ORIGINAL ARTICLE

Use of Ankle-Brachial Index as a Predictor of Severity of Atherosclerosis in Control, High Risk Asymptomatic and Symptomatic Individuals

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ABSTRACT

Objective: To demonstrate that low ABI is closely linked with the severity of atherosclerosis. Our secondary objective is to promote the awareness of screening and management of PAD

Methods and results: A sample size of 230 participants was identified in Out Patient Department (OPD). 100 subjects were in control group with no more than one high risk factor, 100 in high risk asymptomatic group with 2 or >2 high risk factors or diabetes mellitus and 30 were in symptomatic group with manifest peripheral, coronary and/or cerebral arterial disease. Mean ABI of control group's was1.0115±0.081 versus 0.9838±0.08 in high risk asymptomatic group and 0.9302±0.140 in symptomatic group (p<0.01).In control group 15٪ cases were PAD positive with their ABIs in the range of 0.71-0.90 versus high risk asymptomatic and symptomatic group where 43.8٪ and 40.6% cases were PAD positive with ABIs between 0.71-0.90 and <0.7 respectively.

Conclusion: ABI is a simple and inexpensive screening tool in normal population. It can identify the severity of atherosclerosis in high risk asymptomatic and symptomatic subjects. ABI levels are lower in symptomatic group as compared to control and high risk asymptomatic groups, highlighting the long standing effect of cardiovascular risk factors on the extent of atherosclerosis

Key words: Ankle brachial index, atherosclerosis, risk factors, peripheral arterial disease.

INTRODUCTION

Ankle-brachial index (ABI) is the ratio of systolic blood pressure (SBP) in the dorsalis pedis (DP) artery or the posterior tibial (PT) artery to the higher of the systolic blood pressures in the two brachial arteries[1].

Ankle brachial index is a non invasive test of cardiovascular disease. It is quick and easy to measure, has high patient acceptability and is an accurate and reliable indicator of atherosclerosis[2]. ABI 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 a hand held Doppler for the diagnosis of peripheral arterial disease (PAD)[3]. In the Heart Outcomes Prevention Evaluation (HOPE) study subset, majority of the measurements were performed by palpation of foot arteries with no significant difference in ABI between the group measured by manual palpation compared with Doppler[4]. 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[5].

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Atherosclerosis is a diffuse and progressive process with a variable distribution and clinical presentation that is dependent on the regional circulation involved[6].

Peripheral arterial disease (PAD) is a manifestation of systemic atherosclerosis that is common and is associated with increased risk of death and ischemic events[7]. Standard modifiable atherosclerotic risk factors leading to atherosclerosis are smoking, diabetes mellitus, dyslipidemia and hypertension[3].

PAD is associated with impaired lower extremity function[8]. Greater PAD severity, as measured by the ankle brachial index [ABI], is associated with more extensive functional impairment[9]. The most efficient, objective and practical means of documenting the presence and severity of PAD is measurement of ankle brachial index (ABI). A resting ABI of less than 0.9 is considered abnormal[10].

ABI is much better than several standard screening tests like Pap smear, fecal occult blood or Mammography.[11] The presence of PAD as measured non-invasively by ABI is a risk marker for coronary arterial disease [CAD] and predictor of coronary events especially in the elderly.[12]

The goal of this study is to measure and compare ABI values in controls, high risk asymptomatic and symptomatic individuals and to compare its severity among these groups as an indicator of sub clinical disease and/or a predictor of probable cardiovascular outcomes

SUBJECTS AND METHODS

This study consists of two inter-related elements, a diagnostic study and a comparative study. Population was selected at random from the general hospitals serving a range of socio-economic and geographical areas of the city. The survey population was identified prospectively by a predefined subject age, and risk factor profile based on known epidemiology of PAD. Data collection was conducted from April through July 2005. The sample size of 230 participants was identified who were between 40-75 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], and 130 patients with two or more standard modifiable risk factors or having diabetes mellitus were screened. According to inclusion criteria, the cohort was divided into three pre defined clinical subgroups.

1. Those without clinically recognized atherosclerosis in any vascular bed [control or reference group, 100 cases].
2. Those with two or more standard modifiable risk factors but asymptomatic [High risk asymptomatic group, 100 cases].
3. Those with peripheral arterial disease, cardiovascular disease and cerebral vascular disease [symptomatic group 30 cases].

