Association between Bone Mineral Density and Hypertension in Postmenopausal Women

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ABSTRACT

Background: Low bone mineral density (BMD) is a common disorder in the elderly and found to be most prevalent in postmenopausal women which are thought to be associated with several factors including hypertension, however, results are inconsistent in different studies.

Aim of the study: This study aimed to explore the association between BMD and hypertension in postmenopausal women.

Methods and materials: In this study, total 76 postmenopausal women were included. BMD was determined at the lumbar spine and femoral neck by dual-energy x-ray absorptiometry (DEXA). Anthropometric data and status of hypertension and diabetes were collected according to a pre-structured questionnaire.

Results: Age (mean $\pm$ SD) of the postmenopausal women was 57 $\pm$ 9 years. Among them, 46 (60.5%) subjects were hypertensive and 30 (39.5%) were normotensive. Bone mineral density (g/cm²) in normotensive women and in hypertensive women were 0.79 $\pm$ 0.15 vs 0.74 $\pm$ 0.15 (p=0.160) at lumbar spine; 0.70 $\pm$ 0.12 vs 0.69 $\pm$ 0.13 (p=0.271) at right femoral neck and 0.73 $\pm$ 0.15 vs 0.71 $\pm$ 0.13 (p=0.592), respectively. T-scores at lumbar spine, right and left femoral neck in normotensive and hypertensive postmenopausal women were -2.28 $\pm$ 1.37 vs -2.75 $\pm$ 1.35 (p=0.153), -1.70 $\pm$ 1.16 vs -1.95 $\pm$ 1.07 (p=0.363) and -1.82 $\pm$ 0.95 vs -1.93 $\pm$ 1.01 (p=0.632) respectively. On multiple regression analysis, BMD and T-score only at lumbar spine showed inverse association with hypertension (β =-0.069, p=0.045; β =-0.612, p=0.050) on adjusting confounding variables.

Conclusion: Hypertension is independently associated with BMD and T-score measured from the lumbar spine but not with BMD and T-score measured from the femoral neck in postmenopausal women.

Keywords: Bone mineral density, Hypertension, Postmenopausal women, T-score.

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I. INTRODUCTION

With the increasing elderly population and change in lifestyle, hypertension and osteoporosis are becoming important non-communicable public health problems in the world [1]-[3]. In osteoporosis, loss of bone mass and deterioration of bone tissue microarchitecture led to increase bone fragility and the concomitant rise in fracture risk [4]. The incidence of hip fracture due to osteoporosis is higher in developing countries and 6.3 million of the global population is expected to be affected by the year 2050, [5]. The prevalence of osteoporosis was 9%, 15%, 26% among elderly non-Hispanic black, non-Hispanic whites, and Mexican Americans respectively [6]. In Korea, Japan, China, Taiwan,

and Sri Lanka, it is between 24-40% among middle-aged women [7]-[13]. In the Bangladeshi population, the scenario is similar where 41.8% of elders (above 45 years of age) women found to have osteoporosis and in postmenopausal women, it was observed in 49.6% [14]. Bone mineral density (BMD) and Bone mineral content (BMC) are the common tests for the diagnosis of osteoporosis and prediction of fracture risk, various studies suggest that the common risk factors for osteoporosis include age, gender, smoking, coronary heart disease, diabetes, essential hypertension, decreased estrogen level etc. [15]-[17]. Menopause is a physiological condition for elderly women. With the improvement in diagnosis and treatment, life expectancy after menopause has increased in women. After menopause,

abnormality in calcium (Ca) metabolism and reduction of BMD have found to be associated with osteoporosis [18]. Several studies showed that abnormal Ca metabolism is associated with hypertension, but the results are inconclusive [19]-[24]. Besides the effect on Ca metabolism, hypertension also causes secondary activation of the parathyroid gland which results in increased Ca movement from bone [25]-[28]. Hypertension affects the kidney's ability to handle Ca and age-related excessive reduction in BMD. It has also been reported that increased angiotensin II level increases bone resorption and bone demineralization leading to negative effects in hypertensive patients [29]-[31]. Several studies show a negative correlation between hypertension and BMD [22], [32]. A study done on white elderly women found that high blood pressure (BP) is associated with increased bone loss in the femoral neck [31]. Yang *et al.* [32] have also reported similar association. In another study, done on postmenopausal women in North India found a negative association between hypertension and BMD [33]. The negative association between hypertension and BMD has also been supported by a meta-analysis [34]. In opposite, there are studies also that have found no relation between hypertension and BMD [35], [36]. However, based on the National Health and Nutrition Examination Survey (NHANES) data, Mussolino *et al.* reported no significant association between BMD and hypertension in African American Population [37]. No significant differences of BMD in different body parts were found between hypertensive and normotensive groups in a study done on Turkish post-menopausal women [38]. Since there are controversial findings in different studies, the need for new studies on the association of hypertension and BMD arises. Besides, there was no study found on Bangladeshi post-menopausal women, which focuses on the association between hypertension and BMD. So our study aimed to find whether there is an association between hypertension and BMD in postmenopausal women of Bangladesh.

