European Review for Medical and Pharmacological Sciences 2017; 21: 5798-5804

Correlation analysis of ankle-brachial index and brachial-ankle pulse wave velocity with cardiac structures and functions in patients with essential hypertension

Y.-L. LI[1], X. SONG[2], J.-C. REN[2], X.-G. LI[2], S.-A. HOU[2], C. MIAO[3]

[1]Nursing Department, People's Hospital of Rizhao, Rizhao, China
[2]Department of Critical Care Medicine, People's Hospital of Rizhao, Rizhao, China
[3]Maternity and Child Care Hospital of Rizhao, Rizhao, China

Abstract. – OBJECTIVE: To investigate the correlation of ankle-brachial index (ABI) and brachial-ankle pulse wave velocity (baPWV) with cardiac structures and functions changes in patients with essential hypertension (EH).

PATIENTS AND METHODS: A total of 202 patients with hypertension meeting the inclusion criteria were recruited in our hospital from June 2016 to August 2017. They were divided into 4 groups: the low ABI value group, the normal ABI value group, the increased baPWV value group and the normal baPWV group. Clinical data were collected, including medical histories and received physical examinations, blood pressure measurement, biochemical tests and other examinations through the automatic atherosclerosis tester (VP-l00) and echocardiography.

RESULTS: Interventricular septal thickness (IVST) of the low ABI value group was significantly larger than that of the normal ABI value group ($p<0.05$). Compared with those of the normal ABI value group, left ventricular ejection fraction (LVEF) and the ratio of peak velocity flow in the E wave to peak velocity flow in the A wave (E/A) of the low ABI value group were significantly decreased ($p<0.05$). Left atrium diameter (LAD) and IVST of the increased baPWV group were significantly greater than those of the normal baPWV group ($p<0.05$), and left ventricular ejection fraction (LVEF) of the former was smaller than that of the latter ($p<0.05$). Correlation analyses showed that ABI was negatively correlated with IVST ($r=-0.713$, $p<0.05$) but positively correlated with LVEF and E/A ($r=0.685$ and 0.572, respectively, $p<0.05$); baPWV was positively related to LAD and LVST ($r=0.413$ and 0.527, respectively, $p<0.05$) but negatively related to LVEF ($r=-0.546$, $p<0.05$).

CONCLUSIONS: ABI and baPWV are significantly associated with changes in cardiac structures and functions in patients with EH, which provide a basis for early intervention in clinical.

Key Words

Hypertension, Ankle-brachial index, Pulse wave velocity, Cardiac structure, Cardiac function.

Introduction

Hypertension with a high incidence rate and morbidity rate has been recognized as the most important public health problem[1,2]. Continuously increased blood pressure in the long term can promote the formation and development of atherosclerosis in all kinds of vessels, which result in vascular intimal hyperplasia and narrow lumen, thus leading to the decreased blood flows in target organs, such as the heart, brain and kidney, and triggering qualitative changes in organs. The heart, as one of those target organs, has the closest relationship with hypertension. Proper treatment for hypertension could reverse the myocardial remodeling and improve the quality of life[3-5]. Noninvasive atherosclerosis test detects the ankle-brachial index (ABI) and brachial-ankle pulse wave velocity (baPWV) of subjects by using an arteriosclerosis detector for comprehensively assessing the arterial wall hardness of them. ABI is the ratio of the systolic arterial pressure at the ankle to the systolic arterial pressure in the upper arm. In recent years, a large number of clinical trials have confirmed that ABI can be used to measure arterial stiffness[6-9]. Pulse wave velocity (PWV) is the velocity at which the arterial pulse propagates on the vessel wall through the circulatory system. baPWV is widely used as a noninvasive measure for arterial stiffness, and it is considered to be an early and sensitive marker for the diagnosis of atherosclerosis[10-12].

The aim of this study was to investigate the correlation of arteriosclerosis with cardiac structures and functions in patients with essential hypertension (EH) so as to evaluate the effect of hypertension on cardiac functions.

