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RESEARCH ARTICLE

Accuracy of Ankle-Brachial Index Measurements in Evaluation of Critical Leg Ischemia

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Aims: The ankle-brachial index is an efficient tool for objectively documenting the presence of lower extremity peripheral artery disease. However, its applicability for detection of critical leg ischemia is still controversial. We proposed to determine the diagnostic accuracy of the ankle-brachial index for critical ischemia.

Materials and methods: Systolic blood pressure measurements for calculation of the ankle-brachial index were obtained in 90 patients with peripheral artery disease. Ankle-brachial index was computed in 3 different ways (using the lowest ankle pressure, the highest ankle pressure, and the mean of the ankle pressures), sensibility, specificity, positive and negative predictive value and overall accuracy for detecting critical ischemia were determined for each method. A value ≤ 0.4 was taken as cut-off point for critical leg ischemia. Prevalence of coronary and cerebrovascular atherosclerosis and conventional risk factors were also noted.

Results: Using the lowest ankle pressure for computing ankle-brachial index provided higher sensitivity, and lower specificity for detecting critical leg ischemia, using the highest pressure was less sensitive, but more specific, and the mean pressure index gave intermediate results. Overall accuracy was highest for the latest method. The prevalence of generalized atherosclerosis was high in peripheral artery disease, but we found no significant difference between the intermittent claudication and the critical ischemia group.

Conclusion: Ankle-brachial index measurements, regardless of the method used for calculation, cannot identify or rule out reliably critical leg ischemia. Peripheral artery disease confers an increased risk of cardiovascular disease regardless of symptom status or lower extremity perfusion severity.

Keywords: peripheral arterial disease, ankle brachial index, critical leg ischemia, generalized atherosclerosis

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Introduction

The clinical importance of the early identification of peripheral arterial disease (PAD) as a manifestation of generalized atherothrombotic disease has been increasingly acknowledged in recent years, since the presence of PAD is a powerful predictor of future cardiovascular and cerebrovascular events and of increased mortality [1]. The ankle brachial index (ABI) offers a simple and effective method of objectively documenting the functional state of the circulation in the lower limb, and thus for the diagnosis and follow-up of lower extremity PAD. Furthermore, the ABI might be used to detect individuals at high risk of future cardiovascular events in order to initiate cardiovascular risk-reduction measures [2,3]. However, in critical leg ischemia (CLI) the role of ABI measurement is still controversial. Definition of critical leg ischemia is mainly based on the clinical picture, but, as recommended, it should be confirmed by the ankle-brachial index (ABI), toe systolic pressure or transcutaneous oxygen tension [4]. Assessment of ABI is performed by dividing the ankle systolic pressure by the brachial systolic pressure. In clinical practice, according to the American Heart Association's recommendations, the highest arm and leg pressures are used to compute the ABI [5]. In the literature however, different methods are used for ABI calculation (highest, lowest or mean ankle pressure), and the optimal method has not yet been determined. The choice of which pressure to use may have implications for associations between ABI and the underlying burden of atherosclerosis.

Against this background, we aimed to determine the applicability of ABI measurements for identification of CLI, and how different methods used to calculate the ABI influence the estimation of CLI. Our objective was also to evaluate the associations between PAD and both cardiovascular risk factors and other cardiovascular disease (coronary artery disease – CAD, cerebrovascular disease – CBVD), in relation to the severity of PAD.

Methods

Ninety patients were included in this cross-sectional study, patients diagnosed with atherosclerotic PAD, admitted to the 2nd Medical Clinic of Tîrgu Mureş. Diagnosis of PAD was based on history of intermittent claudication, gangrene or amputation of the lower extremities due to ischemia, revascularization procedures; clinical examination; measurement of the ankle–brachial index (ABI) and Duplex ultrasonography. Patients were divided into two groups, those with intermittent claudication (stages IIa, IIb Fontaine) and those with chronic critical leg ischemia, according to the definition: ischemic tissue lesion, or rest pain > 2 weeks with ankle pressure ≤ 50 mmHg. Blood

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Table I. Clinical and laboratory characteristics of PAD patients

