Original Article

Ankle Brachial Index as a Screening Test in Suspected Coronary Artery Disease Patients

Tariq Waseem, Naveed Rashid, Abbas Raza and Muhammad Imran

Abstract: The resting ankle- brachial index (ABI) is a non-invasive method to assess the patency of lower extremity arterial system and to screen for the presence of peripheral occlusive arterial disease. Diagnostic efficacy of ABI to predict atherosclerosis is well documented and reduction in index (< 0.9) is indicative of generalized atherosclerosis. Present study was planned to evaluate the role of ABI as a possible non- invasive marker for coronary atherosclerosis.

Objective: To evaluate the relationship between ABI and the extent of coronary artery disease estimated by angiography.

Study design: Cross Sectional Study.

Settings: Departments of Medicine & Cardiology, Mayo Hospital, Lahore.

Duration: Six months, from July 2006 to January 2007.

Subjects: One hundred and fifty patients referred for coronary angiography were selected. ABI was calculated on each patient before undergoing angiography. A single cardiologist using a computer based quantitative coronary angiography made angiography interpretations.

Results: The mean age of patients was 51.23±10.23 years. There were 147 (98%) patients with normal ABI (>0.9), 2 (1.3%) with mild reduction in ABI (0.7- 0.89), and 1 (0.7%) with moderate ABI (0.4- 0.69). In patients with normal ABI 34 (22.7%) patients had normal coronary angiogram, 43 (28.7%) patients had single vessel disease, 33 (22%) patients had two vessels disease, 35 (23.3%) patients had three vessels disease, and 2 (1.3%) patients had four vessel disease. In patients with mild ABI (0.7- 0.89) there was 1(0.7%) patient who had single vessel disease, and 1 (0.7%) patient with four vessel disease. In the moderate ABI category (0.4 - 0.69) there was 1 (0.7%) patient with two vessel disease.

Conclusion: Ninety eight percent of the studied population with otherwise symptomatic coronary artery disease had normal ABI. On the other hand 77% of patients with normal ABI had abnormalities on coronary angiogram. ABI lacks the sensitivity to screen atheromatous CAD and cannot be recommended as such.

Key Words: Ankle brachial index, coronary artery disease, coronary angiography.

Introduction

Patients already having evidence of atheromatous vascular disease are at higher risk of another vascular event and can be offered a variety of primary and secondary preventive measures to improve their outcome.[1] Patients with peripheral arterial disease (PAD) have a high prevalence of coexistent coronary artery disease (CAD).[2] They are at triple the risk of all cause morality and at more than six times the risk of death from coronary artery disease as compared to those without the disease.[3] Under-diagnosis of peripheral arterial disease in primary care practice may be a barrier to effective secondary prevention of high ischemic cardiovascular risk associated with peripheral arterial disease.[4]

Ankle brachial pressure index (ABI) being simple and easy to perform technique should be included early in the clinical consideration of patients with symptoms suggesting coronary artery disease.[3,5] Ankle brachial index is the ratio of ankle and brachial systolic pressures measured with the help of a hand held Doppler. Normal value of ABI is $\geq$0.9 and $\leq$1.40.[6] The lower the ABI, the greater the severity of peripheral artery disease.[7]

Coronary artery disease (CAD) is one of the most common diseases throughout the world. Studies have shown that brachial-ankle pulse wave velocity (BAPWV) and ABI were equally effective at predicting stenosis of the coronary arteries and stenosis of the arteries of the lower extremities. Different levels of BAPWV with corresponding ABI can express different degrees of arterial sclerosis and

peripheral artery lesion to a certain extent. Measurement of both BAPWV and ABI is thus highly recommended in clinical investigation.[8] A biomarker panel comprising of beta 2M, cystatin C, hsCRP, and glucose, while adding useful information to assess the risk of disease does not address the extent of disease.[9] Prediction models to identify healthy individuals at high risk of cardiovascular disease have limited accuracy. A low ankle brachial index is an indicator of atherosclerosis and has the potential to improve prediction. A low ABI (< or = 0.90) was associated with approximately twice the 10-year total mortality, cardiovascular mortality, and major coronary event rate compared with the overall rate in each Framingham risk score (FRS) category. Inclusion of the ABI in cardiovascular risk stratification using the FRS would result in reclassification of the risk category and modification of treatment recommendations in approximately 19% of men and 36% of women. Measurement of the ABI may improve the accuracy of cardiovascular risk prediction beyond the FRS.[10]

The resting ankle-brachial index (ABI) is a non-invasive method to assess the patency of the lower extremity arterial system and to screen for the presence of peripheral occlusive arterial disease. Many large studies, like VITAMIN study,[11] Edinburgh Artery Study,[12] Study from Heart, Lung and Blood Vessel Centre, China[13] have authenticated the diagnostic efficacy of ABI to predict atherosclerosis. Individuals with ABI < 0.9 were found to be twice as likely to have prevalent CHD as those with ABI >0.9.[14] These data demonstrate that low ABI levels, particularly those of <0.9, are indicative of generalized atherosclerosis.