Corresponding Author: Chao Miao, MD; e-mail: hcz735563@163.com

Patients and Methods

Patients

Patients admitted to our hospital from June 2016 to August 2017 and diagnosed with EH were selected. After a rigorous screening, a total of 202 patients were collected, including 130 males and 72 females with an average age of (63.28±10.97) years old. All patients were divided into 4 groups according to ABI value and baPWV value: the normal ABI value group (ABI>0.9), the low ABI value group (ABI≤0.9), the normal baPWV value group and the increased baPWV value group (Table I) [13]. Signed written informed consents were obtained from all participants before the study. This study was approved by the Ethics committee of People's Hospital of Rizhao.

Methods

Determination of biochemical indexes: triglyceride (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), fasting blood glucose (FBG), serum creatinine (Scr), homocysteine (Hcy) and other biochemical indexes were determined by Beckman Coulter DxC80 automatic biochemical analyzer (Beckman Coulter®, Brea, CA, USA).

Monitoring of dynamic blood pressure: ambulatory blood pressure monitoring (ABPM) was conducted for subjects using the dynamic blood pressure monitor (Suntech Power Holdings Co., Ltd., Farmingdale, NY, USA). According to the setting, the dynamic blood pressure was measured once every 30 min during the day (11 am-11 pm) and once every 1 h during the night (11 pm-11 am the next day). Effective cases were patients with the measurement times of blood pressure > 80%. The average SBP, DBP, and pulse pressure (PP), were recorded throughout the day.

Echocardiography detection: cardiac functions were detected using Acuson 128xp/10c color Doppler ultrasound diagnostic apparatus (Mountain View, CA, USA). Cardiac structural parameters include left atrium diameter (LAD), left ventricular diastolic diameter (LVDd), left ventricular systolic diameter (LVSd), interventricular septal thickness (IVST). The cardiac systolic function indicators [left ventricular ejection fraction (LVEF)] and the cardiac diastolic function indicator [the ratio of peak velocity flow in the E wave to peak velocity flow in the A wave (E/A)] were measured.

Atherosclerosis test: ABI and baPWV were detected using the Colin VP-100 automatic atherosclerosis detector (Komaki, Japan). The detection was conducted consecutively 3 times, the interval between the detection was 5 min, and the average value was calculated. In this study, the lower value on the two sides was chosen as the ABI value, while the higher value on the two sides was chosen as the baPWV value. Both values were used for statistical analysis.

Table I. Aortic elastic function standard range of general population (cm/s).

	Male	Female
20-29 years	1150-1280	982-1092
30-39 years	1176-1304	1037-1147
40-49 years	1211-1353	1106-1229
50-59 years	1280-1435	1221-1382
60-69 years	1392-1578	1370-1556
70-79 years	1553-1814	1552-1811

Statistical Analysis

All the data were statistically analyzed by using Statistical Product and Service Solutions (SPSS) 20.0 software (IBM, Armonk, NY, USA). Measurement data were expressed as mean ± standard deviation ($\bar{x}$±s), and count data were presented as percentage. The *t*-test was performed for comparisons of continuous data and x^2 test for count data. ABI, baPWV and other indicators were used for partial correlation analyses. $p<0.05$ suggested that the difference was statistically significant.

Results

Part I. Relationship of ABI with Various Indicators for Cardiac Structures and Functions

Comparisons of general clinical data between the normal ABI value group and the low ABI value group

According to the ABI value, patients were divided into the normal ABI value group and the low ABI value group. There were 143 cases at the average age of (59.64±11.37) years old in the normal ABI value group, accounting for 70.79% of the total number of cases. There were 44 cases at the average age of (64.04±11.96) years old in the low ABI value group, accounting for 29.21% of the total number of cases. There were no significant differences in age, HDL-C and Hcy between the two groups ($p<0.05$, Table II), and the analysis showed that there were no significant differences in the remaining clinical data between the two groups ($p>0.05$, Table II).

Table II. General clinical characteristics of the normal ABI value group and the low ABI value group ($\bar{x}$±s).