II. MATERIAL AND METHODS

A. Study Design and Sample

This cross-sectional study was conducted in the Dept. of Applied Laboratory Sciences, Bangladesh University of Health Sciences (BUHS), Dhaka, Bangladesh, and National Institute of Nuclear Medicine & Allied Sciences, Bangladesh Atomic Energy Commission. Seventy-six (76) post-Menopausal women who came for screening for osteopenia or osteoporosis by dual-energy X-ray absorptiometry (DEXA) from June 2018 to July 2019, were included in this study. Among them 30 subjects were normotensive and 46 were hypertensive. Subjects with comorbid diseases (infection, stroke, myocardial infarction, major surgery, coronary heart disease, thyroid diseases, severe liver or renal disease, neoplasm, hematological disorders, taking anticoagulants etc.) were excluded from the study.

B. Measurements of Risk Variables

Subjects with blood pressure ≥ 140 mmHg and/or ≥ 90 mmHg, and/or using antihypertensive medication were considered hypertensive. Body mass index (BMI) of the subjects was calculated in kg/m^2 using the standard formula:

$$\text{BMI} = \text{Weight (kg)} / [\text{Height (m)}]^2$$

C. Bone Mineral Density Scans

Bone mineral density (g/cm^2) was measured for the lumbar spine (L2 to L4) and proximal femur using a GE Lunar DPX-NT PRO (Lunar Corp, Adison, WI, USA) by DXA scanning. Bone mineral density was determined according to standard protocols and expressed in g/cm^2 and as peak bone mass percentage in normal subjects (T-score) depending on the software used in the device.

D. Statistical Analysis

All continuous variables were tested for skewness. The distribution of all variables was normal. The continuous parameters were presented as mean $\pm$ standard deviation. Comparisons of demographic, clinical and laboratory characteristics of the patients were performed using an independent sample t-test. Multivariate logistic regression analysis was used to assess the independent association of BMD with hypertension. Statistical analyses were carried out using MedCalc version 11.4 for Windows and a p-value < 0.05 was considered as significant.

III. RESULTS

A. Characteristics of the Study Subjects

Total 76 postmenopausal women were included in this study. The age range was 35 to 85 years. Characteristics of the study subjects were presented in Table I. Among the subjects 46(60.5%) were hypertensive and 30(39.5%) were normotensive; 25(32.9%) were diabetic and 51(67.1%) were nondiabetic. The mean $\pm$ SD of BMI was $26.1 \pm 4.7 \text{ Kg/m}^2$ among them 32 subjects were overweight (BMI: 25-30 kg/m^2) and 12 subjects were obese (BMI $> 30 \text{ kg/m}^2$). Age distributions of the subjects are presented in Fig 1. Most of the study subjects (47.4%) were within the age group 51-64 years, followed by 38-51(27.6%) and 64-77 (23.7%) years; the age distribution followed a normal distribution ($p=0.249$).

TABLE I: CHARACTERISTICS OF THE STUDY SUBJECTS

Variable	Mean $\pm$ SD/%
Age (years)	57 $\pm$ 9
BMI (kg/m^2)	26.1 $\pm$ 4.7
Hypertension (yes)	60.5%
Systolic blood pressure (mmHg)	123 $\pm$ 17
Diastolic blood pressure (mmHg)	77 $\pm$ 10
Diabetes (yes)	32.9%

Results were expressed as mean $\pm$ SD/%.

BMI, Body mass index.

Fig. 1. Age distribution of the study subjects.

B. Bone Mineral Density in the Study Subjects

Bone mineral density (BMD) in Lumbar spine and femoral neck is presented in Table II. BMD was similar in right and left femoral neck and density was higher in lumbar spine than femoral spine.

TABLE II: BMD IN LUMBAR SPINE AND FEMORAL NECK

Area	BMD (g/cm ²)	T-score
Lumbar spine	0.76±0.15	-2.56±1.37
Right femoral neck	0.71±0.14	-1.85±1.11
Left femoral neck	0.71±0.13	-1.88±0.99

C. Comparison of BMD between Normotensive and Hypertensive Postmenopausal Women

Bone mineral density (g/cm²) at the lumbar spine was higher in normotensive postmenopausal women (0.79±0.15) and hypertensive postmenopausal women (0.74±0.15) but it was not statistically significant (p=0.160). Similarly, hypertensive postmenopausal women had lower BMD (g/cm²) at right and left femoral neck (0.69±0.13 and 0.70±0.12) compared to normotensive postmenopausal women (0.73±0.15 and 0.71±0.13) but failed to reach statistical significance (both, p>0.05) (Fig. 2). T-score at the lumbar spine and femoral neck showed no significant difference between normotensive and hypertensive subjects [-2.28±1.37 vs -2.75±1.35; -1.70±1.16 vs -1.95±1.07 and -1.82±0.95 vs -1.93±1.01, respectively (Fig. 3)].

