Low Density Lipoprotein-Cholesterol Levels Affect Vertebral Fracture Risk in Female Patients with Primary Hyperparathyroidism

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Abstract

Although increased arterial sclerosis and dyslipidemia were observed in primary hyperparathyroidism (pHPT) patients in previous studies, it still remains unclear about the relationships between lipid and bone metabolism in pHPT patients, especially about fracture risk. The present study was performed to examine the relationships between lipid metabolism parameters including body composition and bone metabolism in 116 female patients with pHPT and 116 age-matched control subjects. Bone mineral density (BMD) and body composition were measured by dual-energy x-ray absorptiometry. Serum low density lipoprotein (LDL)-cholesterol (Chol) levels were negatively related to only z-score of BMD at femoral neck and serum creatinine levels. Serum levels of LDL-Chol were significantly lower in the group with vertebral fractures in pHPT patients, although body composition parameters were not significantly different. In univariate logistic regression analyses, age, height, BMD at lumbar spine and radius, serum levels of creatinine, total-Chol and LDL-Chol were significantly selected as a predictor of vertebral fractures. LDL-Chol was related to vertebral fractures independently of the other parameters. In conclusion, the present study demonstrated that lower serum LDL-Chol levels were related to vertebral fracture risk independent of renal function, age, body size, bone metabolism parameters and the severity of the disease in pHPT women.

Introduction

Patients with primary hyperparathyroidism (pHPT) have reduced bone mineral density (BMD) especially at the cortical bone with enhanced bone turnover (Dempster et al., 1993; Nakaoka et al., 2000). In our previous study, both cortical and trabecular bone mass were reduced in pHPT patients by forearm volumetric BMD analysis with peripheral quantitative computed tomography (pQCT) in female subjects (Chen et al., 2003). As for fracture risk in pHPT, Khosla et al reported that pHPT was associated with an increased risk of vertebral, forearm, rib, and pelvic fractures, although the risk of femoral fractures was only slightly increased (Kohsla et al., 1999). In that study, increasing age, female gender and higher serum calcium (Ca) levels were predictors of fracture risk. Moreover, other groups reported the increased risk of vertebral and forearm fractures in pHPT patients and subsequent decrease of fracture risk after parathyroidectomy (Melton et al., 1992; Kenny et al., 1995; Vestergaard et al., 2000; 2003). Studies including only patients with mild, asymptomatic pHPT found no increase in fracture prevalence (Wilson et al., 1988: Melton et al., 1992; Larsson et al., 1993). Indeed, our recent study revealed that thresholds of BMD for vertebral fractures were lower especially at radial bone in female patients with pHPT, compared with those in control group (Kaji et al., 2005), suggesting that some factors other than BMD differently affect bone strength in pHPT in the manner, which is different from those of postmenopausal osteoporosis or glucocorticoid-induced osteoporosis (Nawata et al., 2005; Kaji et al., 2006).

There has been increasing evidence suggesting the relationships between lipid metabolism/arterial sclerosis and bone (Tanko et al., 2005; Cennerby et al., 2007). Several reports indicated that the indices related to arterial sclerosis are affected in patients with pHPT (Kosch et al., 2000; Smith et al., 2000; Nuzzo et al., 2002; Fallo et al., 2003; Rubin et al., 2005). Moreover, glucose intolerance, high body mass index and dyslipi-

demia were observed in pHPT patients and normocalcemic patients with pHPT (Hagstrom et al., 2002; 2006). Enhanced arterial sclerosis is considered to be accelerated by structural and functional vascular changes due to hypercalcemia as well as glucose intolerance and hyperlipidemia. On the other hand, several studies (Yamaguchi et al., 2002; Bagger et al., 2007; von Muhlen et al., 2007) indicate that lipid metabolism is related to bone. However, it still remains unclear about the relationships between lipid and bone metabolism in pHPT patients, especially about fracture risk.

