Comparison of Accuracy of Two Different Methods to Determine Ankle-Brachial Index to Predict Peripheral Arterial Disease Severity Confirmed by Angiography

Vinodh Jeevanantham, MD, Bassem Chehab, MD, Edgar Austria, MD, Rakesh Shrivastava, MD, Mark Wiley, MD, Peter Tadros, MD, Buddhadeb Dawn, MD, James L. Vacek, MD, and Kamal Gupta, MD*

Ankle-brachial index (ABI) is conventionally derived as the ratio of higher of the 2 systolic ankle blood pressures to the higher brachial pressure (HABI method). Alternatively, ABI may be derived using the lower of the 2 systolic ankle pressures (LABI method). The objective of this study was to assess the utility and difference between 2 techniques in predicting peripheral artery disease (PAD). Participants who underwent both ABI measurement and arteriography from July 2005 to June 2010 were reviewed. Angiographic disease burden was scored semiquantitatively (0 = <50%, 1 = 50% to 75%, and 2 = >75% stenosis of any lower extremity arterial segment), and PAD by angiography was defined as >50% stenosis of any 1 lower extremity arterial segment. A combined PAD disease score was calculated for each leg. A total of 130 patients were enrolled (260 limbs). The ABI was <0.9 (abnormal) in 68% of patients by HABI method and in 84% by LABI. LABI method had higher sensitivity and overall accuracy to detect PAD compared with the HABI method. Regression analysis showed that an abnormal ABI detected by LABI method is more likely to predict angiographic PAD and total PAD burden compared with HABI. Moreover, abnormal ABI by LABI method had higher sensitivity and accuracy to detect PAD in patients with diabetes and below knee PAD compared with the HABI method. In conclusion, ABI determined by the LABI method has higher sensitivity and is a better predictor of PAD compared with the conventional (HABI) method. **(Am J Cardiol 2014;114:1105−1110)**

Peripheral artery disease (PAD) is highly prevalent and is predicted to increase because of aging of the population.[1,2] The ankle-brachial index (ABI) is as an easy, reliable noninvasive test used to screen patients for lower extremity PAD and has low interobserver variability.[3−5] Conventionally, ABI is calculated as the ratio of the higher of the systolic blood pressures (SBPs) of the 2 ankle arteries of that limb (either the dorsalis pedis or posterior tibial) and the higher of the 2 SBPs of the upper limbs (HABI method).[3,6,7] ABI calculated by HABI method underestimates the true prevalence of PAD, especially in the elderly population.[7−13] This is important because patients with PAD are at increased risk for future cardiovascular events.[14−17] The lack of awareness of signs and symptoms of PAD and ABI calculation by the HABI method may underdiagnose PAD.[18−21] Alternatively, ABI can be calculated using the lower of the 2 ankle pressures (LABI method), which may improve sensitivity for detecting PAD.[7,10−13,22,23] However, there are limited data on verification of diagnostic accuracy of this method using angiography. We hypothesized that LABI method would improve detection of PAD. Therefore, our study aimed to (1) study the diagnostic accuracy of these 2 methods in the detection of PAD and total PAD burden, (2) study the diagnostic accuracy in patients with diabetes in whom ABI determined by the HABI method is often falsely elevated because of medial calcinosis,[6,24] and (3) assess the diagnostic utility for detecting below knee PAD that is unknown.

Methods

This was a single-center retrospective study performed at a major tertiary referral academic medical center. All patients who underwent both ABI measurement and arteriography of the lower extremities with digital subtraction angiography (DSA) performed from July 2005 to June 2010 at our institution were reviewed. Only patients who had an ABI done within 6 months before the angiogram were included in this study. Exclusion criterion included previous limb amputations proximal to the heads of metatarsals or proximal to the elbow in the upper limbs, previous bypass surgery, stenting, or prosthetic vascular reconstruction to the lower limbs or of the arteries of lower limb/abdominal aorta or subclavian or axillary arteries, an ABI >1.3 in both lower limbs, and any abdominal or lower extremity vascular surgery or intervention between the time of having the ABI measurement and the first available angiography. The study protocol was approved by the hospital ethics and human subjects committee.

For measurement of ABI, an Unetixs Vascular Incorporated Multilab Series 2-CP (Unetixs Inc, Rhode Island) with an

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See page 1110 for disclosure information.

*Corresponding author: Tel: 001-913-588-3827; fax: 001-913-588-6010.

E-mail address: kgupta@kumc.edu (K. Gupta).

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Table 1
Patient characteristics

Variable	All Limbs (n = 260)	HABI <0.9 (n = 173)	LABI <0.9 (n = 215)
Mean age (years)	68 ± 9	69 ± 9	62 ± 6
Body mass index (Kg/m^2)	29 ± 6	29 ± 6	30 ± 8
Male sex	59%	54%	57%
Symptomatic	94%	95%	94%
Tobacco use	92%	92%	92%
Hypertension	85%	85%	85%
Diabetes	31%	35%	31%
Dyslipidemia	75%	74%	74%
Chronic kidney disease	17%	14%	15%
Cerebrovascular accident	12%	12%	12%
Coronary artery disease	81%	77%	79%
Renal artery stenosis	8%	9%	9%
Carotid artery stenosis	27%	31%	29%
LVEF	56 ± 12	57 ± 12	61 ± 6

HABI = ankle brachial index calculated as the ratio of the higher of the systolic blood pressures of the 2 ankle arteries of that limb and the higher of the 2 systolic blood pressures of the upper limbs; LABI = ankle brachial index calculated as the ratio of the lower of the systolic blood pressures of the 2 ankle arteries of that limb and the higher of the 2 systolic blood pressures of the upper limbs.