In Pakistan, little work has been done on ABI. [15,16] In 2001, Bashir and Aslam from Army Medical College, Rawalpindi studied peripheral vascular disease in patients with coronary artery disease in 200 patients and found that 22.5% patients were suffering from peripheral vascular disease. According to their results, ABI appears to be simple and cheap technique for evaluation of atherosclerosis.[17]

Studies showing relationship of ABI with severity of CAD are lacking in our community. We planned this study to highlight the role of ABI as possible non-invasive marker for coronary atherosclerosis, and to find a relationship between ABI and the severity of CAD among high-risk group patients.

Objective

To evaluate the relationship between ankle brachial index and the extent of coronary artery disease estimated by coronary angiography.

Material & Methods

Settings: Departments of Medicine & Cardiology, Mayo Hospital, Lahore.

Study Design: Cross sectional study.

Sample Size: 150 patients.

Duration: Six months from July 2006 to Jan 2007.

Sampling Technique: Convenient non-probability sampling.

Inclusion Criteria

1. Patients referred to Mayo Hospital, Lahore for elective coronary angiography either for diagnostic or for follow-up purposes.
2. Age between 17 to 80 years.
3. Both male and female sex.

Exclusion Criteria

1. Patients with past history of angioplasty or coronary artery bypass grafting
2. Patients with any congenital cardiac lesion
3. Patients with valvular heart disease
4. Patients with non-ischemic myocardial disease

Data Collection Procedure

One hundred and fifty patients fulfilling the inclusion criteria referred from outdoor, indoor or emergency departments of Medicine, Mayo Hospital Lahore were studied. Informed consent was taken from the patients.

ABI of these patients was calculated using a standard protocol before undergoing angiography. Three groups of ABI measurements i.e. 0.70-0.89, 0.40-0.69 and <0.40 were made. Angiography and its interpretation was done by a single cardiologist using standardized computer based quantitative coronary angiography (QCA) to give a measure of the severity of CAD.

Statistical Analysis Procedure

All collected information was entered into the computer and analyzed using SPSS version 10.0 software. The study variables were age, sex, ABI, CAD findings, symptoms, NYHA class, smoking, HTN, DM and dyslipidemia. The quantitative variables like age and ABI were presented as mean and standard deviation. The qualitative variables like sex, CAD findings, symptoms, NYHA class, smoking, HTN, DM and dyslipidemia were presented in frequency and percentage. The relationship between ABI and the extent and severity of CAD (using QCA method) was evaluated, by applying Chi-Square test. P value $\leq$0.05 was considered as

Results

One hundred and fifty patients suspected of having coronary artery disease and referred for coronary angiography were selected for this study. The mean age of the patients was 51.23±10.23 years **(Table1).** There were 118 (78.7%) male patients and 32 (21.3%) female patients **(Table 2)**.

In the presenting symptoms, 20 (13.3%) patients had dyspnea, 112 (74.7%) patients had chest pain, 3 (2%) patients had palpitation, 5 (3.3%) patients had arm pain, 4 (2.7%) patients had epigastric pain and 6 (4%) patients had chest heaviness **(Table 3).**

Risk factors profile analysis of our patients revealed that 66 (44%) patients were smokers and 84 (56%) non-smokers, 63 (42%) were hypertensive 87 (58%) were non hypertensive patients, 37 (24.7%) diabetic patients and 113 (75.3%) were non diabetic patients . There were 9 (6%) patients having dyslipidemia and 141 (94%) patients had no dyslipidemia **(Table 4).**

In the ABI distribution, there were 147 (98%) patients of ABI of >0.9 (normal), 2 (1.3%) patients of ABI of 0.7-0.89 (mild), 1 (0.7%) patient of ABI of 0.4-0.69 (moderate) and no patients of severe ABI **(Table 5).**