The present study was, therefore, performed to examine the relationship between lipid metabolism parameters including body composition and bone metabolism in 116 female patients with pHPT. Moreover, we analyzed the factors, which were related to the risk of vertebral fractures in these patients.

Subjects and Methods

Subjects

One hundred sixteen female patients, diagnosed with pHPT, and 116 age-matched control subjects participated in this study. Both groups were selected at random to match for age and were of similar height and weight. All subjects were free of drugs known to influence bone metabolism until the time of the present study. In all pHPT patients enrolled in the present study, abnormal parathyroid gland swelling was successfully identified by at least two imaging technique among ultrasonography, computed tomography, magnetic resonance imaging, or technetium sestamibi scintigraphy; and the biochemical data were compatible with pHPT. In most pHPT patients, parathyroid tumors were identified using ultrasonography and sestamibi scintigraphy. However, computed tomography or magnetic resonance imaging were useful to confirm the localization of tumors in small number of patients with ambiguous tumor identification by only the former two imaging techniques. Moreover, familial hypocalciuric hypercalcemia was excluded, based on a low Ca/creatinine (Cr) clearance ratio (<0.01) by 24 h urine collection. No patients received bisphosphonates.

On the other hand, control subjects were women who visited our patient clinic to find out whether they might be suffering from osteoporosis. They were free of drugs or diseases known to influence bone metabolism until the study, and were free of hormone replacement therapy, statins, calcium and vitamin D. In control subjects, patients, who were referred because of fractures, were not included. Moreover, no control subjects suffered from diabetes, endocrinological and serious cardiovascular disease. The study was approved by the ethics review board of Kobe University Hospital. All subjects agreed to participate in the study and gave informed consent.

Biochemical measurements

Serum and urinary chemistry determinations were performed by standard automated techniques. Serum chemistry was performed in daily routine assays. Urine was collected as second void morning urine except for the measurement of Ca/Cr clearance ratio. Serum concentrations of intact PTH were measured by immunoradiometric assay (Allegro Intact PTH IRMA kit; Nichols Institute Diagnostics, San Juan Capistrano, CA; normal range, 10-65 pg/ml). Serum levels of bone-type alkaline phosphatase (BAP) and osteocalcin (OCN) as well as urinary levels of deoxypyridinoline (DPD) and type I collagen cross-linked N-telopeptides (NTX) were measured as previously described (Sugimoto et al., 2002; Hanson et al., 1992; Kaji et al., 2006).

Radiography

Lateral radiographs of the thoracic and lumbar spine were taken. The anterior, central and posterior heights of each of the 13 vertebral bodies from T4 to L4 were measured using an electronic caliper. Vertebral fractures were diagnosed to be present if at least one of three height measurements taken from along the length of the same vertebra was decreased by more than 20% compared with the height of the nearest uncompressed vertebral body. The criterion in the present study ($>20\%$) was considered to be good for defining vertebral fractures because it had a relatively high true positive rate and low false positive rate based on qualitative classifications from a previous report (Smith-Bindman et al., 1991). Vertebral fractures were diagnosed, when the diagnosis of pHPT was done.

BMD measurements by dual-energy X-ray absorptiometry (DXA)

BMD values were measured by DXA using QDR-2000 (Hologic Inc., Waltham, MA) at the lumbar spine (L2–4), femoral neck (FN), and distal one third of the radius (1/3R). BMD was automatically calculated from the bone area (cm^2) and bone mineral content (g), and expressed absolutely in g/cm^2. The coefficients of variation (precision) of measurements of the lumbar spine, femoral neck and radius were 0.9, 1.7 and 1.9%, respectively. The Z-score is the number of SD a given measurement differs from the mean for a sex-, age-, and race-matched reference population. The coefficient of variation was obtained in vitro using 'phantom' with at least four time measurements for the same subject. Normative data were obtained from a population-based database for Japanese Society of Bone and Mineral Research in 1996.