Exclusion criteria: Patients who had undergone 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 were excluded. Diagnostic criteria for PAD based on ABI are interpreted as follows:

Normal if 0.9-1.3; Mild obstruction if 0.71-0.90; Moderate obstruction if 0.40-0.69; Severe obstruction if <0.40; Poorly compressible if >1.30 (ADA, 2003).[13]

Data collection: Before conducting the main study a pilot study, of the clinical procedure was carried out on 20 volunteers from the medical ward. The quality of clinical measurements was checked by the study supervisor. A detailed history of presenting complaints, past medical /surgical history, family history and personal history were obtained. Relevant data was obtained from the patient history and/or records e.g. hypertension, diabetes, tobacco smoking, hyperlipidemia, age at menopause and any medication.

Patients were designated as hypertensive if they had a systolic blood pressure of 140 mmHg or more and/or a diastolic blood pressure of 90mmHg or more at the time of screening or if they were taking treatment of hypertension. Diabetes was determined from the clinical record, or if fasting blood sugar was more than 126mg/dl. Based on the information about smoking status by patient's self report, patients were characterized as smokers and non smokers. Hypercholesterolemia was defined from as a total cholesterol concentration of 200mg/dl[6.2mmol/L] or more. Women were considered post menopausal by self report or by the use of hormone replacement therapy Subsequently, a standard physical examination was carried out on weekday mornings 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

Techniques for ABI measurement: Methodology for the measurement of ABI varies among different authors. ABI was calculated by O'Hare et al, 2004.[14] by dividing the mean systolic pressure in the arm by the mean systolic pressure in the respective ankle and the lowest ABI obtained for either leg was taken as ABI measurement for the patient.

In a study conducted by Vogt et al. to determine the relationship between ankle brachial index, atherosclerosis, diabetes, smoking and mortality in older men and women, patients were evaluated in supine position. Systolic blood pressure was measured in both arms and in the right and left posterior tibial artery of each leg with a Doppler ultrasonic instrument. ABI was determined for each leg by dividing the systolic blood pressure at the ankle [the average of the pressures recorded in posterior and anterior tibial arteries] by the higher of the right or left brachial pressures. The lower of the ABI values obtained for two legs was used as a measure of disease in the data analysis. In patients for whom it was impossible to obtain both the right and left ABI [due to pain or ulceration/gangrene at the ankle] the value obtained for other limb was used for analysis[12]. Our approach to measure systolic blood pressures in the legs was somewhat different from other authors.

Measurements of ARM blood pressures: After resting for 5 minutes in supine position, brachial artery systolic and diastolic blood pressures were recorded in both arms using a mercury sphygmomanometer. Appropriate sized blood pressure cuffs were applied over each brachial artery. The cuff was rapidly inflated to 20 mmHg above the audible systolic pressure in each arm and then deflated at a rate of 2 mm per heart beat to the lowest even reading. Highest systolic reading was measured in both arms as the pressure at which the first sustained sound was audible.[8] Diastolic pressure was recorded at the disappearance [phase five] of Korotkoff sounds. Higher of the two arm's pressures was taken as index arm. Two more readings were then taken on the same arm and the average taken as the index systolic blood pressure in the arm.

Measurement of ankle blood pressures: In all three groups, in 100% of cases ankle pressure in both ankles 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. 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 8MHz probe was used in 100%of the cases in all three groups to find the systolic blood pressure in the index ankle artery. This is the gold standard. 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.

Laboratory investigations: All subjects were on their usual diets and no intervention was made for food intake except an overnight fast of 12 to 14 hours. Subsequently, a sample of fasting blood was taken to measure serum lipid concentrations including total cholesterol, high density lipoprotein [HDL], low density lipoprotein [LDL], serum triglycerides. Fasting blood glucose concentration was measured.

Statistical analysis: Statistical analysis was performed using the Statistical Program for Social Sciences [version 12.0, SPSS Inc; Chicago, Illinois]. Baseline characteristics of patients were presented, including age, gender, cardiovascular risk factors, ABI, <0.9, and ABI>0.9. Student's T-test was used for comparison between two groups for discrete or categorical variables, whereas 1-way analysis of variance was used for continuous variables among three groups. A p value <0.05 was considered statistically significant. ABI of high risk patients with 2-5 risk score was compared with normal population.

RESULTS

In control group 79% cases were in 40-50 year age group, 17% cases were in51-60 year age group and 4% cases were in >60 year age group. In high risk asymptomatic age group, 50% cases were in 40-50 year age group 38%cases were in 50-60 year age group and 12%cases were in>60 year age group. In symptomatic group, 40% cases in 40-50 year age group, 36.7% cases were in 51-60 year age group and 23.3% cases were in >60 year age group.

Student's t test was used to compare age, mean ABI and systolic blood pressures among various groups.

