Ankle-brachial Pressure Index Measured Using an Automated Oscillometric Method as a Predictor of the Severity of Coronary Atherosclerosis in Patients with Coronary Artery Disease

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Ankle-brachial pressure index (ABI) measured using a conventional Doppler method is an independent predictor of the number of coronary vessels affected in coronary artery disease (CAD). Recently, a new clinical device has been developed to measure ABI using an oscillometric method. It is unclear whether ABI measured using this device is a significant predictor of the severity of coronary atherosclerosis. We retrospectively included 87 patients from our outpatient clinic who had ever undergone coronary angiography. ABI was determined in all subjects using the new ABI-form device. The lower value of ABI in either limb was used for analysis. We divided our subjects into two groups, with either ABI less than 0.9 or at least 0.9, and compared basal characteristics between groups. We analyzed the relationship between ABI and the severity of CAD. In addition, we calculated the sensitivity, specificity, and positive and negative predictive values of ABI less than 0.9 in predicting multivessel (two-vessel + three-vessel) involvement in our patients. There were 15 patients with ABI less than 0.9 and 72 with ABI at least 0.9. Patients with ABI less than 0.9 were older and had higher plasma levels of uric acid. The prevalence of diabetes mellitus, hypertension, smoking, and diuretic use was significantly higher in patients with ABI less than 0.9. In addition, the group with ABI less than 0.9 had a lower prevalence of one-vessel CAD and higher prevalence of three-vessel or multivessel CAD. The sensitivity, specificity, and positive and negative predictive values of ABI less than 0.9 in predicting multivessel CAD were 22%, 96%, 93%, and 34%, respectively. In conclusion, ABI measured using the automated oscillometric method can be used to predict the severity of coronary atherosclerosis in patients with CAD.

Key Words: ankle-brachial pressure index, coronary artery disease, peripheral arterial occlusive disease
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Ankle-brachial pressure index (ABI) is used in clinical practice and epidemiologic studies as an indictor of peripheral arterial occlusive disease (PAOD) [1–6]. Patients with PAOD often have coronary atherosclerosis [7,8], and are at increased risk for adverse cardiovascular events [1,9]. In addition to traditional risk factors, ABI measured using a conventional Doppler method is an independent predictor of the number of coronary vessels affected [10]. Recently, a new clinical device, ABI-form, has been developed to simul-

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taneously measure bilateral arm and ankle blood pressures using an automated oscillometric method. The blood pressures measured with the new device are highly correlated with those obtained using the conventional Doppler method (correlation coefficient 0.95) [11]. In this study, we used the device to measure ABI in patients with coronary artery disease (CAD) and analyzed whether the ABI could serve as a significant predictor of the severity of coronary atherosclerosis.

Patients and Methods

We retrospectively included 87 patients (mean age, 64.9 ± 10.0 years) selected from our outpatient clinic. Demographic data, history of diabetes mellitus, hypertension, smoking, and antihypertensive drug use were recorded from chart review. Total cholesterol, triglyceride, and uric acid levels were checked before coronary angiography (CAG), which was performed in all subjects. Angiographically significant CAD was defined as at least 50% narrowing of a major coronary artery. Before ABI measurement, height and weight were measured and body mass index (BMI) was calculated. ABI and systolic (SBP) and diastolic blood pressure (DBP) were determined in all subjects using the ABI-form (VP-1000; Nippon Colin, Komaki, Japan) device. This device has four cuffs that can automatically and simultaneously measure blood pressure using an oscillometric method in both arms and ankles and calculate the ABI. The lower value of ABI in either limb and left brachial SBP and DBP were used for analysis.

We divided our subjects into two groups, with either ABI < 0.9 or ≥ 0.9. Demographic data, CAD risk factors, antihypertensive and antianginal drug use, plasma uric acid level, and BMI were compared between the groups. We analyzed the relationship between ABI and the severity of CAD. In addition, we calculated the sensitivity, specificity, and positive and negative predictive values of ABI < 0.9 in predicting multivessel (two-vessel + three-vessel) involvement in our patients.