Measurement of body composition

DXA has enabled us to analyze body composition in terms of lean body mass (LBM) and fat mass (FM) easily and precisely (Mazess et al., 1990). The data of body composition were available in 54 and 116 subjects for pHPT and control groups, respectively in the present study. LBM and FM were measured by DXA (QDR-2000 Hologic Inc, Boston, MA, USA), using whole-body absorptiometry software and expressed in kg. Percentage fat mass (% Fat) was calculated by dividing absolute value of body composition by total body mass. The same operator tested all the women during the study to eliminate operator discrepancies. A strong correlation between body weight and total body mass measured by DXA ($r=0.98$) was obtained in a preliminary study. Coefficients of variation of measurements of LBM and FM were 1.0 and 2.0%, respectively. The coefficient of variation was obtained in vitro using 'phantom'.

Statistical analysis

All data are expressed as the mean ± SD for each index. Statistical analyses were performed using StatView IV (Abacus Concepts, Inc., Berkley, CA, USA). Comparisons between two groups were made with the nonparametric Mann-Whitney U-test. Simple or multiple regression analyses were performed to assess the linear relationship among several parameters, and Pearson's correlation coefficients were calculated. Univariate or multiple logistic regression analyses were performed to evaluate association between various indices and vertebral fractures. Values of $p<0.05$ were considered significant.

Table 1 Background data in control and pHPT groups.

	Control	pHPT
age (years)	60.8 ± 10.4	60.8 ± 10.6
body height (cm)	152.8 ± 6.2	151.9 ± 5.8
body weight (kg)	52.0 ± 8.0	52.7 ± 9.3
BMI (kg/m2)	22.3 ± 3.2	22.9 ± 3.9
Ca (mg/dl)	9.3 ± 0.4	11.3 ± 1.0*
ALP (IU/L)	241 ± 86	429 ± 402*
PTH (pg/ml)	42 ± 12	197 ± 224*
Cr (mg/dl)	0.60 ± 0.10	0.65 ± 0.18**
L2-4BMD (g/cm2)	0.791 ± 0.161	0.729 ± 0.172*
Zscore	−0.283 ± 1.176	−0.602 ± 1.186**
FN BMD (g/cm2)	0.616 ± 0.096	0.598 ± 0.204**
Zscore	−0.173 ± 1.039	−0.475 ± 0.892**
Rad1/3 BMD (g/cm2)	0.543 ± 0.090	0.460 ± 0.110*
Zscore	0.110 ± 1.600	−1.556 ± 1.980*

*, $p<0.01$, **, $p<0.05$, compared with control group

Table 2 Comparisons of lipid metabolism and body composition in control and pHPT groups.

	Control	PHPT
T-Chol (mg/dl)	214.0 ± 38.3	200.8 ± 35.0**
LDL-Chol (mg/dl)	124.9 ± 36.1	119.0 ± 32.3
HDL-Chol (mg/dl)	67.2 ± 18.3	60.3 ± 18.3**
LDL-Chol/HDL-Chol ratio	2.0 ± 0.9	2.2 ± 1.1
TG (mg/dl)	109.3 ± 18.3	109.4 ± 67.7
Alb (mg/dl)	4.2 ± 0.3	4.0 ± 0.3*
FM (g)	18410 ± 6000	18922 ± 7085
LBM (g)	31432 ± 4377	31909 ± 3690
% Fat (%)	35.1 ± 7.1	35.1 ± 7.5

*, $p<0.01$, **, $p<0.05$, compared with control group

Results

Background data

Background data of the control group and female patients with pHPT are shown in **Table 1**. Height and body weight were not significantly different between the two groups. Serum Ca levels of pHPT patients was 11.3 ± 1.0 mg/dl, which was higher and compatible with the data of pHPT. Serum levels of PTH and non-specific alkaline phosphatase (ALP) were higher, compatible with the biochemical data of pHPT. Serum Cr levels were slightly higher in pHPT group, although the patients with Cr clearance levels less than 40 ml/min were not included in this study. BMD and the Z score at all sites were significantly lower in pHPT group, compared with those of control group. The extent of BMD decrease seemed to be predominant in radius, which was rich in cortical bone.

