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RESEARCH ARTICLE

The association between augmentation index and arterial stiffness index

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Abstract: **Objective** To explore the association between arterial system augmentation index(AI) and brachial-ankle pulse wave velocity (baPWV). **Methods** All subjects were selected from a local community. The study included 1752 people living in Shijingshan district, Beijing during April to June, 2010. Subjects whose age ranged from 23 to 90 years old [(59.82±11.88) years old] were included and 56.7% of the subjects were women. Pulse wave at the left radial artery was measured and the AI was calculated by Colin pulse wave detection device HEM9000AI. baPWV and ankle-brachial index (ABI) were measured using Colin noninvasive arteriosclerosis tester VP-1000. Color doppler flow imaging was used to measure intima-media thickness (IMT) of the bilateral carotid artery. **Results** The baPWV was significantly higher in ABI⩽0.9 group and IMT⩾0.9 mm group, while there was no significant difference of AI_{75} between groups. AI had a low correlation with baPWV (r = -0.068, P = 0.005). Partial correlation analysis showed that there was no significant association between AI and baPWV (r = -0.033, P = 0.17). In multiple stepwise regression analysis, the factors of AI included gender, age, BMI, waist-to-hip ratio, heart rate, ABI and systolic pressure. **Conclusion** No significant correlation can be found between AI and baPWV. Various factors may influence the measurement of AI. This study suggests that AI may not be a sensitive and reliable index for the evaluation of arterial stiffness.

Keywords: blood vessels; augmentation index (AI); atherosclerosis

Noninvasive method for detecting arterial stiffness to early screen atherosclerosis and cardiovascular risk became the focus of doctors in recent years. Augmentation index (AI) which can be sensitive to the pressure caused by changes in elasticity of large and small arteries wave reflection condition is considered to be a common indicators to evaluate the stiffness of arterial system . The current study shows that AI is independent of cardiovascular events risk factors and can be as an independent predictors of adverse cardiovascular events.[1–3] But there are also research result contrary to this conclusion.[4] This study was designed to analyze the relation and influencing factors between AI and Brachial-ankle pulse wave velocity (baPWV) whch is as the gold standard of arterial stiffness, to explore the meaning of AI as an indicator of arteriosclerosis.

1 Objects and methods

1.1 General information

A cross-sectional survey of residents from Shougang community in Shijingshan District from April to June in 2010, 1752 persons were selected from the general data with full information including 759 males and 993 females aged 23 to 90 years old, the average age is (59.82±11.88) years. Exclusion criteria: cardiac insufficiency, cardiomyopathy, arrhythmia, valvular disease, arterial occlusive disease and other serious heart vascular disease, or with liver, kidney dysfunction, respiratory failure or with known to suffer from cancer or pregnant women. All selected subjects signed the informed consent.

1.2 Methods

A cross-sectional survey was conducted. To collecte the subjects information through questionnaires and physical check. Brachial artery blood pressure was measured for three times to get the average value, detect the ECG, extract the venous blood, leave the urine fluid specimens, detect the blood glucose, blood lipids, urinary creatinine and microalbumin and other biochemical index.

Subjects took a check after a quiet rest for 15 minutes. Left radial artery pressure waveform was measured for 30 seconds by Colin HEM-9000 AI detector collec-

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Table 1. General information of different age groups

Item	18-40 years	40-50years	50-60years	60-70years	≥70 years
Cases(male/female)	67（26/41）	275（113/162）	646（250/396）	335（155/180）	429（215/214）
Age	31.66±5.23	46.75±2.48	55.04±2.71	65.48±3.22	75.36±3.89
BMI（kg/m2）	24.24±4.48	25.21±3.86	25.37±3.55	25.35±3.46	24.97±3.41
Waist–hip ratio	0.83±0.09	0.86±0.07	0.87±0.06	0.88±0.06	0.90±0.06
Fasting glucose（mmol/L）	4.86±1.40	5.22±1.47	5.54±1.69	5.83±1.71	6.08±2.01
TriglycerideS（mmol/L）	2.03±2.63	1.84±1.79	1.80±1.55	1.58±0.95	1.68±1.66
Total cholesterol（mmol/L）	4.55±0.84	4.84±0.80	5.11±0.94	4.97±1.01	5.00±1.04
Low density lipoproten-cholesterol（mmol/L）	2.42±0.77	2.79±0.72	2.99±0.85	2.96±0.86	2.92±0.83
Microalbuminuria/Urine creatinine（g/mol）	8.61±18.33	11.74±28.47	13.65±46.69	16.56±86.61	33.06±163.31

tion, the instrument automatically output AI value, and AI vonverted to the standard correction value of AI_{75} when the heart rate was 75 times / min. The instrument calculates the standard deviation (AI-SD) of the AI, AI-SD control in the range of ±5.6

Application of Colin noninvasive arteriosclerosis analyzer VP-1000 measurement baPWV and ankle-brachial index (ABI), the bilateral carotid artery images were collected by color Doppler ultrasonography measurement of bilateral carotid intima - media thickness (IMT).

According to age, subjects were divided into 5 groups: 18 to 40 years group, 40 to 50 years group, 50 to 60 years group, 60 to 70 years group, and older than 70 years old group. According to baPWV, subjects were divided into baPWV<1400 cm/s group and baPWV⩾1 400 cm/s group. According to ABI points, ABI> 0.9 group and ABI⩽0.9 group. According to the largest IMT is divided into IMT <0.9 mm group and IMT⩾0.9 mm group.

1.3 Statistical methods

Application of SPSS 19.0 statistical software, measurement data were showed by $\bar{x}$±s, and the comparison between groups using independent samples t test and variance analysis. Data are expressed in terms of rate or percentage, and the comparison between groups is based on the test Pearson correlation analysis and multivariate regression analysis were used.