In the CAD findings, there were 34 (22.7%) normal finding, 44 (29.3%) patients of single vessel disease, 34 (22.7%) patients of two vessels disease, 35 (23.3%) patients of three vessels disease and 3 (2%) patients of four vessels disease **(Table 6).**

In the relationship between ABI and extent of coronary artery disease, in the normal ABI (>0.9) there were 34 (22.7%) patients of normal CAD, 43 (28.7%) patients of single vessel disease, 33 (22%) patients of two-vessel disease, 35 (23.3%) patients of three vessels disease and 2 (1.3%) patients of four vessel disease. In the mild ABI (0.7-0.89) there was 1 (0.7%) patient of single vessel disease and 1 (0.7%) patient of four vessels disease. In the moderate ABI (0.4-0.69) there was 1 (0.7%) patient of two vessels disease **(Table 7).**

Table-1: Age distribution in years (n=150).

Age in years	Frequency	Percentage
<50	55	36.7
≥50	95	63.3
Mean±SD	51.23±10.23	

Key: SD=Standard deviation,<=Less than,≥=Equal to or more than

Discussion

Patients with peripheral arterial disease (PAD) have

Table-2: Distribution of patients by sex (n=150)

Sex	No.	Percentage
Male	118	78.7
Female	32	21.3
Total	150	100.0

Table-3: Distribution of patients by symptoms (n=150)

Symptoms	No.	Percentage
Dyspnea	20	13.3
Chest Pain	112	74.7
Palpitations	01	2.0
Arm Pain	05	3.3
Epigastric Pain	04	2.7
Chest Heaviness	06	4.0

Table-4: Frequency of major CVD risk factors (n=150)

Risk Factors	No.	Percentage
Smoking	66	44.0
Hypertension	63	42.0
Diabetes	37	24.7
Dyslipidiemia	09	6.0

Table-5: Distribution of patients by ABI (n=150)

ABI	Frequency	Percentage
≥0.9	147	98.0
0.7-0.89	02	1.3
0.4-0.69	02	0.7
<0.4	0	0

Key: ABI=Ankle brachial index, ≥0.9=Normal, 0.7-0.89=Mild, Moderate, <0.4=Severe

Table-6: Distribution of patients by coronary angiography findings (n=150)

Coronary Angiography findings	No.	Percentage
Normal	34	22.7
Single vessel disease	44	29.3
Two vessel disease	34	22.7
Three vessel disease	35	23.3
Four vessel disease	03	2.0

Table-7: Relationship between ABI and the extent of coronary artery disease (n=150)

ABI	Coronary artery disease					
	Normal	Single VD	Two VD	Three VD	Four VD	Total
≥0.9	34	43	33	35	2	147
0.7 - 0.89	0	1	0	0	1	2
0.4 - 0.69	0	0	1	0	0	1
< 0.4	0	0	0	0	0	0
Total	34	44	34	35	3	150

x^2=28.49,df=8, p=0.001

Key: 0.9=Normal, 0.7-0.89= Mild, 0.4-0.69= Moderate,<0.4=Severe and VD= Vessel Disease

a high prevalence of coexistent coronary artery disease (CAD).[2] They are at triple the risk of all cause morality and at more than six times the risk of death from coronary artery disease as compared to those without the disease.[3] Under-diagnosis of peripheral arterial disease in primary care practice may be a barrier to effective secondary prevention of high ischemic cardiovascular risk associated with peripheral arterial disease.[4] A simple, inexpensive and non invasive test such as ABI with high sensitivity to predict peripheral vascular disease may also predict the severity of co-existing CAD. The present study assumed to find a low ABI in subjects with symptomatic CAD undergoing coronary angio-graphy and to predict pre-test severity of CAD based on ABI. The results do not support this assumption. The differences in age groups selected for our study, risk factors, ethnic and climatic conditions may explain the findings and a low prevalence of peripheral vascular disease on ABI in our patients.

Our patients (51.23±10.23 years) when compared with those of Nunes et al[18] (60.3±9.8 years) were younger by a decade which might explain relatively lesser peripheral arterial disease seen in our patients on ABI.

Risk factor profile of our patients was (44% smokers, 42% hypertensive, 24.7% diabetics and 6% dyslipidemic) was comparable to that was observed by Xu et al.[8] A very similar distribution of risk factors was reported by Aboyans et al.[19]

The frequency of peripheral vascular disease in our population appears less as compared to the western population and climate and environmental conditions might be one reason explaining the difference.