Comparisons of lipid metabolism and body composition data

The lipid metabolism and body composition data are shown in **Table 2**. Serum levels of total cholesterol (T-Chol) and high density lipoprotein-cholesterol (HDL-Chol) as well as albumin (Alb) were significantly lower in pHPT group, compared with those of control group, although these differences were slight. On the other hand, serum levels of low density lipoprotein-cholesterol (LDL-Chol) and trigleceride (TG) as well as LDL-Chol/HDL-Chol ratio were not siginificantly different between both groups. As for body composition, both FM and LBM as well as % Fat were similar between both groups.

Relationships between lipid and bone metabolism in pHPT patients

We examined the relationships between lipid and bone metabolism in pHPT females by using simple regression analysis. As shown in **Table 3**, serum levels of all parameters (T-Chol, LDL-Chol, TG and HDL-Chol) were not significantly related to serum levels of calcium and PTH as well as bone metabolic indices (OCN, BAP, NTX and DPD). As for BMD parameters, only serum LDL-Chol levels were significantly and negatively related to z-score of FN-BMD, but not those of BMD at lumbar spine and radius. Moreover, serum Cr levels were negatively related to serum levels of T-Chol and LDL-Chol. Next, we examined the relationships between body composition indices and calcium metabolism in pHPT females by using simple regression analysis. As shown in **Table 4**, FM was positively related to Z-score of BMD at lumbar spine and femoral neck. On the other hand, LBM was negatively related to serum levels of PTH and bone resorption indices (urinary levels of NTX and DPD). Moreover, Z-scores of BMD at all sites were positively related to LBM.

Comparisons of various indices between females with and without vertebral fractures Next, we compared various indices between females with and without vertebral fractures in control and pHPT groups. Preexisting vertebral fractures were observed in 22 and 11 subjects of control and pHPT groups, respectively. Seven patients with pHPT were preexisting symptomatic vertebral fractures, although they did not have new fractures within the recent one year. As shown in **Table 5**, age and BMI were significantly higher in the group with vertebral fractures in controls, although other parameters were not significantly different between groups with and without vertebral fractures. As for pHPT patients, age and serum Cr levels were higher in the group with vertebral fractures, compared with the group without vertebral fractures. Body height was significantly lower in the group with vertebral fractures. The indices of BMD (Z-score) and bone metabolic indices as well as serum levels of calcium and PTH were not significantly different between both groups with and without vertebral fractures. As for indices about lipid metabolism and body composition, serum levels of T-Chol and LDL-Chol were significantly lower in the group with vertebral fractures, compared with in the group without vertebral fractures, in only pHPT patients, but not in control subjects (**Table 6**). Serum levels of HDL-Chol, TG and Alb as well as body composition parameters (FM, LBM and % Fat) were not significantly different between the groups with and without vertebral fractures in both control and pHPT groups.

Prediction of vertebral fracture risk in pHPT females

In order to analyze the predicting factors for vertebral fracture risk, we employed a univariate logistic regression analysis. When a univariate logistic regression analysis was performed with the presence of vertebral fractures as a dependent variable, age, height, BMD at lumbar spine and radius, serum levels of Cr, T-Chol and LDL-Chol were selected (**Table 7**). In multiple logistic regression analysis, serum levels of LDL-Chol were still significantly related to the risk of vertebral fractures, when age, height, body weight, BMI, BMD at any site, serum levels of Ca , PTH or Cr were separately considered with LDL-Chol as independent variable (data not shown), suggesting that the relationship between

Table 3 Relationships between lipid and bone metabolism in pHPT female.