2 Results

2.1 Baseline data

Among the 752 selected subjects, 929 (53.0%) subjects with high blood pressure, 385 cases of diabetes (22.0%) and dyslipidemia in 657 cases (37.5%). Baseline data for all age groups are shown in Table 1 .

2.2 Differences of baPWV and AI_{75} among groups

Subjects were grouped by age, gender and baPWV. Compared between baPWV 1400 cm/s group and baPWV 1400 cm/s group, the difference of AI_{75}, are statistically significant except for the male 40 to 49 years group [(74.54±10.80)% in the group of baPWV< 1400 cm/s vs. (79.96±9.83)% in the group of baPWV⩾1400 cm/s, P = 0.008]. There was no statistical significant difference of AI_{75} between groups in other age and female groups.

Subjects were grouped according to gender, IMT and ABI, comparing ABI> 0.9 group and ABI⩽0.9 group, IMT< 0.9 mm group and IMT⩾0.9 mm between groups baPWV and AI_{75}. The results showed that there was a statistically significant difference between baTWV and IMT and ABI stratification righteousness, and AI_{75}. There was no significant difference between the two groups. See Table 2.

2.3 Correlation analysis between AI and baPWV

Pearson correlation analysis showed that AI was associated with baPWV (R= -0.068, P= 0.005) in control of age, heart rate, waist to hip ratio, body mass index, systolic and diastolic blood pressure after partial phase. Analysis showed that there was no correlation between AI and baPWV.

2.4 AI multiple linear regression analysis

Age, sex, body mass index, waist to hip ratio, heart rate, ABI, baPWV, maximum IMT and systolic blood pressure as independent variables and Al as dependent variable, multiple linear regression analysis was conducted, inclusion criteria and rejection criteria was 0.05 and 0.1 respectively. The results showed that gender, age, physical means number, waist-to-hip ratio, heart

Table 2. Comparison of AI_{75} and baPMV in groups of gender, ABI and IMT

Item	ABI>0.9	ABI⩽0.9	P vale	IMT<0.9 mm	IMT⩾0.9 mm	P vale
Male						
AI75 (%)	77.25±10.98	79.78±11.71	0.18	76.79±10.56	77.72±11.29	0.26
baPWV (cm/s)	1 670.76±360.99	1 797.68±350.15	0.04	1 646.68±370.20	1 741.84±363.77	0.001
Female						
AI75 (%)	85.81±9.80	86.10±10.28	0.85	85.74±9.46	85.92±10.27	0.78
baPWV (cm/s)	1 604.34±381.07	1 749.35±408.29	0.02	1 518.79±346.74	1 724.71±395.76	< 0.001

rate, ABI and systolic blood pressure are impact factors of AI (R^2 = 0.62, P ¡0.001).

3 Discussion

AI and pulse wave velocity are commonly used to assess noninvasive detection indicators of arterial stiffness, and can be obtained by the calculation of non-invasive detection equipment through the induction pulse wave waveform. Studies have shown that[3] AI elevation suggests early arterial lesions which can predict the risk of adverse cardiovascular events and the risk of death. PWV is a noninvasive index that evaluates arterial stiffness.[5] Predict the independent impact factor of cardiovascular event mortality, which has been clinically widely used.[6] In theory, AI is affected by PWV, PWV and AI will increase when the reflected wave increases. But actually, AI reflecting the flexibility of the entire arterial system, can not distinguish between aorta and small move pulse, and PWV is mainly reflected in the arterial stiffness, depends on in the arterial lumen diameter and wall elasticity. This study shows that there is no correlation between AI and baPWV after control the factors of age, heart rate, waist and hip than the body mass index, systolic blood pressure and diastolic blood pressure and other indicators.

ABI is a noninvasive index that reflects the elasticity of peripheral arteries and has a high sensitivity and specificity to diagnose peripheral arterial disease. Carotid pulse IMT can be used for early evaluation of atherosclerosis, and it is important to measure cardiovascular events. This study shows that for baPWV, there was a statistically significant difference between ABI and IMT stratification groups, while for AI_{75}, the difference between the groups was not statistically significant. Suggesting that AI can not predict ABI and IMT abnormal changes in the assessment of atherosclerosis in terms of no baPWV sensitive, and wich can not be independent as a sensitive and reliable prediction index.

AI have more influential factors, theoretically by the pulse wave propagation speed degree, the distance of the reflection point and the reflection coefficient,[7] so any factors that can influence these AI values, such as age, obesity, dyslipidemia, insulin resistance[8] and those may lead to increase vascular stiffness, affecting PWV, and elevating AI finally. The distance between the spot and the reflex coefficient is closely related to the height and the large blood vessel bifurcation point location, and AI value will decreas in persons with tall, obese, large blood vessels bifurcated close heart of the crowd. AI value of female is higher, perhaps because the body short stature and radial diameter of the smaller diameter.[9]

The noninvasive detector is calculated by recording the left radial artery waveform AI, and the accuracy of the numerical values of AI may be affected by the method of operation and the subject, such as the instrument probe placed position, angle, the subject hand shaking moving and so on. This measurement was conducted to minimize the impact of human factors by special staff, strictly comply with the operation steps of the instrument and quality control range. In addition, the AI value from no invasive radial artery waveform detector was transferred using a fixed formula conversion AI, and there may be defective, which may lead to conversion of the AI value is not accurate, coupled with the community crowd contains more confounding factors, leading to AI and its arterial elasticity assessment index compared to the lack of sensitivity and reliability. Therefore, at present, AI can not be used as an independent risk indicator to assess the valvular stiffness and arteriosclerosis.

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