Statistical analysis

All data were analyzed using SPSS version 11.0 (SPSS Inc, Chicago, IL, USA). Results are presented as mean ± standard deviation. Comparisons of continuous variables between groups were made using the independent-samples *t* test. Categorical variables were compared using the Chi-squared or Fisher's exact test. A *p* value of less than 0.05 was considered statistically significant.

Results

Baseline characteristics of patients are summarized in Table 1. There were 15 patients with ABI < 0.9 and 72 with ABI ≥ 0.9. ABI values in the two groups were 0.77 ± 0.09 and 1.06 ± 0.08, respectively ($p < 0.01$). The 15 patients with ABI < 0.9 were older and had higher plasma levels of uric acid than those with ABI ≥ 0.9. The prevalence of diabetes mellitus, hypertension, smoking, and diuretic use was significantly greater in patients with ABI < 0.9.

The relationship between ABI and severity of CAD is shown in Table 2. The prevalences of one-vessel, two-vessel, and three-vessel CAD in patients with ABI ≥ 0.9 were 34.7% (25/72), 31.9% (23/72), and 33.3% (24/72), respectively, and those with ABI < 0.9 were 6.7% (1/15), 26.7% (4/15), and 66.7% (10/15), respectively. The group with ABI < 0.9 had a lower prevalence of one-vessel CAD and a higher prevalence of three-vessel or multivessel CAD. The sensitivity, specificity, and positive and negative predictive values of ABI < 0.9 for multivessel CAD were 22%, 96%, 93%, and 34%, respectively.

Discussion

ABI measured using a conventional Doppler method is a useful indicator of PAOD, especially when it is less than 0.9. In addition, ABI is a predictor of the extent of coronary atherosclerosis and cardiovascular events in patients with CAD [1–6,10]. A new device was recently developed to measure ABI using an automatic oscillometric method. The major advantage of this device is that it can measure bilateral arm and ankle blood pressures at the same time, and can calculate the ABI using ankle and brachial SBP simultaneously. Using this device, we measured the ABI in our patients, and showed that smoking, hypertension, diabetes mellitus, and age were significantly related to ABI. Smoking is one of the major risk factors for the development of PAOD [1,3], and can increase mortality in patients with symptomatic PAOD. The significant association between diabetes mellitus and ABI < 0.9 is in accordance with the clinical notion that diabetes mellitus is usually accompanied by more diffuse atherosclerosis [12]. Drexler et al demonstrated that age, smoking, and blood glucose were independent predictors of the extent of PAOD [13]. In addition to these three variables, diuretic use, hypertension, and plasma levels of uric acid were also significant predictors of PAOD in our study.

In this study, the prevalence of three-vessel or multivessel CAD was significantly higher when ABI was less than 0.9;

Table 1. Baseline characteristics of patients

Variable	ABI ≥ 0.9 (n = 72)	ABI < 0.9 (n = 15)	p
ABI	1.06 ± 0.08	0.77 ± 0.09	< 0.01
Age (yr)	64.0 ± 10.2	69.0 ± 7.5	0.04
Gender (male)	58	11	0.50
BMI (kg/m^2)	25.2 ± 3.1	24.2 ± 3.2	0.26
SBP (mmHg)	136.8 ± 19.4	145.0 ± 20.0	0.16
DBP (mmHg)	80.2 ± 10.6	78.8 ± 10.4	0.68
Total cholesterol (mg/dL)	198.5 ± 49.0	192.4 ± 69.6	0.76
Triglyceride (mg/dL)	159.7 ± 88.5	122.2 ± 115.9	0.28
Uric acid (mg/dL)	6.8 ± 1.8	8.7 ± 2.6	0.03
Use of β-blocker	47	10	0.92
Use of CCB	25	5	0.92
Use of ACEI	26	5	0.84
Use of ARB	28	8	0.30
Use of nitrate	51	11	1.00
Use of nicorandil	22	5	0.83
Use of diuretic	13	8	< 0.01
Hypertension	45	13	0.03
Diabetes mellitus	22	11	< 0.01
Smoking	26	10	0.03

ABI = ankle-brachial pressure index; BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure; CCB = calcium channel blocker; ACEI = angiotensin-converting enzyme inhibitor; ARB = angiotensin II receptor blocker.

