



Vitamin D Deficiency and Sarcopenia in Hip Fracture Patients

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Background: Vitamin D plays a critical role in the proliferation and differentiation of skeletal muscle and bone metabolism. We compared the prevalence of vitamin D deficiency in elderly patients undergoing hip fracture surgery (HFS) with those undergoing elective primary total hip arthroplasty (THA). We also evaluated the association between vitamin D deficiency and sarcopenia. **Methods:** This prospective study included 70 patients in the HFS group, and 100 patients in the elective THA group. The HFS group included 42 women, while the elective THA group included 74 women. The mean age in the HFS and elective THA groups was 79.8 and 75.4 years, respectively, and the mean preoperative Koval score was 2.1 and 2.3, respectively. Serum 25-hydroxy-vitamin D3 levels were measured by 1125 radioimmunoassay. Bone mineral density and appendicular skeletal muscle mass (ASM) were measured using dual X-ray absorptiometry. Sarcopenia index was calculated by dividing ASM (kg) by the body mass index (kg/m²). Sarcopenia was diagnosed when the sarcopenia index was <0.789 in men and <0.512 in women. **Results:** Serum vitamin D levels were lower, and the percentages of patients with vitamin D insufficiency and deficiency were higher in the HFS group than in the elective THA group. In the HFS group, the prevalence of sarcopenia was higher in men (57%, 16/28) than in women (29%, 12/42; *P*=0.025). **Conclusions:** Vitamin D deficiency was more prevalent in patients undergoing HFS than in patients undergoing elective THA. Among patients undergoing HFS, vitamin D deficiency was more prevalent in sarcopenic than in non-sarcopenic patients.

Key Words: Hip fractures · Osteoporosis · Sarcopenia · Vitamin D

INTRODUCTION

Vitamin D is responsible for intestinal absorption of calcium, magnesium, and phosphate and has a critical role in bone metabolism. It also stimulates the proliferation and differentiation of skeletal muscles.[1]

Elderly people have a higher prevalence of low vitamin D levels due to low dietary intake and reduced exposure to sunlight. Thus, elderly people with vitamin D deficiency are at risk of osteoporosis and sarcopenia.[2]

Osteoporotic fractures are worldwide health problems and socioeconomic burdens.[3] Hip fractures, which are the second most common fractures next to spine fractures, are critical causes of high morbidity and mortality in osteoporotic cohort.[3]

A recent multi-national epidemiologic study of postmenopausal osteoporotic

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women demonstrated that the overall prevalence of vitamin D deficiency: serum 25-hydroxy-vitamin D (25[OH]D) < 30 ng/mL, was 64%. In that study, the mean 25(OH)D concentration was 17.6 ng/mL in South Korean subjects, and 92% of them had vitamin D deficiency.[4] Otherwise, there is a lack of studies on vitamin D deficiency in an elderly population in South Korea.

Therefore, we hypothesized that the prevalence of vitamin D deficiency and sarcopenia would be different among particular groups and conducted a prospective study on consecutive elderly (older than 65 years) patients undergoing hip fracture surgery (HFS) versus elective primary total hip arthroplasty (THA) (1) to compare the prevalence of vitamin D deficiency; and (2) to evaluate the association between vitamin D deficiency and sarcopenia.

METHODS

Among 232 patients who underwent HFS or elective THA by 1 surgeon from March 2017 to April 2018, we included patients who were older than 65 years at the time of surgery and excluded patients who had revision hip arthroplasty, those with metabolic bone disease, chronic renal disease, or rheumatoid arthritis, and those who had a history of calcium, vitamin D, or anti-osteoporosis medication. The most common diagnosis of patients in the elective THA group was the osteonecrosis of the femoral head (54%) following primary arthritis (21%) and arthritis due to dysplastic hip (12%). THA was not performed in HFS group.

This left 170 patients; 70 HFS patients and 100 elective THA patients were subjected to this study. The HFS group included 28 men and 42 women, and the elective THA group included 26 men and 74 women. The mean age at the time of the surgery was 79.8 years vs. 75.4 years, and the mean

preoperative Koval score [5] was 2.1 vs. 2.3, respectively (Table 1).

Serum 25(OH)D level was measured by I125 radioimmunoassay (DIAsource ImmunoAssays SA, Louvain-la-Neuve, Belgium) in the preoperative evaluation.

Vitamin D deficiency was defined as levels less than 10 ng/mL, and insufficiency as levels between 10 and 30 ng/mL.[6]

Bone mineral density and appendicular skeletal muscle mass (ASM) were measured on dual energy X-ray absorptiometry (DXA; QDR 4500A; Hologic Inc., Bedford, MA, USA).

