DETECTION OF ATHEROSCLEROSIS BY ANKLE BRACHIAL INDEX: EVALUATION OF PALPATORY METHOD VERSUS ULTRASOUND DOPPLER TECHNIQUE

Bilquis Akhtar, Saulat Siddique*, Rafiq Ahmad Khan†, Sibgha Zulfiqar††

Department of Physiology, Punjab Postgraduate Medical Institute, *Department of Cardiology, SZ Federal Postgraduate Medical Institute, †University College of Medicine, The University of Lahore, ††Department of Physiology, SZ Postgraduate Medical Institute, Lahore, Pakistan

Background: Peripheral Arterial Disease [PAD], a manifestation of systemic atherosclerosis, is highly prevalent both in community studies and in primary care practice. Estimation of ankle brachial index [ABI] by ultrasound Doppler is the standard screening method for the detection of atherosclerosis in PAD patients. A low ABI is associated with increased risk of stroke or transient ischemic attack, ischemic heart disease and lower extremity gangrene. Though prevalence is high, physician and patient awareness of the condition is low. Primary care physicians are not well versed with the use of Doppler. Initial cost of the equipment is another adverse factor in low income countries. Detection of ankle systolic pressure by palpatory method may offer a cheap, simple and useful alternative approach in office care settings for early detection of disease. This may lead to the use of risk reduction strategies to avoid significant future morbidity and mortality. **Methods:** The sample size of 230 participants was identified. Patients were divided into control (100 cases), high risk asymptomatic (100 cases) and symptomatic groups (30 cases). Ankle systolic pressure was measured by digital palpation of foot arteries and by the gold standard Doppler technique in all patients in the three groups. PAD was defined by an ABI of <0.9. **Results:** In control group, mean±SD value of ABI was 1.0115±0.08167 by Doppler method versus 0.9923±0.08609 by palpatory method (p=0.1), in high risk asymptomatic group, 0.9838±0.08878 versus 0.9608±0.10377 (p=0.13) and in symptomatic group, 0.9302±0.14064 versus 0.9088±0.13274 (p=0.12). Against the more precise Doppler method, palpatory method was equally good in detecting the PAD positive cases. **Conclusion:** Early diagnosis of PAD in primary care practice by manual palpation of foot arteries is a reliable method to identify the population at risk and may lead to aggressive preventive therapies.

Keywords: Peripheral arterial disease, cardiovascular disease, risk factors, ankle blood pressure, ankle brachial index.

INTRODUCTION

Atherosclerosis is a diffuse and progressive process with a variable distribution and clinical presentation that is dependent on the regional circulation involved.[1] In western societies, it is the underlying cause of about 50% of all deaths.[2] Atherosclerosis is becoming a major health problem in developing nations also because of the ageing of population.[3]

Peripheral arterial disease [PAD] is a manifestation of systemic atherosclerosis that is common and is associated with increased risk of death and ischemic events, yet may be under-diagnosed in primary care practice.[4] Patients with PAD are at increased risk of adverse cardiovascular events when compared with those without PAD.[5] Although PAD involves the extra cranial carotid, upper extremity, visceral and renal circulation, the term is usually applied to disease involving the circulation of lower extremity alone. Intermittent claudication [IC], heralded by pain in leg muscles during ambulation is the earliest and most classical symptom in patients with PAD.[6] The diagnosis of peripheral arterial disease, solely from a questionnaire, history of IC or the finding of an absent pedal pulse underestimates the prevalence of the disease.[7] PAD is frequently asymptomatic or accompanied by exertional leg symptoms other than claudication.[8] Symptom of IC and the absence of peripheral pulses are relatively insensitive tools for the diagnosis of atherosclerosis in PAD patients and are only present in the late stages of the disease.[9]. Prevalence of IC was 1/5th the prevalence of PAD whereas prevalence by pulse abnormality was nearly twice the true rate.[10] The most useful initial screening test for arterial disease of the lower extremities is the ankle brachial index [ABI].[11] In the lower extremity of a supine patient at rest, the ankle systolic blood pressure [SBP] divided by arm SBP is the best indicator of presence or absence of haemodynamically significant arterial occlusive disease.[12] Non invasive testing may add information to risk factor screening in a high risk population with a high probability of disease. This may also define the factors associated with the progression of occult disease to clinical events and help refine the concepts of preclinical disease.[13]

In clinical practice, an ABI of <0.9 has been shown to be 95% sensitive in detecting angiogram positive disease.[14] Ankle-brachial index is reported to be a useful simple test with a sensitivity of 96% and specificity of 94-100% and can be performed in an outpatient department [OPD] clinic with the hand-held Doppler for the diagnosis of peripheral arterial disease.[15]

