Peripheral Arterial Disease in General Practice: Ankle-Brachial Index by Palpation in the Diagnosis of Peripheral Arterial Disease

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Background **---** Peripheral arterial disease (PAD) accounts for one of the major clinical manifestation of atherosclerosis. It is strongly associated with increased risk of major cardiovascular events. The easiest accurate non-invasive method for the diagnosis of PAD is the measurement of ankle–brachial index (ABI). However, the standard Doppler method of ABI determination is not readily available.Thus, measuring ABI thru palpation can be considered an alternative method in general practice. This study was done to determine the accuracy of the ABI measured by palpation in comparison with the gold standard ABI measured by Doppler device in determining presence of PAD.

Methods **---** This is a validity study conducted at Philippine Heart Center (PHC). ABI by palpation method was done by the researcher while ABI by Doppler method was done by another physician. Measurements were done independently. Measures of validity of ABI by palpation in the diagnosis of PAD against the standard of ABI by Doppler method were statistically determined.

Results **---** There were 125 adult study subjects with at least one atherosclerosis risk factor, with one subject who had an above the knee amputation of the left lower extremity, making 249 extremities available for ABI determination. The diagnosis of PAD by palpation has a high sensitivity of 90.4%, specificity of 86.1%, positive predictive value of 76.5% and an excellent negative predictive value of 94.7%. There is a weak agreement in the level of severity of PAD as obtained by these two methods. (K=0.466, p=0.00).

Conclusions **---** ABI by palpation has been validated as a simple, noninvasive means of determining ABI without the use of special equipment. This method is good for detecting the presence of PAD but is limited by the poor correlation of the degree of severity with that obtained by Doppler method. Systematic evaluation of ABI by palpation can be incorporated to the physical examination list. Identification of patients possibly affected by PAD or those whose ABI cannot be measured by palpation warrants further evaluation by Doppler ultrasound and prompt referral to a vascular specialist. ***Phil Heart Center J 2012; 16(2):12-18***

Key Words: Peripheral Arterial Disease ■ Ankle-Brachial Index ■ Validity

Peripheral arterial disease (PAD) accounts for one of the major clinical manifestation of atherosclerosis. It is strongly associated with higher risk of major cardiovascular events, and is usually correlated with cerebral and coronary atherosclerosis.[1]

PAD, a manifestation of atherosclerotic disease, has a high prevalence among the general population in western countries.[2,3] It has been known that a majority of the population suffering from PAD are asymptomatic.

The diagnosis of PAD is of public health importance. Both clinical and subclinical PAD are strong prognostic markers for possible future cardiovascular events.[2-4] Knowledge of the existence of PAD should influence the implementation of preventive care. [3,5] Only a fraction of those suffering from PAD are adequately diagnosed by their general practitioners.[2-7]

The easiest and accurate non-invasive method for the diagnosis of PAD is the determination of ankle–brachial index (ABI).[8]

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ABI is one of the clinical tools being used to determine the severity of PAD. It is the ratio of the systolic blood pressure measured at the ankle over the systolic blood pressure measured at the brachial artery.[1]

ABI is highly specific for the diagnosis of PAD but it is a poorly sensitive method for the assessment of vascular risk in asymptomatic patients.[9]

In majority of epidemiological studies, the ABI measured by Doppler ultrasound,[10,11] represents the gold standard. A substudy of the Heart Outcomes Prevention Evaluation study (HOPE) trial showed that the ABI, even when determined by palpation of the pedal arteries, is a strong predictor for future cardiovascular events and for all-cause mortality.[12]

Despite the ease in ABI measurement, which generally requires only a pneumatic pressure cuff and a handheld Doppler device, its application in general practice remains uncommon. The reasons for this include the expense of Doppler devices and the lack of training to use them appropriately.[13]

The potential use of the ABI as measured by palpation of the foot arteries has not been properly assessed and it requires validation of its diagnostic accuracy. If validated, the ABI by palpation can provide a simple to perform, noninvasive, inexpensive and rapid method for PAD detection and vascular risk stratification.

The result of the study will be significant to the investigator and to other colleagues as follows: the result of this study will give local data about the correlation of ABI by Doppler and palpation; and the result of this study will give local data about the validity of using palpation in the measurement of ABI.

The aim of this study is to evaluate, the diagnostic accuracy of the ABI measured by palpation in comparison with the gold standard ABI measured by Doppler ultrasound.

Methodology

This is criterion-reference based study conducted at the Philippine Heart Center. Included were adult patients with at least one atherosclerotic risk factor. We obtained informed consent from all the subjects. The study was approved by the Institutional Review Board (IRB).

