LETTER TO THE EDITOR

Associated Factors of Brachial-Ankle Pulse Wave Velocity in Hypertensive Patients Aged 80 and OverPing-Da Bian,¹ Hong-Hua Pan,² Xiu-Yang Li,³ Wei Lin¹ & Shen-Jiang Hu⁴¹ Department of Cardiology, Zhejiang Provincial People's Hospital, Hangzhou, China² Pharmacy of Clinic, Tongde Hospital of Zhejiang Province, Hangzhou, China³ Department of Epidemiology & Health Statistics, Zhejiang University, Hangzhou, China⁴ Institute of Cardiology, The First Affiliated Hospital, College of Medicine, Zhejiang University, Hangzhou, China**Correspondence**

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Received 27 October 2011; revision 3

November 2011; accepted 4 November 2011

doi: 10.1111/j.1755-5949.2011.00282.x

Decreased elasticity of the arterial wall plays an important role in the development of hypertension and has been recognized as an independent predictor of cardiovascular mortality, fatal and non-fatal coronary events, and fatal strokes [1]. Therefore, noninvasive assessment of arterial stiffness has recently entered the European Society of Hypertension/European Society of Cardiology guidelines for the management of hypertension [2]. Although brachial-ankle pulse wave velocity (baPWV) has been used widely because of its convenience, and some studies identified that baPWV is an important risk factor of cardiovascular event [3,4], associated factors of baPWV in hypertensive patients aged 80 and over have not been studied. The purpose of this study was to probe into associated factors of baPWV in hypertensive patients aged 80 and over.

In the period between January and August 2010, a total of 1008 patients with essential hypertension were recruited. The subjects included 840 men and 168 women, with a mean age of 86 ± 3 years (range: 80 to 96 years). Some subjects had type 2 diabetes mellitus (29.27%). Hypertension was defined as an average blood pressure (BP) $\geq 140/90$ mmHg at least two different occasions, or report of a prior diagnosis of hypertension and current treatment with antihypertensive medications [5].

The demographics (for example, name, sex, age, diabetes mellitus, etc.) were recorded. Weight (kg) and height (m) were measured, and body mass index was calculated as weight to height squared. All patients underwent 24-h ambulatory BP monitoring, blood chemistry measurement, and baPWV measurement.

Ambulatory BP readings were recorded every 15 minutes during the day (6 AM to 10 PM) and every 30 minutes during the

night (10 PM to 6 AM) using a validated SpaceLabs 90207 ambulatory BP monitor (ApaceLabs Medical Instruments Co. Ltd, Tianjin, China) in the arm. The following ambulatory BP parameters were evaluated: (1) average of 24hSBP, 24hDBP, and 24-h heart rate (24hHR); (2) standard deviation (SD, variability) of 24hSBP (24hSBPV), 24hDBP (24hDBPV), and 24hHR (24hHRV).

Blood samples were obtained after an overnight fast. Uric acid, glucose, triglycerides, total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), apolipoprotein AI, apolipoprotein B₁₀₀, high sensitivity C-reactive protein (Hs-CRP), and homocysteine were measured using standard methods.

Bilateral baPWVs were measured using an automatic device (VP 2000, Colin Medical Technology, Komaki, Japan). Waveform data were obtained from volume plethysmographic sensors in cuffs on the right brachium and both ankles, and the time intervals (Tba) between the wave at the right brachium and those at both ankles were calculated. The distance between the brachium and the ankle for baPWV was automatically calculated according to the height of the subject. The distances from aortic valve to brachium (Db) and ankle (Da) were expressed using the following equations: $Db = 0.2195 \times \text{height (cm)} - 2.0734$, $Da = 0.8129 \times \text{height (cm)} - 12.328$. At the last, baPWV was measured using the following equation: $\text{baPWV} = (Da - Db)/Tba$. The average of the bilateral baPWVs obtained on both sides was used for further analysis.