In our study there were 98% patients of normal ABI (>0.9), 1.3% patients of mild ABI (0.7-0.89), 0.7% patient of moderate ABI (0.4-0.69) and no patient of severe ABI (<0.4). When compared with the local study conducted by Bashir and Aslam[5] the normal ABI was found in 95% patients, which is comparable with our study.

According to the study of Mostaza et al[20] the normal ABI was found in 74% of the patients and low ABI was found in 26% of patients, which is not comparable with our study.

Measurement of ABI detected a significant number of patients with peripheral artery disease who did not have coronary heart disease (CHD) or CVD, but whose cardiovascular risk factors were under treated and poorly controlled compared with subjects with CHD and/or CVD.[21]

In our study, in the angiography findings, there were 22.7% patients of normal, 29.3% patients of single vessel disease, 22.7% patients of two-vessel disease, 23.3% patients of three-vessel disease and 2% patients of four-vessel disease. Igarashi et al[22] reported that there were 83% patients with multi vessel disease which is not comparable with our study.

In our study, while assessing the relationship between ABI and extent of coronary artery disease, in the normal ABI (>0.9) patients 22.7% patients had normal angiography, 28.7% patients had single vessel disease, 22% patients had two vessel disease, 23.3% patients had three vessel disease and 1.3% patients had four vessel disease. In the mild ABI (0.7-0.89), 0.7% patient had single vessel disease and 0.7% patient had four-vessel disease. In the moderate ABI (0.4-0.69) 0.7% patient had two-vessel disease.

The ABI is a simple, noninvasive,and reliable test that can be complementary to conventional vascular risk factor profiles to identify individuals from thegeneral population who are at high risk of developing cardiovascular disease and could benefit from preventive measures.[23] After adjusting for conventional cardiovascular risk factors and prevalent cardiovascular disease, a low ABI (<0.90) is

predicting future cardiovascular events (ie, a low ABI helps to "rule in" a high-risk patient), with likelihood ratios of about 2.5 for coronary heart disease, 2.4 for stroke, and 5.6 for cardiovascular death. However, because thesensitivity of a low ABI to predict future cardiovascular outcomesis low (i.e., a normal ABI does not "rule out" a high-risk patient), the ABI lacks usefulness as a screening test for CAD in the general population. Further clarification of the role of ABI awaits evaluation of its incremental predictive value over conventional methods of risk assessment in patients who may be at increased risk of cardiovascular disease.[23] Its optimal application may be as part of the vascular risk assessment among selected individuals without established vascular disease but older than 70 years or amongthose who are aged 50 to 69 years and have 1 or more cardiovascular risk factors i.e., elevated serum cholesterol level, hypertension, dysglycemia, tobacco exposure, or a family history of atherosclerotic disease.[24]

Our patients were younger with a mean age of 51 years when compared with those of Doobay and Anand[23] who were 50-69 years old and had one or more cardiovascular risk factors. Perhaps this is the reason of finding a lower frequency of low ABI and hence lower PAD in our patients who otherwise comprised of symptomatic patients having significant abnormalities on coronary angiography. Despite its documented usefulness to predict peripheral vascular disease ABI remains insensitive to predict CAD in younger patients. Peripheral vascular disease may be lagging behind CAD by a decade to become manifest in our patients.

Conclusion

ABI cannot be recommended as a screening tool for atheromatous CAD in our population. 98% the studied population with otherwise symptomatic coronary artery disease had normal ABI. On the other hand 77% of patients with normal ABI had abnormalities on coronary angiogram. A low ABI helps to "rule in" a high-risk patient but a normal ABI does not "rule out" a high-risk patient. The ABI lacks usefulness as a screening test for CAD in the general population.

Department of Medicine
AIMC/ Jinnah Hospital, Lahore
theesculapio@hotmail.com
www.sims.edu.pk/esculapio.html