Peripheral arterial disease [PAD] affects from 12% to 14% of general population and as many

as 20% of individuals over the age of 75[7]. In the youngest age group, prevalence among women was higher. In the oldest category, the prevalence among men was higher. Though gender differences were not significant, yet, the figures in symptomatic cases, cases with concomitant ischemic heart disease (IHD) or cerebral arterial disease and known cases indicated that proportion of cases with manifest atherosclerosis was evidently higher among men. Also proportion with ABI ratio<0.75 was larger among men.[16]

Stoffers *et al* investigated the value of ABI as a test for PAD in general practice. The optimum cut off value for ABI, its accuracy and diagnostic value were estimated. On the basis of their results, following rule of thumb was suggested; if ABI <0.8 or if the mean of three ABIs <0.9, it is highly probable that PAD is present; if the ABI is >1.1 or if the mean of three ABIs >1.0, PAD can be ruled out.[17] A low ABI reflects the combined effect of many risk factors over time and is a manifestation of overt atherosclerosis. Thus, it would be expected to be a better predictor than any one risk factor alone.[18]

In the Heart Outcome Prevention Evaluation (HOPE) study subset, a low ABI was a strong predictor of cardiovascular morbidity and mortality in patients without clinical peripheral arterial disease. In earlier epidemiological studies, the ankle pressure was measured with the help of ultrasound Doppler. This is a more precise but more expensive method than simple palpation of arteries and is not readily available in most physicians' offices.[19] In the HOPE study subset, majority of the measurements were performed by palpation of foot arteries with no significant difference in ABI between the groups measured by manual palpation compared with Doppler, indicating no systematic bias from the differing method used.[19]

In our country, hand held Doppler ultrasound is not readily available in all OPD settings, initial cost of the equipment being an adverse factor. Primary care physicians are also not well versed in its use. In these circumstances, palpatory method offers a simple and cost-effective approach in the detection of the disease.

The goal of this study is to use a simple and commonly available technique that can be utilized with no additional cost to further stratify patients into high risk category and thus benefit them to a greater extent by preventive treatment.

SUBJECTS AND METHODS

Individuals were selected at random from the general hospitals serving a range of socio-economic and geographical areas of the city, identified prospectively by a predefined subject age and risk factor profile based on known epidemiology of PAD.

The sample size of 230 participants was identified who were between 40 and 75 years of age. Informed consent was sought. The survey was concluded after 100 controls, with not more than one standard modifiable risk factor, (not including DM), 100 asymptomatic patients with two or more standard modifiable risk factors or having diabetes mellitus and 30 patients with symptomatic atherosclerosis were screened. Control group consisted of subjects with 0–1 standard modifiable risk factor, not including diabetes mellitus were included in the study. **High Risk Asymptomatic Group included s**ubjects with 2 or more standard modifiable risk factors or the presence of diabetes mellitus. The **Symptomatic Group included s**ubjects already known to be suffering from PAD with either history of limb vascular surgery, amputation or intermittent claudication, ischemic heart disease or cerebral arterial disease.

Subjects excluded were the patients with any severe systemic disease like renal insufficiency; who had major surgery within past 3 months; wheelchair bound patients; patients with ABI of 1.50 or higher, consistent with poorly compressible arteries and inability to gauge arterial perfusion accurately; and patients with no palpable pedal pulses.

A detailed history of presenting complaints, past medical/surgical history, family history and personal history were obtained. Patients were designated as hypertensive, diabetic, smokers and dyslipidemic according to a predefined protocol. Patients were designated as hypertensive if they had a systolic blood pressure of 140 mmHg or more or a diastolic blood pressure of 90 mmHg or more at the time of screening. Hypertension was also diagnosed from the chart by the use of calcium channel blockers, angiotensin converting enzyme inhibitors, beta blockers or diuretics for the indication of treatment of hypertension. Diabetes was determined from the fasting blood glucose, (≥126 mg/dl) or from clinical record whether using insulin or oral hypoglycaemic agents. Information about smoking status was based solely on the patient's self report. Patients were asked whether they were current, former or lifelong non-smokers; and if smokers, how many years they had smoked, number of packs smoked per day; former smokers were asked when they had stopped smoking. Since a substantial number of former smokers reported quitting smoking within a week or month prior to their visit, it was decided to categorize the smokers as 'ever' or 'never' for the data analysis.