Continuous variables were expressed as mean $\pm$ SD ($\bar{x} \pm s$). The one-sample Kolmogorov-Smirnov test was applied to assess data

Table 1. Univariate correlation between baPWV and selected clinical variables

Variables	<i>t</i>	<i>r</i>	<i>P</i>
Gender	−0.505		0.613
Diabetes mellitus	−0.967		0.334
Age (years)		0.152	0.000
Body mass index (kg/m ²)		−0.017	0.582
24hSBP (mmHg)		0.180	0.000
24hDBP (mmHg)		0.124	0.000
24hHR (beats/min)		0.227	0.000
24hSBPV (mmHg)		0.069	0.033
24hDBPV (mmHg)		0.067	0.038
24hHRV (beats/min)		0.097	0.003
Uric acid (μmol/L)		0.008	0.799
Glucose (mmol/L)		0.099	0.002
Triglycerides (mmol/L)		0.020	0.529
Total cholesterol (mmol/L)		−0.030	0.338
HDL-C (mmol/L)		−0.035	0.270
LDL-C (mmol/L)		−0.011	0.737
Apolipoprotein AI (g/L)		0.010	0.751
Apolipoprotein B ₁₀₀ (g/L)		0.015	0.641
Hs-CRP (mg/L)		0.058	0.068
Homocysteine (μmol/L)		−0.020	0.589

24hSBP, 24-h systolic blood pressure; 24hDBP, 24-h diastolic blood pressure; 24hHR, 24-h heart rate; 24hSBPV, 24-h systolic blood pressure variability; 24hDBPV, 24-h diastolic blood pressure variability; 24hHRV, 24-h HR variability; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; Hs-CRP, high sensitivity C-reactive protein.

distribution. The means of quantitative variables were compared by the independent-Samples *t*-test, while the Mann–Whitney *U*-test was used to assess the data that were not normally distributed. Linear correlations were determined using Spearman's rank-order correlation coefficient, and stepwise multiple regression analysis was performed to determine independent associated factors of baPWV. All *P*-values were two-sided, and the level of statistical significance was set at *P*-values ≤0.05. Statistical analysis was performed with SPSS software version 17.0 (SPSS, Chicago, IL, USA).

Univariate analyses demonstrated that baPWV was significantly related to age (*r* = 0.152, *P* = 0.000), 24hSBP (*r* = 0.180, *P* = 0.000), 24hDBP (*r* = 0.124, *P* = 0.000), 24hHR (*r* = 0.227, *P* = 0.000), 24hSBPV (*r* = 0.069, *P* = 0.033), 24hDBPV (*r* = 0.067, *P* = 0.038), glucose (*r* = 0.099, *P* = 0.002) (Table 1).

Multivariate regression analysis (with baPWV as the dependent variable) revealed that age (β = 0.013, *P* = 0.000), 24hSBP (β = 0.002, *P* = 0.023), 24hHR (β = 0.007, *P* = 0.000), and glucose (β = 0.027, *P* = 0.002) were independent associated factors of baPWV in hypertensive patients aged 80 and over (Table 2).

With aging, arterial stiffness increases, which may result in cardiovascular diseases. Aging of the arterial system is accompanied by structural changes, including fragmentation and degeneration of elastin, increase of collagen, thickening of the arterial wall, and

Table 2. Multiple regression analysis of BaPWV in 1008 hypertensive patients aged 80 and over

Variable	β	<i>t</i>	<i>P</i>
Age	0.013	4.100	0.000
24hSBP	0.002	2.279	0.023
24hDBP	0.002	1.201	0.230
24hHR	0.007	5.375	0.000
24hSBPV	0.003	0.884	0.377
24hDBPV	−0.003	−0.590	0.555
24hHRV	0.000	0.135	0.893
Glucose	0.027	3.076	0.002

24hSBP, 24-h systolic blood pressure; 24hDBP, 24-h diastolic blood pressure; 24hHR, 24-h heart rate; 24hSBPV, 24-h systolic blood pressure variability; 24hDBPV, 24-h diastolic blood pressure variability; 24hHRV, 24-h HR variability.

progressive dilation of the arteries. These changes may result in a gradual stiffening of the vasculature and an increase in the PWV as it travels down to the artery [6].

