite findings concerning BMD loss in HD patients. There is a report that radial-BMD was negatively correlated with the duration of HD in male patients, whereas female patients showed strong and negative correlations between patient age and each of the absolute BMD values[4]. In contrast, however, there are several reports that BMD did not correlate with the duration of HD, patient age or with any other biochemical parameters[5,8,9]. In the present study, we found significant correlations between BMD and both BMI and the duration of HD in male patients. Nevertheless, we could find no correlation between BMD and duration of HD and age in female patients. As shown in Table 2, prolonged HD patients, both male and female, were slightly younger (mean age; 44.8 years in males, 53.8 years in females). Given all this, it could be conceived that bone loss was strongly affected by long-term HD, rather than age-dependent bone decrease. To elucidate the influence of the duration of HD, we divided the patients into two groups; one for patients on HD for 100 months or less and the other for those on HD for 101 months or more. The former group showed greater bone loss than the latter group ($p<0.05$) (Student's t-test). This might suggest that the decrease in BMD in HD patients occurred at the relatively early stages of maintenance HD. Further cross sectional and longitudinal assessment of bone loss in HD patients could be of prognostic and therapeutic value.

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