The Value of Ankle Brachial Index in Predicting the Severity of Coronary Artery Disease

Essam M Mahfouz[1]*, Fawzia M Eldemerdash[1], Mohamed S Altantawy[2] and Mona M Abdel Rehim[1]

1Cardiology Department, Mansoura University, Egypt.

2Diagnostic radiology department, Mansoura University, Egypt.

*Correspondence:
Essam M Mahfouz, Department of Cardiology, Mansoura University, Egypt, E-mail mahfouzessams@gmail.com.

Received: 14 March 2018; **Accepted:** 29 March 2018

ABSTRACT

Background: Ankle brachial index (ABI) is a simple clinical test used for detection of peripheral arterial disease (PAD) in asymptomatic patient and is related to the severity of atherosclerosis.

Aim of work: To evaluate ABI in patient with suspected coronary artery disease (CAD) and correlate its value with the severity of CAD assessed by SYNTAX score.

Patients and Method: ABI was assessed by standard Doppler ultrasound technique in 500 adult patient referred for coronary angiography for suspected CAD. The severity of CAD was assessed by 2 intervention cardiologist blinded for ABI data calculating the SYNTAX score (SS1).

Results: A highly significant negative correlation was observed between ABI and SS1 (r = 0.05 P< 0.001) and patient with low ABI had a signifantly higher SS1 as compared to patient with normal ABI (P<0.001). Higher prevalence of male sex, hypertension, smoking and dyslipidemia was found in patients with low ABI Vs normal ABI.

Conclusion: ABI can be used as a simple cheap clinical test for prediction of severity of CAD and for decision making in selection of patients for diagnostic coronary angiography.

Keywords
Ankle brachial index, Peripheral arterial disease, SYNTAX score.

Introduction

Atherosclerosis, the most common cause of mortality and morbidity worldwide, is considered a generalized process, which affects coronary, cerebral, and peripheral arteries of the lower extremities [1,2]. Peripheral artery disease (PAD) is the most common manifestation of systemic atherosclerosis in which the arterial lumens of the lower extremities become progressively occluded by atherosclerotic plaque [3]. Peripheral arterial disease (PAD), whether symptomatic or asymptomatic, is a risk factor for non-fatal and fatal coronary artery disease and cerebrovascular events [4].

Ankle-brachial index (ABI) is a simple, noninvasive tool used to screen PAD by comparing systolic blood pressures in the ankle to the higher of the brachial systolic blood pressures [5]. Several studies have shown that ABI is strongly correlated with the presence of atherosclerosis in the coronary arteries [6,7].

SYNTAX (Synergy between PCI with TAXUS and Cardiac Surgery) score (SS1) was originally developed to characterize the coronary anatomy of patients with multi-vessel / complex coronary artery disease allocated to PCI or coronary artery bypass graft (CABG) in the SYNTAX trial and it is an important tool that can help clinicians to establish the optimum revascularization approach in patients with complex CAD [8].

Our study aimed to investigate the correlation of ABI and the severity of CAD diagnosed by coronary angiography using SS1 and to determine different risk factors altering this correlation.

Patients and Methods

The present study is a cross-sectional prospective observational study, conducted on a total of 550 patients with suspected CAD who were scheduled to undergo elective coronary angiography in the Department of Cardiovascular Medicine in the specialized Medical hospital, Mansoura University, Egypt. Of those, 50 patients were excluded because of incomplete data on admission or, inability to accurately calculate ABI or SYNTAX Score during the study period from May 2015 to May 2016.

The study was approved by the ethical committee of Mansoura faculty of medicine and a written informed consent was obtained from every patient. Patients with documented PAD or CAD, patient with ABI >1.4 or <0.4, patients with cardiomyopathy, valvular heart disease, pulmonary hypertension or congenital heart disease were excluded from the study.

Every patient was subjected to a detailed history was taken and full clinical examination with special stress on atherosclerotic risk factors and vital signs. Ankle brachial index (ABI) was calculated after measurement of brachial blood pressure with a calibrated oscillometric sphygmomanometer (ALPK2, 300-V) using a cuff adapted to the upper arm. The cuff was chosen according to the limb size. The width should contour at least 40% of the limb circumference [9] and ankle pressure in both ankles was measured by using a Bistos hand-held vascular Doppler (BT 200V, 8 MHz; East Shore Medical, Illinois), with 8 MHz probe as described by Crawford et al., 2016 [10].

SYNTAX score 1 was calculated after coronary angiography from every patient by two interventional cardiologists who were blind to the patient data using SYNTAX Score Calculator software version 2.11 (SYNTAX Score Working Group), www.SYNTAXscore. com. An electrocardiogram, echocardiogram and laboratory investigations including CBC, kidney function test, liver function test, fasting and 2h postprandial blood glucose, HbA1c, and lipid profile were done for every studied patient.

The patients were classified according to ABI in to two groups:
Reference Group: Subjects with normal ABI: ≥ 0.9 (0.9-1.4) include 373 patients.
Study Group: Subjects with low ABI: <0.9 (0.4 - 0.8) include 127 patients.

Data was collected and tabulated and subjected to statistical analysis using SPSS package version 22.