There are two reasons why high 24hSBP leads to a rise in baPWV. One reason is that high 24hSBP can quicken the conduction of PWV, and one study reported that the baPWV was significantly decreased shortly after SBP decreased [7]. The other reason is that hypertension can speed up the course of atherosclerosis.

The mechanism that high HR leads to a rise of baPWV is because the rise of HR shorts the filling period of heart and speeds up the conduction of PWV [8]. The results of our study indicate that hypertensive patients aged 80 and over whose both baPWV and HR are high may take precedence of beta-blockers.

There are two probable reasons why high plasma glucose leads to a rise in baPWV. One is that high plasma glucose may heighten blood viscosity and quicken the conduction of PWV [9]. Another is that high plasma glucose can quicken the course of atherosclerosis because high plasma can raise the content of advanced glycation endproducts [10].

Some studies recently indicate that all of serum lipid, Hs-CRP, homocysteine, and blood pressure variability are risk factors of atherosclerosis, but our results indicate that none of them is independent associated factor of baPWV, and further studies required to elucidate it.

In conclusion, the baPWV of the hypertensive patients aged 80 and over are influenced by some factors, for example, age, 24hSBP, 24hHR, and fasting plasma glucose. The probable ways to reduce baPWV in hypertensive patients aged 80 and over are to decrease the levels of 24hSBP and 24hHR, and decrease the concentration of fasting plasma glucose. Of course, further longitudinal studies are needed to confirm it.

Acknowledgments

This work was supported by a grant from the Health Bureau of Zhejiang Province, China (No. 2010KYB009).

References

1. Tuttolomondo A, Di Sciacca R, Di Raimondo D, et al. Arterial stiffness indexes in acute ischemic stroke: Relationship with stroke subtype. *Atherosclerosis* 2010;**211**:187–194.
2. Mancia G, De Backer G, Dominiczak A, et al. Guidelines for the management of arterial hypertension: The Task Force for the Management of Arterial Hypertension for the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *J Hypertens* 2007;**25**:1105–1187.
3. Miyana I, Nishinaga M, Takata J, et al. Association between brachial-ankle pulse wave velocity and 3-year mortality in community-dwelling older adults. *Hypertens Res* 2010;**33**:678–682.
4. Kim DH, Kim J, Kim JM, Lee AY. Increased brachial-ankle pulse wave velocity is independently associated with risk of cerebral ischemic small vessel disease in elderly hypertensive patients. *Clin Neurol Neurosurg* 2008;**110**:599–604.
5. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. *Hypertension* 2003;**42**:1206–1252.
6. Lewis TT, Sutton-Tyrrell K, Penninx BW, et al. Race, psychosocial factors, and aortic pulse wave velocity: The health, aging, and body composition study. *J Gerontol A Biol Sci Med Sci* 2010;**65**:1079–1085.
7. Park HJ, Rho TH, Park CS, et al. The relationship between the acute changes of the systolic blood pressure and the brachial-ankle pulse wave velocity. *Korean J Intern Med* 2007;**22**:147–151.
8. Lantelme P, Mestre C, Lievre M, Greeard A, Milon H. Heart rate: An important confounder of pulse wave velocity assessment. *Hypertension* 2002;**39**:1083–1087.
9. Vaya A, Simo M, Santaolara M, Carrasco P, Corella D. Plasma viscosity and related cardiovascular risk factors in a Spanish Mediterranean population. *Thromb Res* 2007;**120**:489–495.
10. Basta G, Castagnini M, Del Turco S, et al. High plasma levels of the soluble receptor for advanced glycation endproducts in patients with symptomatic carotid atherosclerosis. *Eur J Clin Invest* 2009;**39**:1065–1072.