	Normal ABI value group (n=143)	Low ABI value group (n=59)	t/χ^2	*p*
Age (y)	59.64±11.37	64.04±11.96	-2.159	0.039
Male, n (%)	84 (58.74)	44 (74.58)	1.196	0.231
Duration of hypertension (y)	5.86±6.59	6.79±0.95	-0.814	0.358
TC (mmol/L)	1.85±1.14	1.60±0.87	1.535	0.216
TG (mmol/L)	4.52±1.03	4.11±1.32	1.741	0.144
HDL-C (mmol/L)	1.18±0.46	1.05±0.31	2.634	0.027
LDL-C (mmol/L)	2.84±0.79	2.59±1.23	1.169	0.340
FBG (mmol/L)	5.65±1.66	6.84±1.30	-2.013	0.089
Scr (μmol/L)	68.79±16.92	86.58±11.43	-2.583	0.067
Hcy (μmol/L)	13.54±2.69	24.02±13.37	-1.978	0.007
Average SBP (mmHg)	120.47±16.16	126.03±14.25	-1.658	0.225
Average DBP (mmHg)	70.08±9.67	68.24±10.85	0.624	0.624
Mean pulse pressure	50.25±9.98	52.16±10.09	-1.469	0.313

Abbreviation: TC, total cholesterol; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; FBG, fasting blood glucose; Scr, serum creatinine; Hcy, homocysteine; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Comparisons of cardiac structures and functions between the normal ABI value group and the low ABI value group

Comparisons of cardiac structures and functions in patients between the normal ABI value group and the low ABI value group showed that IVST of the low ABI value group was larger than that of the normal ABI value group ($p<0.05$, Table III). Compared with those of the normal ABI value group, LVEF and E/A of the low ABI value group were significantly decreased ($p<0.05$, Table III). LAD, LVDd and LVSd of the low ABI value group were larger than those of the normal ABI group, but the differences were not statistically significant ($p>0.05$, Table III).

Correlation analyses of ABI with indicators for cardiac structures and functions

After age and other possible confounding factors were controlled, correlation analyses were conducted. The results indicated that ABI was negatively related to IVST (r=-0.713, $p<0.05$, Table IV), but positively correlated with LVEF and E/A (r=0.685 and 0.572, respectively, $p<0.05$, Table IV).

Part II. Correlation of baPWV with Various Indicators for Cardiac Structures and Functions

Comparisons of general data between the normal baPWV value group and the increased baPWV value group

According to the baPWV value, patients were divided into the normal baPWV value group and the increased baPWV value group. There were 135 patients at the average age of (58.99±11.32) years old in the normal baPWV value group, accounting for 66.83% of the total number of cases. There were 67 cases at the average age of (64.86±10.24) years old in the increased baPWV value group, accounting for 33.17% of the total number of cases. There were statistically significant differences in age, gender, systolic blood

Table III. Comparisons of cardiac structures and functions between the normal ABI value group and the low ABI value group.

	Normal ABI value group (n=143)	Low ABI value group (n=59)	*t*	*p*
LAD (mm)	33.65±4.12	35.22±4.35	-1.698	0.716
LADd (mm)	48.49±4.34	49.80±6.37	-1.416	0.272
LVSd (mm)	31.46±4.35	32.87±5.41	-1.355	0.219
IVST (mm)	8.68±0.86	11.84±1.46	-12.147	0.000
LVEF (%)	64.82±3.43	54.09±8.74	9.264	0.001
E/A	1.09±0.27	0.86±0.19	7.822	0.000

Abbreviation: LAD, left atrium diameter; LVDd, left ventricular diastolic diameter; LVSd, left ventricular systolic diameter; IVST, interventricular septal thickness; LVEF, left ventricular ejection fraction; E/A, the ratio of peak velocity flow in he E wave to peak velocity flow in the A wave.

Table IV. Correlation of ABI with indicators for cardiac structures and functions.

	Correlation coefficient	*p*
IVST (mm)	-0.713	0.000
LVEF (%)	0.685	0.000
E/A	0.572	0.000

Abbreviation: IVST, interventricular septal thickness; LVEF, left ventricular ejection fraction; E/A, the ratio of peak velocity flow in he E wave to peak velocity flow in the A wave.

pressure and PP between the two groups ($p<0.05$, Table V), but there were no significant differences in the remaining clinical data between the two groups ($p>0.05$, Table V).

Comparisons of cardiac structures and functions between the normal baPWV value group and the increased baPWV value group

Comparisons of different cardiac structures and functions between the two groups of patients revealed that LVEF of the increased baPWV value group was smaller than that of the normal baPWV value group ($p<0.05$, Table VI). LAD and IVST of the increased baPWV value group were significantly higher than those of the normal baPWV value group ($p<0.05$, Table VI). LVDd and LVSd of the increased baPWV value group were larger than those of the normal baPWV value group, E/A of the former was smaller than that of the latter, but the differences were not statistically significant ($p>0.05$, Table VI).