Figure1 shows the progressive decrease in the percentage of healthy subjects in high risk asymptomatic and symptomatic groups as compared with controls. Association of increasing age with occult to manifest disease is evident and is statistically significant too ($p<0.01$). Figure 2 shows that among controls versus high risk asymptomatic and symptomatic ABI was found to be significantly higher among controls. Mean ABI was 1.0115±0.081, 0.9838±0.887and 0.9302±0.140 respectively ($p<0.01$). Among high risk asymptomatic and symptomatic groups versus controls mean systolic blood pressures in index arm were significantly higher among high risk asymptomatic and symptomatic groups (133.90±15.407 and 138.20±18.483 versus 120.90±13.372 respectively) ($p<0.01$).Similarly mean systolic blood pressures in index leg in high risk asymptomatic and symptomatic versus controls were significantly higher (131.43±16.922 and 128.27±24.152 versus 122.12 ±15.645respectively) ($p<0.01$). Table 1 shows the comparison of mean ABI between control and High risk asymptomatic group to be significant ($p<0.02$).

Table 2 shows the comparison of mean ABI between controls and symptomatic group to be highly significant ($p< 0.0001$). Table 3 shows lower ABI in symptomatic versus high risk asymptomatic ($p<0.02$)

Table 4 shows that differences between the means of ABIs of all the three groups is Significant ($p<0.01$).

Table 5 shows that number of PAD positive cases is higher in high risk asymptomatic group as compared with control group and highest in symptomatic group.

Figure 1: Age wise distribution of patients in various study group

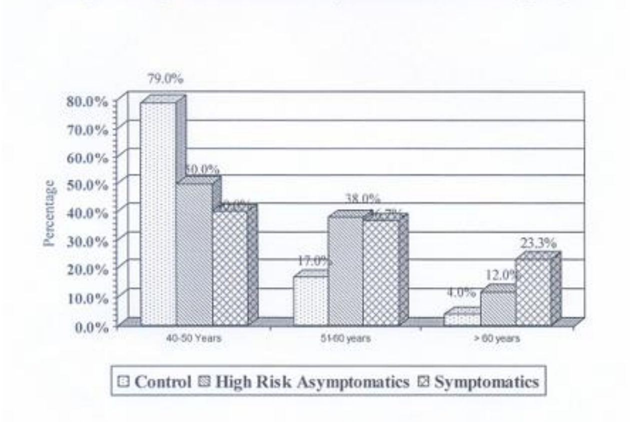

Fig. 2: Distribution of patients according to mean values of ABI (Doppler and palpatory) in various study groups (All patients)

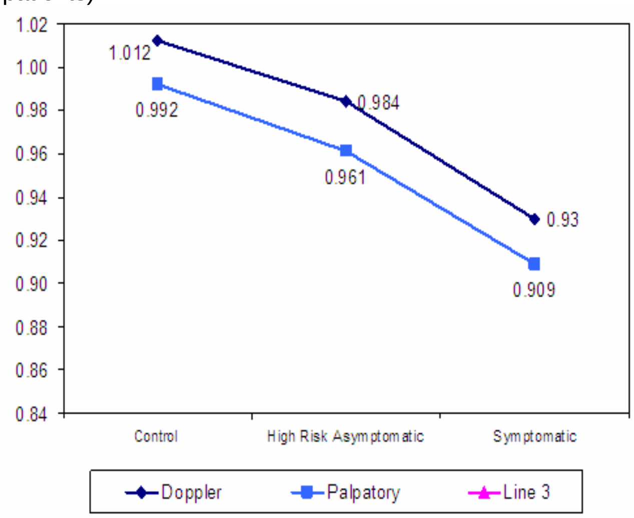

Figure 3: Distribution of patients according to mean values of systolic blood pressure of arm and leg in various study groups (All Patients)

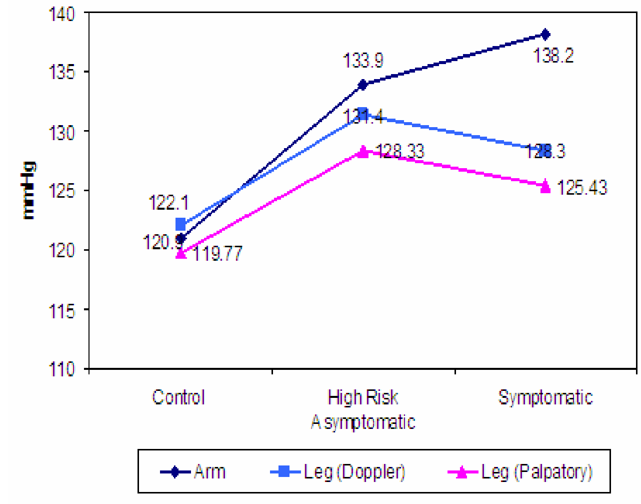

Table 1: Distribution of patients according to mean Ankle Brachial Index (ABI) Control and High Risk Asymptomatic Groups