	T-Chol	LDL-Chol	TG	HDL-Chol
Ca	0.046	−0.094	0.054	−0.128
PTH	−0.115	−0.117	−0.090	−0.034
L_{2-4} BMD z-score	0.034	−0.098	0.170	0.161
FN BMD z-score	−0.207	−0.279**	0.189	−0.230
1/3R BMD z-score	−0.043	−0.035	0.060	0.095
OCN	0.012	−0.039	0.086	−0.192
BAP	−0.043	−0.042	0.032	−0.230
NTX	0.137	0.043	−0.082	−0.048
DPD	0.067	−0.008	0.106	−0.123
Cr	−0.192**	−0.352*	0.005	0.067

*, $p<0.01$; **, $p<0.05$

Table 4 Relationships between body composition parameters and bone metabolism in pHPT females.

	FM	LBM
Ca	−0.257	−0.173
PTH	−0.235	−0.393*
L2-4BMD z-score	0.326**	0.378*
FN BMD z-score	0.381*	0.420*
1/3R BMD z-score	0.216	0.271**
OCN	−0.245	−0.215
BAP	−0.119	−0.317
NTX	−0.338	−0.530*
DPD	−0.216	−0.379*

*, $p<0.01$; **, $p<0.05$

LDL-Chol and vertebral fractures was independent of these parameters.

Discussion

In the present study, serum T-Chol and LDL-Chol levels were significantly lower in the group with vertebral fractures, compared with the group without vertebral fractures in pHPT patients, but not control. Moreover, these parameters were significant and negative predictors for preexistent vertebral fracture in pHPT patients. Kumagai et al. reported that vertebral fracture was more frequent for patients with high T-Chol values (>280 mg/dl) than for those with normal T-Chol values (<220 mg/dl) in the glucocorticoid-treated patients with vertebral fractures, compared with the patients without vertebral fractures (Kumagai et al., 2005). These findings suggest that T-Chol differently affects vertebral fracture risk dependent of the type of secondary osteoporosis.

The mechanism why serum LDL-Chol levels are related to vertebral fracture risk in pHPT women is unknown. In the present study, serum levels of Cr were negatively related to serum T-Chol and LDL-Chol levels in pHPT patients. Moreover, serum Cr levels were significant positive predictor for vertebral fracture risk in pHPT patients in univariate logistic analysis. Therefore, lower LDL-Chol levels and decreased renal function might be the coincident results of sever state in pHPT, leading to sever osteoporotic state. However, the relationships between T-Chol or LDL-Chol levels and vertebral fracture risk were independent of renal function, because these parameters were significantly related to vertebral fracture risk, even if serum Cr levels were also considered as independent variables in multiple logistic analyses.

The extent of BMD decrease and bone metabolic indices are very important parameters related to vertebral fracture risk in osteoporotic patients. Indeed, BMD at lumbar spine and distal radius were selected as predictors for vertebral fracture risk in pHPT patients in the present study. However, LDL-Chol levels were negatively related to Z-score of BMD at femoral neck in pHPT patients, which is contradictory of negative correlation between LDL-Chol and vertebral fracture risk. In addition, in multiple logistic analysis, serum T-Chol and LDL-Chol levels were related to vertebral fracture risk independently of BMD at any sites in pHPT patients. Taken together, the effects of pHPT on BMD or bone metabolic indices cannot explain the relationship between T-Chol or LDL-Chol levels and vertebral fracture risk in pHPT patients.