References

1. Boon NA, Fox KAA, Bloomfield P, Bradbury A. Pathophysiology: Atherosclerotic vascular disease. In: Haslett C, Chilvers ER, Boon NA, Colledge NR editors. Davidson's Principles and Practice of Medicine.19th ed. New York: Churchill Livingstone; 2002: 420-4.
2. Sukhija R, Yalamanchili K, Aronow WS. Prevalence of left main coronary artery disease, of 3-vessel or 4-vessel coronary artery disease, and of obstructive coronary artery disease in patients with and without peripheral arterial disease undergoing coronary angio- graphy for suspected coronary artery disease. Am J Cardiol 2003; 92: 304-05.
3. Mohler ER III. Peripheral arterial disease. Identification and implications. Arch Intern Med 2003; 163:2306-14.
4. Hirsch AT, Criqui MH, Jacobson DT, Regensteiner JG, Creager MA, Olin JW et al. Peripheral arterial disease detection, awareness, and treatment in primary care. J Am Med Assoc 2001; 286:1317-24.
5. Bashir EA, Aslam N. Peripheral vascular disease in patients with coronary artery disease. J Coll Phys Surg Pak 2001; 11:614-6.
6. Resnick HE, Lindsay RS, McDermott MM, Devereux RB, Jones KL, Fabsitz RRet al. Relationship of high and low ankle brachial index to all-cause and cardiovascular disease mortality. Circulation 2004; 109: 733-9.
7. Sukhija R, Aronow WS, Yalamachili K, Peterson SJ, Frishman WH, Babu S. Association of Ankle Brachial Index with severity of angiographic coronary disease in patients with peripheral arterial disease and coronary artery disease. Cardiology 2005; 103: 158-60.
8. Xu Y, Wu Y, Li J, Ma W, Guo X, Luo Y et al. The predictive value of brachial-ankle pulse wave velocity in coronary athero-sclerosis and peripheral artery diseases in urban Chinese patients. Hypertens Res 2008; 31: 1079-85.
9. Fung ET, Wilson AM, Zhang F, Harris N, Edwards KA, Olin JW et al. A biomarker panel for peripheral arterial disease. Vasc Med 2008; 13: 217-24.
10. Ankle Brachial Index Collabo-ration, Fowkes FG, Murray GD, Butcher I, Heald CL, Lee RJ et al. Ankle brachial index combined with Framingham Risk Score to predict cardiovascular events and mortality: a meta-analysis. J Am

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Department of Medicine
AIMC/ Jinnah Hospital, Lahore
theesculapio@hotmail.com
www.sims.edu.pk/esculapio.html

References

1. Boon NA, Fox KAA, Bloomfield P, Bradbury A. Pathophysiology: Atherosclerotic vascular disease. In: Haslett C, Chilvers ER, Boon NA, Colledge NR editors. Davidson's Principles and Practice of Medicine.19th ed. New York: Churchill Livingstone; 2002: 420-4.
2. Sukhija R, Yalamanchili K, Aronow WS. Prevalence of left main coronary artery disease, of 3-vessel or 4-vessel coronary artery disease, and of obstructive coronary artery disease in patients with and without peripheral arterial disease undergoing coronary angio- graphy for suspected coronary artery disease. Am J Cardiol 2003; 92: 304-05.
3. Mohler ER III. Peripheral arterial disease. Identification and implications. Arch Intern Med 2003; 163:2306-14.
4. Hirsch AT, Criqui MH, Jacobson DT, Regensteiner JG, Creager MA, Olin JW et al. Peripheral arterial disease detection, awareness, and treatment in primary care. J Am Med Assoc 2001; 286:1317-24.
5. Bashir EA, Aslam N. Peripheral vascular disease in patients with coronary artery disease. J Coll Phys Surg Pak 2001; 11:614-6.
6. Resnick HE, Lindsay RS, McDermott MM, Devereux RB, Jones KL, Fabsitz RRet al. Relationship of high and low ankle brachial index to all-cause and cardiovascular disease mortality. Circulation 2004; 109: 733-9.
7. Sukhija R, Aronow WS, Yalamachili K, Peterson SJ, Frishman WH, Babu S. Association of Ankle Brachial Index with severity of angiographic coronary disease in patients with peripheral arterial disease and coronary artery disease. Cardiology 2005; 103: 158-60.
8. Xu Y, Wu Y, Li J, Ma W, Guo X, Luo Y et al. The predictive value of brachial-ankle pulse wave velocity in coronary athero-sclerosis and peripheral artery diseases in urban Chinese patients. Hypertens Res 2008; 31: 1079-85.
9. Fung ET, Wilson AM, Zhang F, Harris N, Edwards KA, Olin JW et al. A biomarker panel for peripheral arterial disease. Vasc Med 2008; 13: 217-24.
10. Ankle Brachial Index Collabo-ration, Fowkes FG, Murray GD, Butcher I, Heald CL, Lee RJ et al. Ankle brachial index combined with Framingham Risk Score to predict cardiovascular events and mortality: a meta-analysis. J Am