After seeking consent and assessing patient eligibility, we reviewed the patient records and conducted subsequent interview to determine presence of risk factors for atherosclerosis such as cigarette smoking, diabetes, dyslipidemia and hypertension, which increases the likelihood of developing lower extremity PAD.[14] We also interviewed for other concomitant co-morbidities such as coronary artery disease (CAD) and cerebrovascular disease (CVD). Renal status was determined based on the estimated creatinine clearance using the Cockroft-Gault formula. CAD diagnosis was based on either echocardiographic findings of wall motion abnormalities, history of myocardial infarction or angiographic findings.

The primary investigator determined the ABI through palpation of the pulses, while another physician determined the ABI through the use of handheld Doppler device. (See ABI technique below). The determinations of ABI were made independently and both MD' s were blinded of each other's determined ABI. The results of each MD's (palpation and Doppler method) were recorded and compared at a later time.

ABI determination technique: Blood pressure measurements were taken while the patient is in a supine position and after a 10 minutes rest period. The blood pressure cuff is placed over the patients arm and inflated above systolic blood pressure. The first detected pulse by Doppler or first palpable pulse denotes the resumption of blood flow and recorded as the systolic pressure. Systolic blood pressures were measured in the bilateral brachial arteries first, followed by the dorsalis pedis and posterior tibial arteries of the lower extremities. The ABIs were calculated from the average of two determinations as the ratio between the highest systolic blood pressure of the ankle and the highest systolic blood pressure of the upper limbs. When only one of the two

foot arteries was palpable, the one with palpable artery was used for pressure measurement. If there is a discrepancy in the pressure between the bilateral arms, the higher of the two systolic pressures was used.

At present, the PHC Peripheral Vascular Laboratory uses the following parameters in classifying the severity of PAD by ABI (adapted from AHA guidelines 2005).[15]

ABI	Interpretation
>1.30	Noncompressible
1.0-1.29	Normal
0.90-0.99	Equivocal or borderline
0.70-0.89	Mild
0.40-0.69	Moderate

The same ABI parameters were used in this study. Once pulses were not detected by Doppler or by palpation, the ABI cannot be determined and is reported as abnormal ABI or ABI of zero.

Diagnostic accuracy of the ABI measurement by pulse palpation was calculated versus the reference standard, ABI measured by Doppler device.

Sample size: The computed sample size, based on 95% confidence level, relative error of 15%, and assumed specificity of 88%, is 73. The assumed specificity of 88% was based the result of the study done by Migliacci, et.al.[16]

Statistical Analysis - Data were presented as frequency and percent distribution; mean and standard deviation. To determine agreement of ABI obtained by palpation with ABI obtained by Doppler method, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were computed. The degree of agreement was determined using kappa test. A p-value ≤ 0.050 was considered significant.

Results

Patients' Demographic Profile

We enrolled a total of 125 subjects They have at least one risk factor for atherosclerosis. They were grouped according to several categories as gender, co-morbidities (hypertension, dyslipidemia, DM, CAD, CVD and kidney status, smoking and history of intermittent claudication. Patients' baseline characteristics are shown in Table 1.

Of the 125 subjects, majority, 68 (54%) were males. The age ranged from 21 to 98 years old. The mean age of the study population was 58 years.

In terms of the presence of co-morbidities, 85% of the subjects were hypertensive, 84% were dyslipidemics and almost half had CAD (46%). There were 29 (23%) with diabetes mellitus, 16 (13%) had history of CVD and majority had

Table 1. Baseline characteristics of subjects with at least 1 risk factor for atherosclerosis included in the study (PHC, 2010)

Characteristics	(N = 125)	
GENDER	**Frequency**	**(%)**
Male	68	54%
Female	57	46%
AGE		
Range	21-98	
Mean	58	
CO-MORBIDITY		
Hypertension	106	85%
Diabetes Mellitus	29	23%
CAD	57	46%
CVD	16	13%
Dyslipidemia	104	84%
Kidney Status (CKD)		
Stage I	35	28%
Stage 2	52	42%
Stage 3	32	25%
Stage 4	4	3%
Stage 5	2	2%
SMOKING HISTORY		
Nonsmoker	67	54%
Smoker	58	46%
Mean (# of packyears)	8	
CLAUDICATION	21	17%

CAD- coronary artery disease CVD Cerebrovascular disease CKD Chronic Kidney Disease

Table 2. Classification of the severity of PAD by ABI (PHC, 2010)