Ankle brachial index	**Control Group (n=100)**		**High Risk Asymptomatic Group (n=100)**		**T test**
	Mean	**S.D.**	**Mean**	**S.D.**	
Doppler	1.0115	0.08167	0.9838	0.08878	5.33 P=0.0211
Palpatory	0.9923	0.08609	0.9608	0.10377	5.48 P= 0.0202

Table 2: comparison of mean Ankle Brachial Index (ABI) In Control and Symptomatic Groups

Ankle brachial index	**Control Group (n=100)**		**High Risk Asymptomatic Group (n=100)**		**T test**
	Mean	**S.D.**	**Mean**	**S.D.**	
Doppler	1.0115	0.08167	0.9302	0.14064	15.94 P= 0.0001
Palpatory	0.9923	0.08609	0.9088	0.13274	16.57 P= 0.0001

Table 3: Comparison of mean Ankle Brachial Index (ABI) In High Risk Asymptomatic and Symptomatic Groups

Ankle brachial index	**Control Group (n=100)**		**High Risk Asymptomatic Group (n=100)**		**T test**
	Mean	**S.D.**	**Mean**	**S.D.**	
Doppler	0.9838	0.08878	0.9302	0.14064	6.32 P= 0.0132
Palpatory	0.9608	0.10377	0.9088	0.13274	5.09 P= 0.0257

Table 4: Comparison of mean ankle brachial index between control, high risk asymptomatic and symptomatic groups

Ankle Brachial Index	Control group (n=100)		High Risk Asymptomatic (n=100)		Symptomatic (n=30)		ANOVA Test
	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Doppler Method	1.0115	0.08167	0.9838	0.08878	0.9302	0.14064	F-Statistics= 8.85 (P<0.01)
Palpatory Method	0.9923	0.08609	0.9608	0.10377	0.9088	0.13274	F-Statistics= 8.31 (P< 0.01)
	P=0.1		P=0.12		P=0.13		

Table 5: Distribution of ABI and PAD positive cases in various group

Group	<0.7		0.7-0.9		0.9-1.4	
	Frequency	%age	Frequency	%age	Frequency	%age
Control Group (n=100)	0	0	5	5	95	95
High risk asymptomatic(n=100)	0	0	14	14	86	86
symptomatic(n=30)	1	3.33	13	43.33	16	53.33

DISCUSSION

Noninvasive techniques play an important role in the screening of asymptomatic individuals, diagnosis of the disease and follow up of the patients or the efficacy of medical, interventional or surgical procedures[15]. This helps in the identification of high risk individuals, who may be candidates for more active intervention to prevent clinical events. With a non-invasive approach a risk marker for coronary arterial disease [CAD] and a predictor of coronary events especially in the elderly can be estimated.[16]In this study we demonstrated that severity of peripheral arterial disease can be predicted by ABI values. In healthy controls ABI values were in normal range and mean ABI was >1.0. On the other hand mean ABI in other two groups were significantly lower, a manifestation of atherosclerosis and a predictor of ischemic cardiovascular outcomes. The distribution of ABI in three groups clearly shows the decreasing levels of ABI in high risk asymptomatic group and symptomatic group versus control group. As the brachial systolic blood pressures increase, ankle systolic pressures decrease showing the positive effect of hypertension on the development of atherosclerosis resulting in lower ABI. ABI values below 1.10 [men] and 1.00 [women] give a good estimation of coronary and carotid atherosclerosis and finding of borderline and low-normal ABI increases the risk of cardiovascular events[9].

An ABI of <0.90 predicted the presence of >3 vessel or left main coronary artery disease with a sensitivity of 85% and specificity of 77%[16]. Our results indicate that advanced age, greater number of total risk factors and presence of PAD-related

physical and clinical findings are associated with low ABI. Similar findings are also reported in other related studies in different populations[17,2,12]. An accurate ankle brachial index is an important method to predict the severity of vascular disease in out patient department setting. Asymptomatic patients are more likely to have their PAD diagnosis and treatment protocol established early based on the very initial finding of the severity of low ABI. Limitations of our study included a small sample size and possibility of bias due to selection of a high risk groups both symptomatic and asymptomatic, therefore the results of this study can not be extrapolated to general population. It is imperative that preventive strategies in the form of patient education, life style modification, institution of pharmacological therapies and early and appropriate interventions be provided at the earliest so that cost burden of the disease can be avoided from both the individual and the society.

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