Sarcopenia index was calculated by dividing ASM (kg) by body mass index (kg/m²). A diagnosis of sarcopenia was made when the sarcopenia index was <0.789 in males and <0.512 in females as described in the Foundation for the National Institutes of Health (FNIH) Sarcopenia Project.[7]

Handgrip power was measured 3 to 5 days after the operation using a dynamometer with patients seated, their elbow flexed to right angles, and a neutral wrist position. For each hand, the mean of three trials of grip strength was calculated.

This study was approved by the Institutional Review Board (IRB) of the Seoul National University Bundang Hospital (IRB no. B-1701/378-303).

Statistical analysis

Descriptive statistics were performed in SPSS version 16 (IBM Corp., Armonk, NY, USA), and *P*-values of less than 0.05 were considered to indicate statistical significance. The χ^2 test was performed for categorical variables, and student's *t*-test was used for continuous variables

Table 1. Patient demographics

	Hip fracture surgery (N=70)	Total hip arthroplasty (N=100)	<i>P</i> -value
Age (yr)	79.8±6.2	74.5±6.3	<0.001
Gender			0.066
Male	28 (40.0)	26 (26.0)	
Female	42 (60.0)	74 (74.0)	
Koval score	2.1±1.9	2.3±1.9	0.449

The data is presented as mean ± standard deviation or number (%).

Table 2. Comparison of hip fracture surgery patients and total hip arthroplasty patients

	Hip fracture surgery	Total hip arthroplasty	<i>P</i> -value
Handgrip power (kg)	16.9±7.8	22.8±13.9	0.007
Vitamin D level (ng/mL)	18.6±12.9	33.3±17.2	<0.001
Vitamin D insufficiency ^{a)}	56 (80.0)	34 (34.0)	<0.001
Vitamin D deficiency ^{b)}	20 (29.0)	14 (14.0)	0.310
ASM/BMI	0.65±0.139	0.62±0.139	0.097
Sarcopenia	28 (40.0)	36 (36.0)	0.632

The data is presented as mean ± standard deviation or number (%).

^{a)}Vitamin D insufficiency: <30 ng/mL. ^{b)}Vitamin D deficiency: <10 ng/mL. ASM, appendicular skeletal muscle mass; BMI, body mass index.

Table 3. Overall comparison of sarcopenia patients and non-sarcopenia patients

	Sarcopenia (N=64)	Non-sarcopenia (N=106)	P-value
Age (yr)	76.9±6.6	76.5±7.0	0.731
Gender			0.001
Female	34 (53.1)	82 (77.4)	
Male	30 (46.9)	24 (22.6)	
Hip fracture surgery	28 (43.8)	42 (39.6)	0.623
Total hip arthroplasty	36 (56.3)	64 (60.4)	
Koval score	2.1±1.8	2.3±2.0	0.518
Handgrip power (kg)	23.5±16.8	19.4±9.1	0.061
Vitamin D level (ng/mL)	28.2±18.6	27.1±16.3	0.673
Vitamin D insufficiency ^{a)}	38 (59.4)	52 (49.1)	0.208
Vitamin D deficiency ^{b)}	10 (15.6)	24 (22.6)	0.325

The data is presented as mean ± standard deviation or number (%).

^{a)}Vitamin D insufficiency: <30 ng/mL. ^{b)}Vitamin D deficiency: <10 ng/mL.

RESULTS

1. Vitamin D level and prevalence of vitamin D deficiency

The level of serum vitamin D was lower, and the percentages of vitamin D insufficiency and deficiency patients were higher in the HFS patients compared to those in the THA patients.

There was no significant difference in the prevalence of sarcopenia between 2 groups (Table 2).

When the patients were divided into sarcopenia group (64 patients) and non-sarcopenia group (106 patients), there were no significant differences in Koval score, handgrip power, and serum vitamin D level (Table 3).

2. Relationship between sarcopenia and vitamin D deficiency

Overall, 64 patients (37.6%, 64/170) were sarcopenic: 28 HFS patients (40%, 28/70) and 36 THA patients (36%, 36/100). The level of vitamin D and the percentages of vitamin D insufficiency and deficiency were not significantly different between the sarcopenia group and the non-sarcopenia group (Table 3).