Classification of PAD*	Method of obtaining ABI (n=249)	
	Doppler n(%)	Palpation n(%)
Incompressible	7 (2.8)	8 (3.2)
Normal	133 (53.2)	122 (48.8)
Equivocal	33 (13.2)	29 (11.6)
Mild	42 (16.8)	38 (15.2)
Moderate	24 (9.6)	17 (6.8)
Severe	10 (4.0)	35 (14.0)
PAD prevalence	33.2%	39.2%

*Adapted from AHA 2005
PAD Peripheral arterial disease ABI Ankle-Brachial Index

stage 2 CKD. Almost half had significant smoking history. Majority were asymptomatic for PAD with only 17% of the enrolled subjects had experienced intermittent claudication.

In this study, ABI was determined on the bilateral lower extremities of 125 subjects. However, there was one patient who had above the knee amputation of the left lower extremity; thus, only 249 extremities were available for ABI determination.

Result showed that PAD prevalence was 33.2% based on ABI by Doppler method and 39.2% based on ABI by palpation method. ABI results were classified as incompressible, normal, equivocal or borderline, mild PAD, moderate PAD and severe PAD (*Table 2*). From the 249 extremities available for ABI determinations, frequency result under each category showed: under the category of being incompressible, ABI by Doppler versus ABI by palpation were (2.8% vs. 3.2%), normal (53.2% vs. 48.8%), equivocal (13.2% vs. 11.6%), mild PAD (16.8% vs. 15.2%) and moderate PAD (9.6% vs 6.8%) are comparable with each other except under the category of severe PAD (4.0% vs 14.0%) which had a noticeable large marginal difference.

Furthermore, this study showed an excellent result in determining PAD by the use of ABI by palpation method versus ABI by the use of handheld Doppler device, with a high sensitivity of 90.4%, specificity of 86.1%, positive predictive value of 76.5% and negative predictive value of 94.7% and a high kappa value of 0.732 ± 0.045 and p-value of 0.000 (*Table 3*). The kappa value of 0.732 ± 0.045 and p-value of 0.000 simply shows an excellent agreement of the above mentioned variables.

Because of high sensitivity and negative predictive value obtained from this study, ABI by palpation can be considered as a good screening tool for patients with PAD.

Using both handheld Doppler device and palpation to determine ABI, there were 81 (32.5%) extremities where Doppler signals were detected but no pulse were palpated (false negative results) and there were 25 (10%) extremities were no Doppler signal were detected and no pulse were also palpated (true negative results). Furthermore, there were 31 (12.4%) extremities where ABI by Doppler were detected but no ABI by palpation (false negative results) and there were 5 (2%) extremities where no ABI detected by Doppler as well as no ABI detected by palpation (true positive results).

Analysis regarding the correlation of ABI by Doppler method and ABI by palpation method in the diagnosis of PAD by category as incompressible, normal, equivocal, mild PAD, moderate PAD and severe PAD were also done. However, statistical result showed a kappa value of 0.466 ± 0.39. The data suggests a weak correlation exists for these parameters. (Table 4).

Table 3. Assessment of ABI results by palpation method with ABI by Doppler method in the diagnosis of PAD. (PHC, 2012)

		ABI By Doppler Ultrasound		
		(+) PAD	(-) PAD	Total
ABI by	(+) PAD	75	23	98
Palpation	(-) PAD	8	143	151
	Total	83	166	249
	Sn	90.4%	PPV	76.5%
	Sp	86.1%	NPV	94.7%
Kappa	0.732 ± 0.045		p-value	0.000

PAD Peripheral arterial disease ABI Ankle-Brachial Index
Sn Sensitivity Sp Specificity NPV Negative Predictive Value
PPV- Positive Predictive Value

Table 4. Measure of agreement between ABI by palpation and ABI by Doppler method in detecting severity of PAD (PHC, 2010)

PAD severity by palpation method	PAD severity by Doppler method						
	Incompressible	Normal	Equivocal	Mild PAD	Moderate PAD	Severe PAD	Total
Incompressible	4	4	0	0	0	0	8
Normal	3	107	11	0	1	0	122
Equivocal	0	13	12	3	1	0	29
Mild PAD	0	8	9	17	4	0	38
Moderate PAD	0	0	0	9	8	0	17
Severe PAD	0	1	1	13	10	10	35
Total	7	133	33	42	24	10	249

PAD Peripheral arterial disease ABI Ankle-Brachial Index

Discussion

This study has validated the measurement of ABI by palpation in the diagnosis of PAD among patients with at least one risk factor for atherosclerosis. The prevalence of PAD in this study was 33.2% based on ABI by Doppler method. This figure was at par with the figures cited by Abola et al in 2003, which is 31.67 %,[17] but much lower than that obtained by Gallardo, MD et. al[16] of 40.4% wherein she utilized CAD patients who had higher atherosclerotic risks.