Correlation analyses of baPWV with cardiac structures and functions

After age and other possible confounding factors were controlled, correlation analyses of baPWV value with different indicators for cardiac structures and functions were conducted. The results indicated that baPWV was positively related to LAD and IVST (r=0.413 and 0.527, respectively, $p<0.05$, Table VII), but negatively associated with LVEF (r=-0.546, $p<0.05$, Table VII).

Discussion

Hypertension is one of the most common cardiovascular diseases endangering human health, and China is one of the countries with a high incidence rate of EH[3]. For a long time, the prevention and treatment of hypertension have mainly focused on reducing the risk and mortality rate of cardiovascular and cerebrovascular diseases. People pay little attention to the changes of cardiac structures and functions in patients with hypertension[1,4,5]. However, hypertension in the early phase can lead to changes in cardiac structures and functions, and the diastolic dysfunction occurs earlier than the systolic dysfunction.

The clinical significance of arteriosclerosis test in evaluating early vascular lesions has received more and more attention. Abnormalities in ABI and baPWV are potent predictors of cardiovascular diseases and their mortality

Table V. General clinical characteristics of the normal ABI valuegroup and the low ABI value group ($\bar{x}$±s).

	Normal baPWV value group (n=135)	Increased baPWV value group (n=67)	t/χ^2	*p*
Age (y)	58.99±11.32	64.86±10.24	-4.513	0.003
Male, n (%)	84 (62.22)	44 (65.67)	3.839	0.034
Duration of hypertension (y)	5.80±6.47	6.44±6.73	-0.825	0.435
TC (mmol/L)	1.85±1.23	1.58±0.95	1.744	0.226
TG (mmol/L)	4.49±1.04	4.12±1.21	2.572	0.068
HDL-C (mmol/L)	1.16±0.45	1.10±0.30	3.014	0.624
LDL-C (mmol/L)	2.84±0.86	2.59±0.98	1.549	0.072
FBG (mmol/L)	6.34±2.01	6.05±1.84	0.966	0.433
Scr (μmol/L)	66.59±14.23	72.42±15.62	-1.708	0.095
Hcy (μmol/L)	17.29±3.32	19.00±4.15	-2.125	0.122
Average SBP (mmHg)	119.82±14.85	124.58±13.54	-1.982	0.041
Average DBP (mmHg)	69.71±9.49	66.59±10.83	1.825	0.086
Mean pluse pressure	48.89±9.33	53.88±9.71	-4.147	0.001

Abbreviation: TC, total cholesterol; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; FBG, fasting blood glucose; Scr, serum creatinine; Hcy, homocysteine; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table VI. Comparisons of cardiac structures and functions between the normal baPWV value group and the increased baPWV value group.

	Normal baPWV value group (n=135)	Increased baPWV value group (n=67)	*t*	*p*
LAD (mm)	32.95±3.26	36.27±4.18	-4.459	0.000
LADd (mm)	48.36±4.11	49.82±6.74	-1.895	0.245
LVSd (mm)	31.62±4.59	33.05±5.16	-1.476	0.069
IVST (mm)	9.27±1.25	11.23±2.09	-5.018	0.002
LVEF (%)	64.13±3.68	57.14±8.52	4.773	0.000
E/A	1.06±0.21	0.99±0.23	0.842	0.074

Abbreviation: LAD, left atrium diameter; LVDd, left ventricular diastolic diameter; LVSd, left ventricular systolic diameter; IVST, interventricular septal thickness; LVEF, left ventricular ejection fraction; E/A, the ratio of peak velocity flow in he E wave to peak velocity flow in the A wave.

rates, especially in patients with EH, which could play an important role in early prevention and early treatment of cardiovascular diseases.