In the HFS patients, sarcopenia was more frequent in men (57.1%, 16/28) than in women (28.6%, 12/42) ($P=0.025$), and vitamin D level was not significantly different between the sarcopenic and non-sarcopenic groups. The prevalence of vitamin D insufficiency was higher in sarcopenic patients

Table 4. Comparison of sarcopenia patients and non-sarcopenia patients among hip fracture patients

	Sarcopenia (N=28)	Non-sarcopenia (N=42)	P-value
Age (yr)	78.3±5.4	80.8±6.5	0.092
Gender			0.025
Female	12 (42.9)	30 (71.4)	
Male	16 (57.1)	12 (28.6)	
Koval score	1.8±1.7	2.3±2.0	0.242
Handgrip power (kg)	17.8±6.8	16.4±8.4	0.543
Vitamin D level (ng/mL)	16.4±9.4	20.1±14.7	0.208
Vitamin D insufficiency ^{a)}	26 (92.9)	30 (71.4)	0.035
Vitamin D deficiency ^{b)}	6 (21.4)	14 (33.3)	0.418

The data is presented as mean ± standard deviation or number (%).

^{a)}Vitamin D insufficiency: <30 ng/mL. ^{b)}Vitamin D deficiency: <10 ng/mL.

(92.9%, 26/28) than in non-sarcopenic patients (71.4%, 30/42; $P=0.035$) (Table 4).

DISCUSSION

Hip fractures are the second common osteoporotic fractures next to spinal fractures. Elderly people are prone to have vitamin D deficiency. This is mainly due to reduced sunlight exposure, though decreased capacity for cutaneous production, low dietary intake, poor absorption, and impaired hepatic hydroxylation of vitamin D may also contribute to low 25(OH)D levels.[8] Several epidemiological studies showed that osteomalacia is common in hip fracture patients, but vitamin D levels in these patients were inconsistent.[9]

In our study, 80% of HFS patients and 36% of THA patients had vitamin D insufficiency.

The 1,25-dihydroxy-cholecalciferol (1,25(OH)₂D₃), the active form of vitamin D, plays a major role in maintaining neuromuscular function. Previous studies showed that a low level of this hormone results in poor functional level, and hip fracture patients had low serum 1,25(OH)₂D levels.

Carpintero et al. [10] performed a prospective study in 109 elderly hip fracture patients to verify the relationship between 1,25(OH)₂D₃ levels and functional recovery. In their study, a significant relationship was found between low 1,25(OH)₂D₃ levels and a poor functional recovery 1 year after the fracture.

Vitamin D also has important effects on skeletal muscle. Unlike other authentic vitamins, vitamin D is produced in

the skin using ultraviolet sunlight. Through its nuclear receptor (i.e., vitamin D receptor) located throughout the muscle, vitamin D regulates myocyte proliferation and growth. In some studies, vitamin D supplementation has been shown to increase muscle strength, particularly in people who have a deficiency of vitamin D.[11]

A recent study from Taiwan to assess the prevalence of vitamin D inadequacy among non-supplemented postmenopausal women with osteoporosis and fragility fractures of the hip or spine, high prevalence of vitamin D deficiency was found across all age groups among non-supplemented women with osteoporosis and fragility fractures.[11]

Conversely, vitamin D appears to play a role in muscle strength, injury prevention, and sports performance, and a significant positive correlation was found between $1,25(\text{OH})_2\text{D}_3$ levels and muscle strength.[8,12,13]

Even though we could not find an association between vitamin D deficiency and sarcopenia, sarcopenia was frequent in hip fracture patients, especially in men.

There are several limitations of this study. First, the sample size was small. Second, we measured the 25(OH)D levels at admission. Third, we did not measure parathyroid hormone, which could have contributed to the relationship between 25(OH)D levels and hip fracture. Fourth, the portion of patients who were diagnosed with sarcopenia might have been different if other criteria such as the Asian Working Group for Sarcopenia [14] or the European Working Group on Sarcopenia in Older People [15] were used. Fifth, there might be differences in comorbidities in each group, which should be dealt with in future studies. Sixth, the significant difference in age might obscure the interpretation of results. Further studies using propensity score matching on a large number of patients would be needed.

In conclusion, we found that vitamin D deficiency was more prevalent in hip fracture patients, compared with elective THA patients, and sarcopenia was prevalent especially in men with hip fractures. Recent studies showed that supplementation strategy of vitamin D is effective in decreasing the incidence of osteoporotic fractures in an elderly population.[16,17] We hope that our study would improve our understanding of hypovitaminosis D in hip fracture patients and could guide to prevent osteoporotic fractures.

DECLARATIONS

Funding

This study was supported by research funding from Korean Society for Bone and Mineral Research.

Ethics approval and consent to participate

This study conformed to the ethical guidelines of the 1975 Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of the Seoul National University Bundang Hospital (IRB no. B-1701/378-303).

Conflict of interest

Young-Kyun Lee has been the associate editor of the Journal of Bone Metabolism since 2009. No potential conflict of interest relevant to this article was reported.

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