In one study done by Migliacci, et al[16] conducted among general practitioners, ABI measured by palpation has a sensitivity of 88%, a specificity of 82%, a positive predictive value of 18% and a negative predictive value of 99% in detecting PAD. This was similar to the results of this study with sensitivity of 90.4%, specificity of 86.1%, positive predictive value of 76.5% and negative predictive value of 94.7%. This means that 90.4% of patients with PAD had an abnormal ABI and 86.1% of patients without PAD had normal ABI. On the other hand, 76.5% of the patients with an abnormal ABI had PAD and 94.7% of the patients with normal ABI had no PAD. Therefore, the low probability of having PAD in patients with normal ABI allows the clinician to consider the test as an adequate screening tool for PAD identification and to exclude the need for further testing. However, special consideration should be taken among diabetics and elderly because of the falsely elevated pressures due to arterial calcifications. Therefore, diabetic patients would require Segmental Pressure and Waveform Study (SPWS) to identify the presence of PAD accurately and if found positive, a referral to a vascular specialist is imperative.[18]

A study done by Palmes MD et. al,[18] at West Visayas State University Medical Center last 2004 showed that ABI by palpation is highly accurate in detecting the absence of PAD and in detecting mild arterial occlusive disease with comparable results with that of Doppler- derived ABI. However, in this study, data showed a weak agreement among the study variables (kappa = 0.466 ± 0.39) when correlated as to the severity of PAD (incompressible, normal, etc,); thus, correlation in terms of PAD severity is undeniably not statistically reliable in this study.

With the local data for the prevalence of PAD of 31.67% and the high prevalence rate of PAD among CAD patients and the false negative rate of 12.4% of palpation to detect ABI, patients identified by palpation as possibly affected by PAD (ABI < 0.9), or those whose ABI cannot be measured by palpation should be further evaluated by Doppler ultrasound for ABI measurement and for PAD grading as to severity. Patients should be worked up for PAD and modification of atherosclerosis risk factors as well as lifestyle changes

be instituted. If patients are found positive for PAD, they should be started on appropriate and adequate treatment. Screening for CAD and CVD should also be initiated. Referral to a vascular specialist is also warranted for proper evaluation and management.

There are several limitations of this study that should be taken into consideration. Palpation of pulses is subjective and is dependent on the ability and the senses of the one performing it. Pulse detection may be also be affected by pulse intensity.[15] Also the presence of pedal edema, as encountered in few patients, can affect the measured pulse pressure, which may have a significant influence on the results.

Conclusion

ABI by palpation has been validated to be a simple, fast and inexpensive method for the measurement of ABI without requiring special equipment.

The low cost and less expensive equipments for the screening of ABI by palpation may be of particular importance for developing countries, like the Philippines, where the prevalence of atherosclerotic disease is greatly increasing.[21]

ABI determination by palpation method showed a high degree of sensitivity, specificity and negative predictive value among subjects with at least one risk factor for atherosclerosis.

Therefore, it is a convenient, inexpensive and valid screening tool for detection of PAD. However, this tool is limited by its poor correlation with degree of severity of ABI obtained by Doppler method.

Being an easy, inexpensive, faster and reliable tool for PAD screening, systematic evaluation of ABI by palpation method can be incorporated to the physical examination list. This can substantially improve the negative predictive value of physical examination with regard to PAD diagnosis.

Patients identified as possibly affected by PAD or those whose ABI cannot be measured by palpation should be further evaluated by Doppler ultrasound and referral to a vascular specialist is also warranted.

Investigation for other comorbidities and modification of atherosclerosis risk factors as well as life style changes should be recommended.

Recommendation

Further study with larger population size is recommended to have a more variability in subjects and to increase its power. Inter-observer reproducibility should be done to further substantiate the validity of the study.

This study was conducted in a hospital setting of cardiovascular care referral center. The prevalence as well as the performance of the diagnostic examination is influenced by the characteristics of the subjects. A similar study to be conducted in the community is therefore recommended to assess the performance of ABI by palpation in a community setting to determine its utility in mass screening of subjects for PAD.