Nutritional state may affect serum T-Chol and LDL-Chol levels and osteoporosis simultaneously. Our previous study revealed that serum Alb was selected as predictors of vertebral fracture risk in postmenopausal Japanese women (Nakaoka et al., 2001). However, serum Alb levels were not different between the groups with and without vertebral fractures in pHPT patients. Moreover, serum Alb levels were not significant parameters for the prediction of vertebral fracture risk in univariate logistic analysis, and multiple logistic analysis showed that serum LDL-Chol levels were related to vertebral fracture risk independently of serum Alb levels in pHPT patients. These findings indicate that serum Alb cannot explain the relationship between LDL-Chol level and vertebral fracture risk in pHPT patients, although nutritional state may affect LDL-Chol levels as well as vertebral fracture risk in pHPT patients. Further studies of other nutritional parameters are necessary. Delfini et al reported that increased serum level of leptin and decreased serum level of adiponectin coexist in patients with pHPT (Delfini et al., 2007). These cytokines, such as leptin and adiponectin may influence lipid metabolism as well as bone fragility in pHPT women. Moreover, some unknown factors produced by parathyroid tumor might be responsible for the relationships between decreased LDL-Chol and vertebral fracture risk.

Body composition is also considered to be nutrition-related parameters, and the data of body composition were available in 54 subjects in the present study. The role of body composition in pHPT patients still remains unknown. Body weight, fat mass and proportion of android fat were increased in postmenopausal women with pHPT, lean mass was not different (Grey et al., 1994). In meta analysis, patients with pHPT were heavier than their eucalcemic peers (Bolland et al., 2005). In the present study, body weight, BMI, FM and LBM were not significantly different between pHPT and control groups, which was in contrast

Table 5 Comparisons of various indices between females with and without vertebral fractures in control and pHPT group.

Vertebral fracture	Control		pHPT	
	(−)	(+)	(−)	(+)
No. of subjects	94	22	97	11
age (years)	59.0±9.7	70.0±6.9*	59.1±10.0	69.2±6.7*
height (cm)	153.2±6.0	151.2±7.1	153.2±5.3	147.1±5.1*
BMI (kg/m2)	22.0±3.2	23.4±2.7**	22.8± 3.5	23.2±4.1
Cr (mg/dl)	0.6±0.1	0.6±0.1	0.6± 0.2	0.8±0.3**
L2-4BMD Zscore	−0.306±1.189	−0.204±1.194	−0.635±1.142	−0.738±1.289
FN BMD Zscore	−0.171±1.026	0.065±1.082	−0.507±0.900	−0.362±0.786
Rad1/3 BMD Zscore	0.078±1.579	0.152±1.771	−1.523±1.854	−1.300±1.809
Ca (mg/dl)	9.4±0.4	9.3±0.4	11.4±1.0	11.3±1.0
PTH (pg/ml)	43±12	37±12	187±176	355±511
OCN (ng/ml)	–	–	18.4±15.7	24.3±17.6
BAP(IU/L)	–	–	63.1±50.0	67.1±60.2
NTX(nmol/pmol.Cr)	–	–	112± 76	1180±252

*, p<0.01, **, p<0.05

Table 6 Comparisons of lipid metabolism indices between women with and without vertebral fractures in control and pHPT group.

Vertebral fracture	Control		pHPT	
	(−)	(+)	(−)	(+)
T-Chol (mg/dl)	217.9±39.7	198.9±29.7	204.0±33.9	171.6±24.6*
LDL-Chol (mg/dl)	127.5±38.1	115.7±26.0	152.4±5.8	88.3±10.8*
HDL-Chol (mg/dl)	68.5±18.5	61.2±16.7	58.7±17.7	63.1±20.5
TG (mg/dl)	109.4±51.2	109.8±36.0	109.5±67.0	87.5±30.4
Alb (mg/dl)	4.2±0.3	4.1±0.4	4.1±0.3	3.9±0.3
FM (g)	18073±6058	19555±5517	19864±6801	14664±13048
LBM (g)	31423±4630	31516±3425	32272±3323	30145±9262
% Fat (%)	34.6 ±7.2	36.8 ±6.9	36.1±7.1	28.6±12.1

*, p<0.01, **, p<0.05

Table 7 Univariate logistic regression analyses in the prediction of vertebral fractures in pHPT patients.