In a similar fashion, hypercholesterolemia was defined from the medical record as a total cholesterol concentration of 200 mg/dl (6.2 mmol/L) or more, Low Density Lipoprotein (LDL) cholesterol concentration of 130 mg/dl (4.1 mmol/L) or more, HDL cholesterol concentration of 40 mg/dl (0.9

mmol/L) or less, Triglyceride (TG) concentration of 200 mg/dl (2.26 mmol/L) or more, or if the medical record included past or present use of lipid lowering agents.

Modified Rose claudication questionnaire was used to identify the prevalence of claudication or other exertional leg pains defined as exercised induced calf pain, not present at rest, which required stopping and remitted in ten minutes or less.

Women were considered post menopausal by self report or by the use of hormone replacement therapy.

A standard physical examination was carried out including weight and standing height. A standard bilateral palpation of the carotid, femoral, popliteal, posterior tibial and dorsalis pedis arteries was performed. Pedal pulses were called abnormal if both pulses of that foot were absent or weak.

Technique of ABI measurement

Arm blood pressure was recorded by routine standard protocol. The arm with higher pressures was taken as index arm. Two more readings were taken on the same arm and the average taken as the index systolic blood pressure in the arm.

In all three groups, in 100% of cases, ankle pressure in both legs was measured by inflation of the cuff around one calf just above the ankle and systolic pressure was recorded by palpation of first dorsalis pedis and later posterior tibial arteries during deflation with the ankle pressure read at the reappearance of the respective foot pulse. The leg with the lower systolic pressure was taken as index leg as this was more likely to have arterial disease. Within the index leg, dorsalis pedis artery pressure was taken as index ankle pressure if it was higher than the posterior tibial and vice versa. Two more readings were taken on the same artery and the average recorded.

Doppler ultrasound with 8 MHz probe was also used in 100% of the cases in all three groups to find the systolic blood pressure in the index ankle artery.

The cuff was positioned on the ankle proximal to malleoli. The pulse was located with the Doppler probe and the cuff inflated until the pulse was obliterated; the cuff was then deflated and the pressure recorded at the point when the pulse reappeared.

ABI was calculated by dividing the average systolic blood pressure of the index ankle artery by the average systolic blood pressure of the index arm. Correlation of ABI measurement by both palpatory and Doppler was done in control, asymptomatic and symptomatic cases to check any possible limitation of the procedure.

Laboratory investigations

1. All subjects were on their usual diets and no intervention was made for food intake except an overnight fast of 12 to 13 hours. Subsequently, a sample of fasting blood was taken to measure serum lipid concentrations including total cholesterol, HDL, LDL, and TG.
2. Fasting blood glucose concentration was measured.

Statistical analysis was performed using the SPSS ver 12.0. Differences between groups were analysed with Pearson's Chi-square test for discrete or categorical variables, whereas 1-way analysis of variance was used for continuous variables. Pearson's correlation coefficient between the two methodologies was determined and *p*-value was calculated. A *p*-value <0.05 was considered statistically significant.

RESULTS

The results are presented in Tables 1–5 and Figures 1–3 below.

Table-1: Distribution of patients according to mean Ankle Brachial Index (ABI)

Ankle Brachial Index	Control group (n=100)		High Risk Asymptomatic (n=100)		Symptomatic (n=30)		ANOVA
	Mean	SD	Mean	SD	Mean	SD	
Doppler Method	1.012	0.081	0.984	0.089	0.930	0.141	F-Statistics= 8.85 $p<0.01$
Palpatory Method	0.99	0.086	0.96	0.104	0.909	0.133	F-Statistics= 8.31 $p<0.01$
	$p=0.1$		$p=0.12$		$p=0.13$		

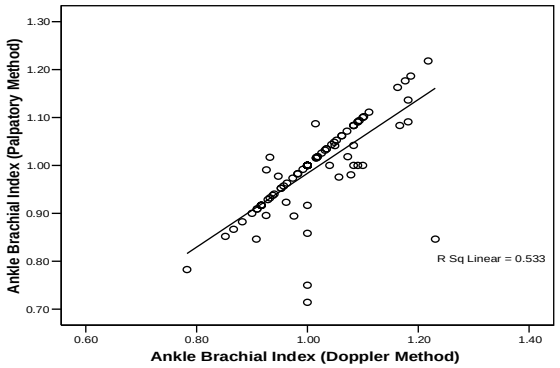

Figure-1: Scatter diagram showing relationship of Ankle Brachial Index (ABI) with Doppler and Palpatory methods

Figure-1 shows that there is a significant correlation between the ABI measured by Doppler method and the ABI measured by the palpatory method for the patients in the control group (Pearson's Correlation Coefficient (r) = 0.730, p=0.01).