References

1. Zipes DP, Libby P, Bonow R. Peripheral Arterial Diseases. Braunwald, E. Braunwald's Heart Disease, a Textbook of Cardiovascular Medicine. 8th Edition. c2008.
2. Pasternak RC, Criqui MH, Benjamin EJ et al. AHA conference proceedings. Atherosclerotic Vascular Disease Conference. Writing group I: Epidemiology. Circulation 2004; 109: 2605–12.
3. Belch JF, Topol EJ, Agnelli G et al. Critical issues in peripheral arterial disease detection and management: a call to action. Arch Intern Med 2003; 163: 884–92
4. Aboyans V, Criqui MH. Can we improve the cardiovascular risk prediction beyond risk equations in the physician's office? J Clin Epidemiol 2006; 59: 547–58.
5. AHA Prevention Conference V, writing group III. Beyond secondary prevention: identifying the high-risk patient for primary prevention. Noninvasive tests of atherosclerotic burden. Circulation 2000;101:e16–22.
6. Hirsch AT, Criqui MH, Treat-Jacobson D et al. Peripheral arterial disease detection, awareness, and treatment in primary care. JAMA 2001; 286: 1317–24.
7. Hirsch AT, Halverson SL, Treat-Jacobson D et al. The Minnesota regional peripheral arterial disease screening program: toward a definition of community standards of care. Vasc Med 2001; 6: 87–96.

8. Norgren L, Hiatt WR, Dormandy JA et al. Inter-society consensus for the management of peripheral arterial disease (TASC II). Eur J Vasc Endovasc Surg 2007; 33: S1–75.
9. Doobay AV, Anand SS. Sensitivity and specificity of the anklebrachial index to predict future cardiovascular outcomes: a systematic review. Arterioscler Thromb Vasc Biol 2005; 25: 1463–1469.
10. Diehm C, Lange S, Darius H et al. Association of low ankle brachial index with high mortality in primary care. Eur Heart J 2006; 27: 1743–1749.
11. Hayoz D, Bounameaux H, Canova CR. Swiss Atherothrombosis Survey: a field report on the occurrence of symptomatic and asymptomatic peripheral arterial disease. J Intern Med 2005; 258: 238–243.
12. Ostergren J, Sleight P, Dagenais G et al. Impact of ramipril in patients with evidence of clinical or subclinical peripheral arterial disease. Eur Heart J 2004; 25: 17–24.
13. Mohler ER III, Treat-Jacobson D, Reilly MP et al. Utility and barriers to performance of the ankle–brachial index in primary care practice. Vasc Med 2004; 9: 253–60.
14. Hirsch et.al. ACC/AHA 2005 guidelines for the management pf patients with peripheral arterial disease (lower extremity, renal, mesenteric and abdominal aortic): executive summary a collaborative report from the American Association for Vascular surgery/Society for Vascular Medicine and Biology, Society of Interventional Radiology and the ACC/AHA Task force on Practice Guidelines (Writing Committee to Develop Guidelines for the Management of Patients with Peripheral Arterial Disease) endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation; National Heart, Lung and Blood Institute; Society for Vascular Nursing; TransAtlantic Inter-Society Consensus; and Vascular Disease Foundation. J Am Coll Cardiol 2006;47:1239-312.
15. Gallardo E et.al, The Severity of Peripheral Arterial Disease by Ankle-Brachial Index Determination as Predictor of the Severity and Jeopardy Scores of Coronary Artery Disease. PHC research 2008-2009. pp. 6.
16. Migliacci et.al. Ankle–brachial index measured by palpation for the diagnosis of peripheral arterial disease. Oxford Journal. Oxford University Press. 20 June 2008, pp. 228-232.
17. Abola MT et. al, Prevalence of Peripheral Arterial Disease in the Philippines. Phase 3: Prevalence of PAD in a High-Risk Population. Phil. J. Internal Medicine, 41: 71-74, March-April, 2003 pp. 72.
18. Palmes MD et.al, Ankle-Brachial Index by Palpation Method in the Diagnosis of Peripheral Arterial Disease. Phil. Journal of Cardiology. Issue April-June 2004. pp. 46.
19. Leng GC, et. al. Incidence, natural history and cardiovascular events in symptomatic and asymptomatic peripheral arterial disease in the general population. Int J Epidemiol 1996; 25: 1172-81.
20 Jauhar S. The demise of the physical exam. N Engl J Med 2006; 354: 548–551.
21. Ghaffar AG, Reddy KS, Singhi M. Burden of non-communicable diseases in South Asia. BMJ 2004; 328: 807–810.