	Odds ratio	p
age (Years)	3.673	0.0009*
height (cm)	0.237	0.0004*
BMI (kg/m2)	1.121	0.7509
L2-4BMD (g/cm2)	0.465	0.0493**
FN BMD (g/cm2)	0.332	0.1360
Rad1/3 BMD (g/cm2)	0.271	0.0058*
Alb (g/dl)	0.611	0.1098
Ca (mg/dl)	0.917	0.7860
PTH (pg/ml)	1.510	0.0702
Cr (mg/dl)	2.043	0.0068*
T-Chol (mg/dl)	0.341	0.0024*
LDL-Chol (mg/dl)	0.136	0.0014*

Odds ratios were expressed per standard deviation. *, p<0.01, **, p<0.05

to the previous findings. These discrepancies might be also due to study population or disease severity, in a similar manner with those of the data of lipid metabolism.

FM and LBM affects BMD and vertebral fracture risk (Bevier et al., 1989; Reid et al., 1992; Khosla et al., 1996). In the present study, LBM was significantly related to BMD (Zscore) and bone resorption indices as well as serum PTH levels in pHPT patients, although FM was only related to BMD (Z-score) at lumbar spine and femoral neck. These findings indicate that LBM is more important for the protection of BMD decrease induced by pHPT, compared with FM. Our previous study indicated that LBM is a more important determinant of BMD than fat mass at any site except the femoral neck in postmenopausal Japanese women (Nakaoka et al., 2001). Other report agreed about the importance of LBM in the protection of postmenopausal osteoporosis (Bevier et al., 1989), although several studies suggested the importance of both LBM and FM (Reid et al., 1992; Khosla et al., 1996). The significance of LBM seemed to be common between postmenopausal osteoporosis and osteopenia in pHPT.

There have been several previous reports, in which examined the lipid metabolism in pHPT patients. In 21 patients with mild pHPT and controls, there were no differences in serum T-Chol and LDL-Chol levels, although serum HDL-Chol and TG levels were significantly lower and higher in pHPT group, respectively (Simth et al., 2000). Subjects with normocalcemic pHPT had increased serum LDL-Chol/HDL-Chol ratio and TG levels, compared with controls in the study with 30 pHPT among 5202 population-based screening (Hagstrom et al., 2006). Delfini et al. recently reported that patients with pHPT presented significantly higher serum T-Chol, LDL-Chol, TG and lower HDL-Chol levels, compared with controls, in the study with 67 pHPT patients and 46 control subjects (Delfini et al., 2007). Moreover, dyslipidemia was normalized after parathyroidiectomy in mild pHPT patients (Hagstrom et al., 2002). In the present study, serum LDL-Chol and TG levels were not significantly different between 116 pHPT patients and 116 controls, although serum HDL-Chol levels were significantly lower in pHPT group. These findings are not partly consistent with the previous findings with relatively small number of subjects, while the results of each parameter seem different among the previous studies. These discrepancies might be due to the population of pHPT patients and control subjects. Because pHPT patients of the

present study includes somewhat severe cases, compared with previous study, and only female subjects. Moreover, control subjects might include ones with lower BMD in the present study. Since recent studies indicate that dyslipidemia was related to osteoporosis (Yamaguchi et al., 2002; Bagger et al., 2007; von Muhlen et al., 2007), higher T-Chol, TG and LDL-Chol levels in controls might hide somewhat higher tendency of these parameters in pHPT patients.

The present study has some limitations. First, the sample size was not large enough to make definite conclusions. Second, the data of 25-hydroxyvitamin D were not obtained for the assessment of vitamin D status in the present study. Thus, the differences of vitamin D status might affect the severity of disease, bone turnover and BMD in pHPT patients.

In conclusion, the present study demonstrated that lower serum LDL-Chol levels were related to vertebral fracture risk independently of renal function, age, body size index, BMD, bone turnover and serum levels of Ca, PTH, Alb in pHPT women.

Conflict of interest: None.

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