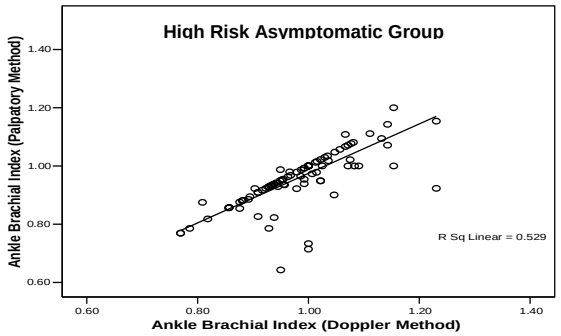

Figure-2: Scatter diagram showing relationship of Ankle Brachial Index (ABI) with Doppler and Palpatory method

Figure-2 indicates that a similarly strong correlation exists between ABI measured with Doppler method and ABI measured with the palpatory method, for the patients in the high risk asymptomatic group. (Pearson's Correlation Coefficient (r) = 0.727, p=0.01)

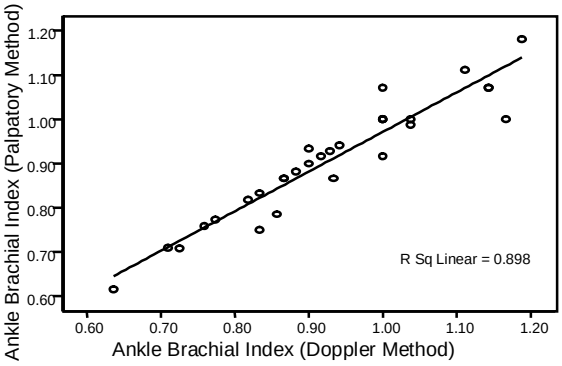

Figure-3: Scatter diagram showing relationship of Ankle Brachial Index (ABI) with Doppler and Palpatory methods

Figure-3 indicates a similar strong correlation between ABI measured with Doppler method and ABI measured with the palpatory method, for the patients in the symptomatic group. (Pearson's Correlation Coefficient (r) = 0.948, p= 0.01).

Table-2: Validity of palpatory vs Doppler techniques (Control group)

PAD	Palpatory	Doppler	
		Positive	Negative
Positive	14	8	6
Negative	86	0	86
Total	100	8	92

Table-3: Validity of palpatory vs Doppler techniques (High Risk Asymptomatic)

PAD	Palpatory	Doppler	
		Positive	Negative
Positive	23	17	6
Negative	77	1	76
Total	100	18	82

Table-4: Validity of palpatory vs. Doppler techniques (Symptomatic)

PAD	Palpatory	Doppler	
		Positive	Negative
Positive	14	13	1
Negative	16	1	15
Total	30	14	16

Table-5: Validity of palpatory vs. Doppler techniques (All groups)

PAD	Palpatory	Doppler	
		Positive	Negative
Positive	51	38	13
Negative	179	2	177
Total	230	40	190

Evaluation of palpatory method vs. ultrasound Doppler was done on 230 subjects, divided into three groups of 100 control cases, 100 high risk asymptomatic cases and 30 symptomatic cases.

Seventy-nine percent cases of control group, 50% cases of high risk asymptomatic group and 40% cases of symptomatic group belonged to 40–50 year age group. Seventeen percent cases of control group, 38% cases of high risk asymptomatic group and 36.9% cases of symptomatic group belonged to 51–60 year age group. Four percent cases of control group, 12% cases of high risk asymptomatic group and 23.3% cases of symptomatic group belonged to >60 year age group.

Table-1 shows that in control group, mean ABI obtained by Doppler method vs. palpatory method is 1.012±0.082 vs. 0.99±0.086 (p=0.1). In high risk asymptomatic group, mean ABI obtained by Doppler method vs. palpatory method is 0.984±0.089 vs. 0.96±0.104 (p=0.12). In symptomatic group, mean ABI obtained by Doppler vs. palpatory method is 0.93±0.141 vs. 0.909±0.133 (p=0.13). This indicates that no statistically important difference exists between the two methodologies. Scatter grams in Figures-3, 4 and 5 show Pearson's correlation coefficient (r) of the two methodologies. In the control group r=0.730 (p<0.01), in high risk asymptomatic group 0.727 (p< 0.01) and in symptomatic group 0.948 (p<0.01), showing significant correlation between the two techniques.