ABI is the ratio of the systolic arterial pressure at the ankle (posterior tibial artery or arteria dorsalis pedis) to the systolic arterial pressure in the upper arm. Age is the most important factor affecting ABI[6-9]. Previous studies confirmed that age is significantly associated with ABI abnormalities, which was consistent with the findings of this study. However, reports on whether gender is related to ABI abnormalities are different. There was no significant difference in gender between the two ABI groups in this study. A large number of studies have shown that the concentration of blood HDL-C is inversely proportional to the incidence rates of atherosclerosis and cardiovascular diseases; the low-concentration HDL-C is an independent risk factor for coronary heart disease. The decrease degree of HDL-C concentration is no less than that of LDL-C, and HDL-C is a more significant high-risk factor affecting atherosclerosis than LDL-C. In this study, HDL-C was a protective factor for a significant decrease in ABI, which was consistent with the conclusion that HDL-C has been known to have the anti-atherosclerosis function. The high-concentration Hcy is closely related to cardiovascular diseases; in particular, patients with hypertension combined with high-concentration Hcy suffer more serious harms, and its mechanism may be closely related to inflammatory responses. It was found in this study that ABI was significantly associated with Hcy. For patients with hypertension, the concentration of plasma Hcy needs to be regularly measured while the blood pressure is reduced to the standard level, and folic acid and Vitamin B12 are supplemented to prevent or reduce the risk of Hcy on cardiovascular events. In this study, it was also found that IVST of the hypertensive low ABI value group was significantly larger than that of the normal ABI value group, and EF and E/A of the low ABI value group were significantly lower than those of the normal ABI value group. ABI was negatively correlated with IVST but positively correlated with LVEF and E/A. LAD of the low ABI value group was larger than that of the normal ABI value group, but the difference was not statistically significant (p>0.05). The reason might be related to the small sample size exerting effects on study results to some degree. Therefore, there still need further large-scale clinical research and experiments for exploring the relationship of ABI with cardiac structures and functions and the application value of ABI in the clinical practice.

Table VII. Correlation of baPWV with indicators for cardiac structures and functions.

	Correlation coefficient	*p*
IVST (mm)	0.413	0.000
LVEF (%)	0.527	0.000
E/A	-0.546	0.000

Abbreviation: IVST, interventricular septal thickness; LVEF, left ventricular ejection fraction; E/A, the ratio of peak velocity flow in he E wave to peak velocity flow in the A wave.

PWV changes are the overall reflection of the central arterial morphology and functional abnormalities, which can better reflect the arterial elasticity and are an important indicator for arteriosclerosis[10-12]. A number of studies have indicated that age is one of the major influencing factors for baPWV; the baPWV value will increase gradually with age, which is consistent with the results of this investigation. In this study, the difference in gender between the two baPWV groups was statistically significant. Studies have shown that the average PWV values in men in different age groups are higher than those of women, suggesting that the estrogen secretion may be related to changes in baPWV. Clinical findings show that the effect of blood pressure on baPWV is also important, which is related to the fact that blood pressure is the original motility of pulse formation. Compared with systemic vascular resistance and diastolic blood pressure, systolic blood pressure is a key factor in determining "ventricular-vascular interactions". It was revealed in this study that there was a correlation between systolic blood pressure and baPWV, manifesting that systolic blood pressure might play a great role in promoting arteriosclerosis. There was no significant difference in mean diastolic blood pressure between the normal baPWV value group and the increased baPWV value group, indicating that compared with diastolic blood pressure, systolic blood pressure is the main factor influencing PWV, which was consistent with the results of previous studies. Therefore, in clinical work, clinicians should pay attention to the control of systolic blood pressure and PP, which play a vital role in slowing down the hardening of the arteries and reducing the occurrence and development rates of various cardiovascular diseases. The results of this study revealed that IVST and LAD of the increased baPWV value group were significantly larger than those of the normal baPWV value group, while EF of the former was smaller than that of the latter. Therefore, in patients with hypertension, the increased baPWV value is associated with the deterioration of cardiac functions, and baPWV can be used as an indicator for the assessment of cardiac functions.

In summary, both ABI and baPWV are good predictors of arteriosclerosis, which are closely related to the occurrence, development, and prognosis of central and peripheral arteriosclerotic diseases. Measurements of ABI and baPWV are conductive to the early understanding of the degree of atherosclerosis in patients, thus providing useful information for clinical work so as to take individualized intervention measures to actively prevent atherosclerosis and prevent or delay the development and progression of cardiovascular diseases.

Conclusions

ABI and baPWV in patients with EH are significantly correlated with relevant indicators for cardiac structures and functions. As noninvasive indicators for detecting aortic atherosclerosis, ABI and baPWV can be used to evaluate cardiac functions in the clinical practice.