Fig. 2. Comparison of BMD between normotensive and hypertensive postmenopausal women at lumbar spine (A), right femoral neck (B) and left femoral neck (C).

Fig. 3. Comparison of T-score between normotensive and hypertensive postmenopausal women at lumbar spine (A), right femoral neck (B) and left femoral neck (C).

D. Multiple Regression Analysis

Unadjusted coefficient (β) in multiple regression analysis considering BMD at the lumbar spine, right femoral neck or left femoral neck as dependent variable and hypertension, diabetes, age, and BMI as independent variables presented in Table III. In all cases, BMI showed a positive association with BMD. However, hypertension showed an inverse association with BMD and reached statistical significance at the lumbar spine (Table III).

TABLE III: COEFFICIENT OF BMD WITH HYPERTENSION IN MULTIPLE REGRESSION ANALYSIS

BMD (g/cm ²)	Lumbar spine		Right femoral neck		Left femoral neck	
	β	p-value	β	p-value	β	p-value
Age	-0.002	0.917	-0.004	0.035	-0.003	0.075
BMI	0.014	0.002	0.007	0.029	0.007	0.023
HTN	-0.069	0.045	-0.040	0.209	-0.019	0.503
DM	-0.004	0.910	0.004	0.889	0.001	0.997
T-score						
Age	-0.004	0.802	-0.029	0.034	-0.023	0.059
BMI	0.121	0.004	0.057	0.037	0.056	0.023
HTN	-0.612	0.050	-0.257	0.315	-0.136	0.552
DM	-0.070	0.824	0.001	0.997	-0.007	0.977

BMI, body mass index; HTN, hypertension and DM, diabetes mellitus.

IV. DISCUSSION

In this study, analysis of BMD by DEXA method showed similar results for BMD and T score at lumbar femur in both postmenopausal normotensive and hypertensive women. Hypertension was found to be independently associated with BMD and T-score measured from the lumbar spine but not with BMD and T-score measured from the femoral neck on multiple regression analysis.

Metabolic changes occur more prominently in Trabecular bone (Lumbar spine) than Cortical bone (Femoral Neck) [39]. The association between hypertension and osteopenia is shown to be different for different sites of bone [40-42] and found to be inconsistent in different races [22], [23], [31], [40]-[46]. Tsuda *et al.* found an inverse relationship between lumbar spine BMD and SBP in Japanese women [43]. In another study, Gotoh *et al.* found an association between abnormal Ca metabolism and hypertension [44]. In a study done on post-menopausal women, Afghani *et al.* found a negative association between hypertension and bone mineral content (BMC). Here SBP was independently associated with BMC but the association with BMD was not done [45]. Cappuccio *et al.* found an inverse relationship between femoral neck BMD and blood pressure in a study done on white postmenopausal elderly women [22]. However, the difference to our study, their study was performed only on the femoral neck they could not establish the association at different sites. Lidfeldt *et al.* found a positive association between BMD and SBP without adjusting confounding variables [23]. Yang *et al.* also found a lower BMD at the femoral neck in hypertensive women compared to normotensive women (0.79 versus 0.82 g/cm², P = 0.02) [32]. In North Indian post-menopausal women, a similar finding was reported [33]. The inverse relationship between hypertension and BMD was also evident from the Meta-analysis [34].

Some studies conclude no significant relationship between hypertension and BMD [37], [47]. In these studies, BMD was measured only from the femoral neck, and they could not find any association between hypertension and BMD. However, as it is established that BMD differs with different sites of bone, we performed our study on both the Lumbar spine and femoral neck and found that hypertension is independently associated with BMD measured only from the Lumbar spine. Primary Hypertension has an association with Ca metabolism, which causes loss of Ca and secondary activation of the parathyroid gland causing increased removal of Ca from bone [19]-[23].

These differences in findings of different studies may be due to differences in patient selections (such as age, ethnicity, sample size, the inclusion of patients with comorbidities, extent and etiology of osteoporosis or hypertension) and diagnostic methods or criteria. In our study, we only included postmenopausal women, therefore; the findings are not generalizable to men or younger women. Moreover, the cross-sectional study design of the study made it impossible to find any cause-effect relationship between hypertension and BMD in postmenopausal women. So, a prospectively designed study with a bigger sample size, which incorporates the measurement of biochemical indices of bone mineral metabolism, is required to be done to grasp the relationship between hypertension and BMD.

In conclusion, the current study is the first to seek out the association between hypertension and bone mineral density in postmenopausal Bangladeshi women. The presence of hypertension was found to be an independent predictor of low bone density.

V. CONCLUSION

BMD and T-scores at lumbar and femur are similar in postmenopausal normotensive and postmenopausal hypertensive women. Hypertension is independently associated with BMD and T-score measured from the lumbar spine but not with BMD and T-score measured from the femoral neck in postmenopausal women.

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