Tables-2, 3 and 4 again show the validity of palpatory method vs. Doppler technique. In control group, 14 cases were positive by palpatory method whereas 8 cases were positive by ultrasound Doppler. Sensitivity of the test by palpatory method was 100% and specificity was 93%. Positive predictive value was 57% and negative predictive value was 100%.

In high risk asymptomatic group, 23 cases were positive by palpatory method whereas ultrasound Doppler detected 17 positive cases. Sensitivity of the test by palpatory method was 94% and specificity of the test was 93%. Positive predictive value was 74% and negative predictive

value was 99%. In symptomatic group, 14 cases were positive by palpatory method whereas 13 cases were positive by ultrasound Doppler. Sensitivity of the test by palpatory method was 93% and specificity 94%. Positive predictive value was 93% and negative predictive value was 94%. In all groups combined, i.e., in all 230 subjects 51 cases were positive by palpatory method whereas 38 cases were positive by ultrasound Doppler. Sensitivity of the test by palpatory method was 95% and specificity of the test was 93%. Positive predictive value was 75% and negative predictive value was 99%.

DISCUSSION

Peripheral Arterial Disease (PAD) is a progressive disease, which has a variable prevalence depending on the method of diagnosis, age, sex, race and the geographic area. PAD affects more than 27 million people in North America and Europe.[2] However, estimates of PAD prevalence in general US population vary widely. According to the National Health and Nutrition Examination Survey 1999–2000, (NHANES), the study that reports nationally representative estimates of PAD in the US adult population, PAD affects about 5 million US adults. As the US population ages, an estimated seven million individuals aged 40 years and over will have PAD by year 2020, according to census population projections. PAD was assessed by determining ABI which was taken as the ratio of systolic BP in the ankle (posterior tibial vessels) to that of arm (right brachial vessel) using a 8.1 MHz Doppler probe. NHANES 1999–2000 was the first survey to perform ankle-brachial pressure measurements on participants and hence, allows for direct comparison with prior prevalence studies in adult populations.[21]

Several studies have confirmed the cost-effectiveness of non-invasive techniques in the detection and follow up of vascular disease. The first study reported by Hull *et al* documented that non-invasive indirect techniques (IPG and 1-225 Fibrinogen Leg Scanning) were more cost effective than clinical diagnoses or venography in managing patients with suspected deep vein thrombosis. Zierler *et al*, reported that duplex scanning was more cost effective than angiography alone in screening patients for asymptomatic carotid artery disease. No previous studies have reported on the cost effectiveness of non-invasive techniques for PAD (Barnes, 1991). There are relatively few non invasive diagnostic tests that can reveal evidence of atherosclerosis before the development of symptoms. One such simple, low cost diagnostic test is comparison of blood pressure measurements in the ankle and arm by using manual palpation to measure ABI. Present study, following the HOPE study by Ostergren *et al* used palpatory method for ankle blood pressure measurement. The Tables 2–4 show the sensitivity of the test by palpatory method to be 94–100% in all three groups tested in this study versus the gold standard ultrasound Doppler technique. Doppler has a reported sensitivity of 94–96%.[15] Specificity of palpatory method was 93–94% in all three groups which is also comparable to Doppler results.[15] Negative predictive value was 94–100% with palpatory method which means that subjects with low ABI were rarely missed. However, positive predictive value was 57% in control group, 74% in high risk asymptomatic group and 93% in symptomatic group. This indicates that false positive rate was high in subjects who were less likely to have the disease. This was an obvious drawback of palpatory method. However, it would still be a good screening test as all those who test positive with this simple, no cost, bedside procedure could then go on to be confirmed by Doppler method which is not readily available especially in low income countries. A significant correlation was found in this study between the palpatory and Doppler method of measuring ABI. The *r* value was 0.730 in control group, 0.727 in high risk asymptomatic group and 0.948 in symptomatic group. As expected from the results mentioned above, the correlation between two methodologies was most marked in the symptomatic group.

The present study demonstrates that PAD is easily detected with the ABI technique by the palpatory method in primary care settings. Palpatory method offers a valid, simple and objective approach which can be used in the physician's office when employed as an initial screening technique for early identification of patients at high risk of morbidity and mortality.

Limitations of our study include a relatively small sample size. As patients were selected according to a predefined protocol to compare the validity of the palpatory method vs. gold standard Doppler so the results cannot be generalized for a population based study.

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Address for Correspondence:

Dr. Bilquis Akhtar, House No. 4, Army Housing Scheme, DHA, Lahore, Pakistan. Tel: +92-42-35723921, Cell: +92-300-4440713

Email: bilquisakhtarkhakwani@gmail.com