	PAD patients (n = 90)
Age	63.8 ± 10.24
Males	70 (77.77%)
Diabetes	30 (33.33%)
Hypertension	76 (84.44%)
CAD	65 (72.22%)
Angina	15 (16.66%)
Prior MI	11 (12.22%)
Carotid plaques	71 (78.88%)
<50% stenosis	54 (60%)
50-69% stenosis	8 (8.88%)
>70% stenosis	5 (5.55%)
Occlusion	4 (4.44%)
Total cholesterol (mg%)	190.07 ± 47.78
LDL cholesterol (mg%)	117.04 ± 35.51
HDL cholesterol (mg%)	48.97 ± 11.30
Triglycerides (mg%)	122.52 ± 53.29
Fibrinogen (mg%)	484.73 ± 176.50
hsCRP (mg/l)	8.96 ± 18.20
ABI-hi	0.50 ± 0.25
ABI-lo	0.39 ± 0.25
ABI-mn	0.45 ± 0.24

Continuous variables are expressed as mean±SD; categorical variables in number and percentages

was collected from each patient, cholesterol (LDL, HDL), triglyceride levels, fasting glucose, haemostatic and inflammatory factors (fibrinogen, hsCRP) were determined. Hypertension was defined as blood pressure > 140/90 mmHg, or current use of antihypertensive medication. Patients were evaluated for coronary artery disease based on clinical history (angina pectoris – AP, prior myocardial infarction – MI) or ECG changes suggestive of ST-segment depression, Q-wave changes or T-wave changes. Color Duplex carotid artery scan has been performed using a GE Agilent Image Point HXB.1 Sonos 4500/5500B.1 ultrasound system, with a 5–10 MHz linear-array transducer, on both the left and the right common and internal carotid arteries to identify arterial wall lesions and stenosis. Categories of carotid stenosis have been defined on the basis of B-mode and on velocity criteria.

Systolic blood pressure measurements for the calculation of the ABI were obtained using a hand-held Doppler instrument with an 8 MHz probe, in the bilateral brachial, dorsalis pedis, and posterior tibial arteries. ABI was calculated for each leg with 3 distinct methods: dividing the highest ankle pressure of the dorsalis pedis artery and the posterior tibial artery measurements by the highest of the two brachial measurements (ABI-hi); dividing the lowest ankle pressure by the highest of the two brachial measurements (ABI-lo); and dividing the mean of the ankle pressures by the highest of the two brachial measurements (ABI-mn). For further analysis we used the lower of the right and left leg values for each method.

Statistical analysis was performed with GraphPad Instat 4.0 Software. Comparison of quantitative data was made by unpaired t test or Mann-Whitney test. Comparison of qualitative data was performed by chi-square test. Sensitivity, specificity, positive and negative predictive value, accuracy of ABI to detect critical ischemia was determined.

Table II. Prevalence of risk factors and associated atherosclerotic vascular involvement by the severity of lower extremity perfusion

	No critical ischemia (n = 47)	Critical ischemia (n = 39)	P
Age	62.78 ± 10.03	65.02 ± 10.92	0.3255
Diabetes (%)	19.14	46.15	0.0101
Hypertension (%)	78.72	89.74	0.2424
CAD (%)	78.72	61.53	0.0982
Carotid plaques (%)	82.97	76.92	0.5893
Total cholesterol (mg%)	192.67 ± 43.53	188.39 ± 54.62	0.6909
LDL cholesterol (mg%)	116.93 ± 33.87	118.90 ± 39.34	0.8234
HDL cholesterol (mg%)	49.31 ± 11.65	49.03 ± 11.15	0.9193
Triglycerides (mg%)	121.50 ± 44.77	124.92 ± 64.36	0.7827
Fibrinogen (mg%)	463.35 ± 163.85	490.00 ± 188.48	0.5703
hsCRP (mg/l)	10.15 ± 23.75	7.88 ± 8.65	0.6995
ABI-hi	0.57 ± 0.17	0.36 ± 0.24	<0.0001
ABI-lo	0.49 ± 0.17	0.23 ± 0.21	<0.0001
ABI-mn	0.53 ± 0.16	0.30 ± 0.21	<0.0001

P value from unpaired t test or Mann-Whitney test, respectively from chi-square test

Results

There were 90 patients recruited in this study, 70 males, and 20 females. After ABI measurements were performed, 4 patients were excluded with an ABI > 1.4, consistent with poorly compressible arteries, due to mediosclerosis. The baseline clinical characteristics of the PAD patient population are shown in Table I.

Forty-seven patients had symptoms of intermittent claudication, and 39 of critical leg ischemia. There were no significant differences in age, gender and risk factors prevalence between the intermittent claudication and the critical ischemia group, excepting the prevalence of diabetes mellitus, which was significantly higher in the latter (p = 0.01) (Table II).