Table 2
Diagnostic ability of using higher of the two ankle systolic blood pressures versus lower of the two ankle systolic blood pressures in the ratio of ankle brachial index methods to detect at least one arterial segment ≥50% and ≥75%

	At Least One Segment ≥50%		At Least One Segment ≥75%	
	HABI	LABI	HABI	LABI
Sensitivity	75%	90%	81	92
Specificity	63%	47%	57	34
Positive predictive value	90%	88%	79	74
Negative predictive value	36%	52%	60	69
Overall accuracy	73%	83%	73	73

HABI = ankle brachial index calculated as the ratio of the higher of the systolic blood pressures of the 2 ankle arteries of that limb and the higher of the 2 systolic blood pressures of the upper limbs; LABI = ankle brachial index calculated as the ratio of the lower of the systolic blood pressures of the 2 ankle arteries of that limb and the higher of the 2 systolic blood pressures of the upper limbs.

8- and 5-MHz bidirectional Doppler wave probe device was used. It also incorporated a calibrated dual-channel pulse volume recording for definitive quality waveform assessment. Appropriately sized cuffs were applied on the lower extremities, just above the malleoli, and on the arms. These were performed by an experienced examiner who was blinded to all clinical baseline parameters assessed. Measurements were performed, after a 5- to 10-minute rest, in the supine position with the upper body as flat as possible to minimize the effect of an increased tibial artery blood pressure because of sitting or semi-sitting position. ABI values were then calculated applying 2 different methods: the higher ankle pressure (either the posterior tibial or dorsalis pedis artery) was used as the numerator for the HABI method and the lower ankle pressure

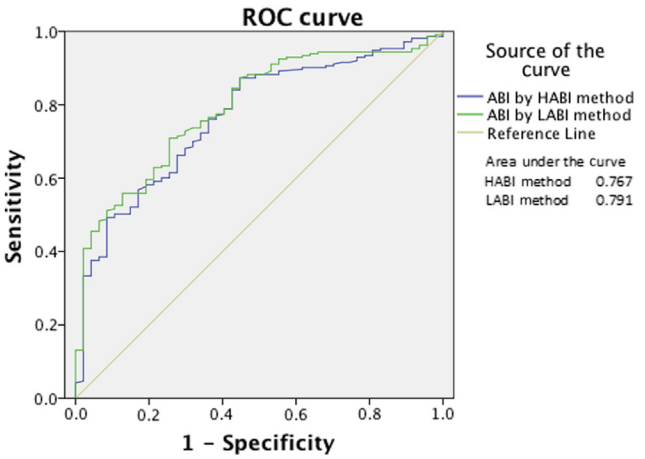

Figure 1. ROC curves for the association between LABI values and HABI values (according to different methods for ABI calculation) and PAD defined by ≥50% stenosis in at least 1 arterial segment by angiography.

Table 3
Binary logistic regression analysis showing predictors of peripheral artery disease

	Odds Ratio	95% CI	p Value
LABI	5.3	1.6−16	0.005*
HABI	3.4	1.2−10	0.022*
Male gender	6	2.5−14	<0.001*
Age	1.02	0.98−1.07	0.19
Body mass index	0.98	0.92−1.05	0.737
Hypertension	1.3	0.421−4.03	0.65
Hyperlipidemia	0.8	0.3−1.9	0.65
Diabetes mellitus	1.6	0.58−4.7	0.33
Chronic kidney disease	1.3	0.46−4.08	0.56
Smoking	1.4	0.34−6	0.61

HABI = ankle brachial index calculated as the ratio of the higher of the systolic blood pressures of the 2 ankle arteries of that limb and the higher of the 2 systolic blood pressures of the upper limbs; LABI = ankle brachial index calculated as the ratio of the lower of the systolic blood pressures of the 2 ankle arteries of that limb and the higher of the 2 systolic blood pressures of the upper limbs.

* Final predictors of PAD after adjusting for variables age, BMI, DM, HTN, HLD, CKD, and smoking.

(either posterior tibial or dorsalis pedis artery) was used as the numerator for the LABI method. An abnormal ABI was defined as <0.9 for both methods.

Intra-arterial DSA was performed and assessed by consensus agreement by 2 experienced readers who were blinded to the clinical and ABI data. Arteriographies were performed within a 6-month period from the ABI measurements. Appropriate anteroposterior sequential views of the lower abdomen, pelvis, and lower extremities were obtained. Oblique views were obtained for the iliac and the proximal femoral arteries. Percentage stenosis was defined as a >50% diameter reduction determined by visual estimation and by quantitative measurement assessment. Stenosis was calculated as the ratio of the residual target vessel lumen diameter to the diameter of the reference segment of artery. Discrepant results between the 2 readers were assessed by a third experienced reader. All readers were blinded to the ABI data and measurements.