Conflict of Interest

The authors declared no conflicts of interest.

References

1) Ashoorkhani M, Bozorgi A, Majdzadeh R, Hosseini H, Yoonessi A, Ramezankhani A, Eftekhar H. Comparing the effectiveness of the BPMAP (Blood Pressure Management Application) and usual care in self-management of primary hypertension and adherence to treatment in patients aged 30-60 years: study protocol for a randomized controlled trial. Trials 2016; 17: 511.
2) Garjon J, Saiz LC, Azparren A, Elizondo JJ, Gaminde I, Ariz MJ, Erviti J. First-line combination therapy versus first-line monotherapy for primary hypertension. Cochrane Database Syst Rev 2017; 1: D10316.
3) Yang FF, Peng F, Xing YB, Yuan M, Ma XC, Li G, Guo HY. Impacts of serum P-selectin on blood pressure control after PCI in patients with coronary heart disease complicated with hypertension. Eur Rev Med Pharmacol Sci 2017; 21: 78-83.
4) Jenner R, Fatureto-Borges F, Costa-Hong V, Lopes HF, Teixeira SH, Marum E, Giorgi D, Consolim-Colombo FM, Bortolotto LA, Lorenzi-Filho G, Krieger EM, Drager LF. Association of obstructive sleep apnea with arterial stiffness and nondipping blood pressure in patients with hypertension. J Clin Hypertens (Greenwich) 2017; 19: 910-918.
5) Jurio-Iriarte B, Gorostegi-Anduaga I, Aispuru GR, Perez-Asenjo J, Brubaker PH, Maldonado-Martin S. Association between Modified Shuttle Walk Test and cardiorespiratory fitness in overweight/obese adults with primary hypertension: EXERDIET-HTA study. J Am Soc Hypertens 2017; 11: 186-195.
6) Desormais I, Aboyans V, Guerchet M, Ndamba-Bandzouzi B, Mbelesso P, Mohty D, Marin B, Dartigues JF, Preux PM, Lacroix P. Ankle-brachial index: an ubiquitous marker of cognitive impairment-The EPIDEMCA study. Angiology 2017: 291983200.
7) Chongthawonsatid S, Dutsadeevettakul S. Validity and reliability of the ankle-brachial index by oscillometric blood pressure and automated ankle-brachial index. J Res Med Sci 2017; 22: 44.
8) Miura T, Minamisawa M, Ueki Y, Abe N, Nishimura H, Hashizume N, Mochidome T, Harada M, Oguchi Y,

Yoshie K, Shoin W, Saigusa T, Ebisawa S, Motoki H, Koyama J, Ikeda U, Kuwahara K. Impressive predictive value of ankle-brachial index for very long-term outcomes in patients with cardiovascular disease: IMPACT-ABI study. PLoS One 2017; 12: e177609.

9) Herraiz-Adillo A, Cavero-Redondo I, Alvarez-Bueno C, Martinez-Vizcaino V, Pozuelo-Carrascosa DP, Notario-Pacheco B. The accuracy of an oscillometric ankle-brachial index in the diagnosis of lower limb peripheral arterial disease: a systematic review and meta-analysis. Int J Clin Pract 2017; 71(9). doi: 10.1111/ijcp.12994.

10) Munakata M. Brachial-Ankle pulse wave velocity: background, method, and clinical evidence. Pulse (Basel) 2016; 3: 195-204.

11) Wang Y, Zhang J, Qain Y, Tang X, Ling H, Chen K, Li Y, Gao P, Zhu D. Association of brachial-ankle pulse wave velocity with asymptomatic intracranial arterial stenosis in hypertension patients. J Stroke Cerebrovasc Dis 2016; 25: 1922-1928.

12) Ato D, Sawayama T. Factors associated with high brachial-ankle pulse wave velocity in non-hypertensive and appropriately treated hypertensive patients with atherosclerotic risk factors. Vasc Health Risk Manag 2017; 13: 383-392.

13) Yiming G, Zhou X, Lv W, Peng Y, Zhang W, Cheng X, Li Y, Xing Q, Zhang J, Zhou Q, Zhang L, Lu Y, Wang H, Tang B. Reference values of brachial-ankle pulse wave velocity according to age and blood pressure in a central Asia population. PLoS One 2017; 12: e171737.