Table 2. Relationship between ankle-brachial pressure index (ABI) and the severity of coronary artery disease

Variable	ABI ≥ 0.9 (n = 72)	ABI < 0.9 (n = 15)	p
One-vessel disease	25	1	0.03
Two-vessel disease	23	4	0.77
Three-vessel disease	24	10	0.02
Multivessel disease	47	14	0.03

Multivessel = two-vessel + three-vessel.

the prevalence of three-vessel CAD in patients with ABI < 0.9 (66.7%) was twice that in patients with ABI ≥ 0.9 (33.3%). These findings are in agreement with the report that the coexistence of PAOD in CAD patients is associated with more diffuse and severe CAD [14].

The sensitivity, specificity, and positive and negative predictive values of ABI < 0.9 for multivessel involvement in our patients were 22%, 96%, 93%, and 34%, respectively. The high specificity and high positive predictive value were similar to those reported in previous studies [10,14]. These findings indicate that most patients with one-vessel CAD have ABI ≥ 0.9, and also suggest that ABI measurement is an effective method for predicting which patients with CAD will have multivessel involvement.

Study limitations

This was a retrospective study and CAG was not simultaneously performed with ABI measurement. Thus, the severity of CAD in some patients might have changed before ABI data collection. We lacked follow-up data, so our study could not provide any information about the prognosis of patients with CAD.

Conclusion

ABI measured using the automated oscillometric method can be used to predict the severity of coronary atherosclerosis in patients with CAD.

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以自動化脈衝式的方法所測得的踝臂血壓比可當做冠狀動脈病人動脈硬化嚴重度的指標

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以傳統都卜勒的方法所測得的踝臂血壓比已報告過可做為冠狀動脈嚴重度的指標。最近，有一個新的儀器發明，可用自動化脈衝式的方法來測量踝臂血壓比。但是用此種儀器測量的踝臂血壓比是否也可當做冠狀動脈嚴重度的指標，仍不清楚。我們從門診回溯性地收了 87 位已做過心導管檢查的病人。我們以新的 ABI-form 的儀器為每一位病人測量踝臂血壓比，並以兩側較低一側的值當作分析的數值。我們將病人分為兩組，一組為踝臂血壓比大於或等於 0.9 、另一組為踝臂血壓比小於 0.9 ，並比較這兩組病人的基本資料。我們也分析這兩組病人其踝臂血壓比和冠狀動脈嚴重度的關係。此外，我們計算踝臂血壓比小於 0.9 在預測多條血管病變的敏感度、特異度、陽性預測值和陰性預測值。 87 位病人有 15 位病人的踝臂血壓比小於 0.9 ，有 72 位病人的踝臂血壓比大於或等於 0.9 。踝臂血壓比小於 0.9 的病人年紀較大、尿酸較高；糖尿病、高血壓、抽煙、利尿劑使用的盛行率較高。除此之外，踝臂血壓比小於 0.9 的病人一條血管病變的盛行率較低，而三條或多條血管病變的盛行率較高。踝臂血壓比小於 0.9 在預測多條血管病變的敏感度、特異度、陽性預測值和陰性預測值分別為 22% 、 96% 、 93% 和 34% 。結論，以此自動化脈衝式的方法所測得的踝臂血壓比可當做冠狀動脈病人動脈硬化嚴重度的指標。

關鍵詞：踝臂血壓比，冠狀動脈疾病，周邊動脈阻塞性病變

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