Using a cut-off point of 0.4 we determined sensitivity, specificity, positive and negative predictive values for ABI to detect critical leg ischemia with each of the 3 distinct methods. We found higher sensitivity, and lower specificity when taking the ABI-lo value (79.4% and 74.4% respectively). In contrast lower sensitivity, and higher specificity was found when using the ABI-hi value (61.5% and 87.3%

Table III. Performance of ABI calculated with different ankle pressures in CLI detection

	ABI-hi*	ABI-lo*	ABI-mn*
Sensitivity %	61.54	79.49	74.36
Specificity %	87.23	74.47	80.85
Positiv predictive value %	80.00	72.09	76.32
Negativ predictive value %	73.21	81.40	79.17
Accuracy	75.50	76.70	77.90
p	<0.0001	<0.0001	<0.0001

*A value of ABI ≤ 0.4 was used as cut-off point, as recommended in the literature

respectively). Using the mean ABI resulted in intermediate sensitivity, specificity, and overall accuracy was the highest for this method (77.9%) (Table III).

Evaluating the association between a low ABI (≤ 0.4 using the ABI high method, as recommended by the AHA) and the extent of the atherosclerotic vascular bed involvement, we found no significant difference in CAD (RR = 2.022, p = 0.053) and CBVD (RR = 1.018, p = 1.018) prevalence between the ABI ≤ 0.4 and > 0.4 group. Similarly, no significant difference in the occurrence of associated atherosclerotic arterial lesions (CAD, CBVD) was found between PAD patients with or without critical leg ischemia (RR = 1.8, p = 0.098 for CAD; RR = 1.356, p = 0.5893 for CBVD).

Discussion

The ABI offers a simple, easily performed, non-invasive and reliable method for PAD detection, and is widely accepted in screening for claudication. However, different modes of ABI calculation are used in the literature, resulting in differences in estimating PAD prevalence. Although critical leg ischemia may be easily recognized in many cases by its clinical picture alone, the early identification of CLI in general healthcare continues to be one of the main diagnostic problems in the PAD population. The role of pressure measurement in screening for CLI is still under debate [6]. Ischemic rest pain most commonly occurs below an ankle pressure of 50 mmHg, and in cases of ulcers or gangrene, the presence of CLI is suggested by an ankle pressure smaller than 70 mmHg [4]. As ABI < 0.9 is considered as evidence of PAD, an ABI value ≤ 0.4 was proposed for defining CLI [5]. Classifying patients according to definition we assessed the sensitivity and specificity of the ABI (using as cut-off point the 0.4 value) to detect CLI with 3 different methods, as mentioned. Several attempts have been made in the literature to compare different methods of calculating the ABI, and found ABI-lo in comparison with ABI-hi more sensitive and less specific [7,8]. Most of the authors agree that ABI-lo should be used for screening for PAD and generalized atherosclerosis. Since abnormal findings using the ABI-hi indicate a more severe disease, ABI-hi is preferred for evaluation of lower extremity perfusion abnormalities in PAD patients [8]. For diagnosing CLI we found ABI-lo being more sensitive and less specific compared to ABI-hi, while ABI-mn gave us intermediate results. Overall diagnostic accuracy was highest for ABI-mn. A limitation of our study is the small number of patients, however, based on our results, we can conclude that using the most sensitive method is still poor at confirming CLI, and a negative result misses an important part of patients at risk for amputation.

The ABI is not only a diagnostic method for PAD screening, but it is also used as a marker of generalized atherosclerosis. There is a consistent series of prospective epidemiological studies indicating that abnormal ABI predicts premature mortality and cardiovascular and cerebrovascular events [3]. Data comparing the relative risk for cardiovascular disease of asymptomatic versus symptomatic PAD are limited, but it seems to be clear that PAD confers a significantly increased risk of cardiovascular disease, regardless of symptom status [1]. Our results are consistent with these findings, because we found a high prevalence of CAD and CBVD in the PAD population, but no significant difference in the prevalence of associated atherosclerotic arterial involvement between the intermittent claudication and the CLI group. Similarly, no significant difference was found in the magnitude of association between PAD and CAD and CBVD respectively, using an ABI value of 0.4 as cut-off point.

Conclusion

Ankle-brachial index measurements, regardless of the method used for calculation, cannot identify or rule out reliably critical leg ischemia. Therefore, all patients with symptoms indicating CLI should be further investigated by Duplex ultrasonography or angiography, and referred to a vascular unit in order to avoid excess mortality and amputation.

The presence of peripheral artery disease is an indicator of widespread atherosclerosis in other vascular territories. Peripheral artery disease confers an increased risk of incident cardiovascular disease regardless of symptom status, or lower extremity perfusion severity.

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