Results

The study includes 500 patients of which 127 patients (25%) have ABI<0.9 and 373 patients (75%) have ABI>0.9 Figure 1. Regarding the demographic data 393 patients were male and 107 were females with a significantly higher age in the females in comparison to male P<0.001 (Table 1). Also, a significant increase in normal ABI >0.9 in females <60 y of age in comparison to female >60 y and male subgroups P = 0.02 and a trend for low ABI < 0.9 in male > 60 y in comparison to male < 60 y and female subgroups

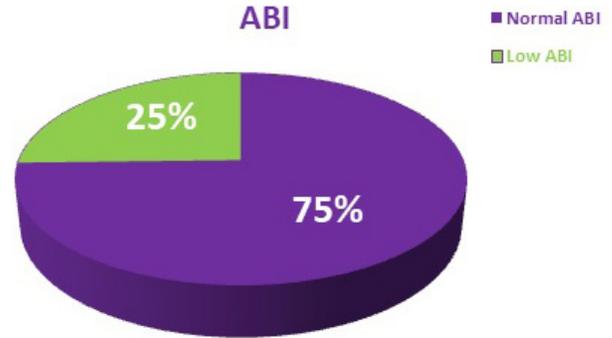P= 0.06 (Table 2). A poor correlation was found between ABI and age in our study r = 0.036, P 0.436 (Figure 2).

Figure 1: ABI in the study patients.

Age/years	Male (n=393)		Female (n=107)		Test of sig.	p-value
	No	%	No	%		
≤60y (n=346)	284	72.3	62	57.9	χ^2=8.092	0.004*
>60y (n=154)	109	27.7	45	42.1		
Mean ± SD	54.97 ± 9.24		59.05 ± 8.01		t=4.154	<0.001**

Table 1: Demographic data in the study patient.

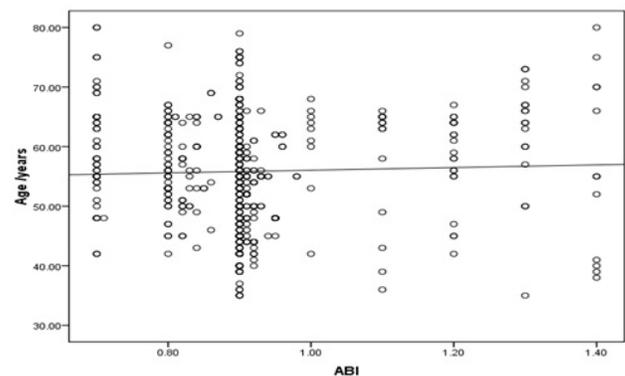|	Male				Female				Total (n=500)		χ^2	p-value
	≤60y (n=284)		>60y (n=109)		≤60y (n=62)		>60y (n=45)					
	NO	%	NO	%	NO	%	NO	%	NO	%		
Ref.group (Normal ABI ≥0.9)	213	75	76	69.7	51	82.3	33	73.3	373	74.6	5.31	0.021*
Study group (Low ABI <0.9)	71	25	33	30.3	11	17.7	12	26.7	127	25.4	3.44	0.064

Table 2: ABI in relation to age and sex.

Figure 2: Correlation of ABI and age. r = 0.036; P 0.436.

Comparative analysis of the prevalence of risk factors in the group with low ABI <0.9 versus the group with normal ABI revealed a significant increase in hypertension, smoking and dyslipidemia but non-significant increase in diabetes mellitus (Table 3). Dyslipidemia and smoking were found to be the independent predictors of low ABI <0.9 on logistic regression analysis (Table 4).

	Ref. group (Normal ABI ≥0.9) (n=373)		Study group (Low ABI <0.9) (n=127)		Total (n=500)		χ²	p- value
HTN	N	%	N	%				
Hypertensive	181	48.5	86	67.7	267	53.4	14.02	<0.001**
Normotensive	192	51.5	41	32.3	233	46.6		
DM	N	%	N	%				
Diabetic	142	38.1	58	45.7	200	40	2.28	0.131
Non -diabetic	231	61.9	69	54.3	300	60		
Smoking	N	%	N	%				
Smokers	159	42.6	72	56.7	231	46.2	7.54	0.006*
Non-smokers	214	57.4	55	43.3	269	53.8		
Dyslipidemia	N	%	N	%				
Dyslipidemia	212	56.8	91	71.7	231	46.2	8.71	0.003*
Normal lipid profile	161	43.2	36	28.3	269	53.8		

Table 3: Comparative analysis of risk factors in the group with low ABI Vs High ABI.

	Univariate regression			Multivariate regression	
	β	P	COR (95%CI)	P	AOR (95%CI)
HTN	0.80	<0.001	2.22 (1.46- 3.39)	-	-
Smoking	0.566	0.006	1.76 (1.17- 2.65)	0.013	1.89 (1.14-3.13)
Dyslipidemia	0.652	0.003	1.92 (1.24- 2.97)	<0.001	2.68 (1.56-4.6)
Constant Model χ² % correctly predicted	-3.24 153.88, P < 0.001 81.2%				

Table 4: Logistic regression analysis of independent predictors of Low ABI <0.9.

On calculating SS1 in our patients a 71% have low score <22, 21% have intermediate score (23-32) and 8% have high score >33 (Figure 3). Also, a highly significant increase in SS1 in patients with low ABI as compared to normal ABI P<0.001 (Table 5) and a significant difference in the percentage of different grades of SS in the group with low ABI versus the group of normal ABI P<0.001 (Table 6). Lastly a significant negative correlation was found between ABI and SS1 r =-0.5, P<0.001 (Figure 4).

SS	Ref. group (Normal ABI ≥0.9) (n=373)	Study group (Low ABI <0.9) (n=127)	t-test	p-value
Mean ± SD	12.81 ± 6.82	26.51 ± 10.45	16.86	<0.001
Range	0-31	0-55		

Table 5: Comparative analysis of SSI in the low ABI group Vs normal ABI.

	Ref. group (Normal ABI ≥0.9) n=373		Study group (Low ABI <0.9) n=127		Total (n=500)		χ²	p- value
	N	%	N	%	N	%		
Low	315	84..5	41	32.3	356	71.2	130.4	<0.001**
Intermediate	48	12.8	59	46.5	107	21.4		
High	10	2.7	27	21.2	37	7.4		

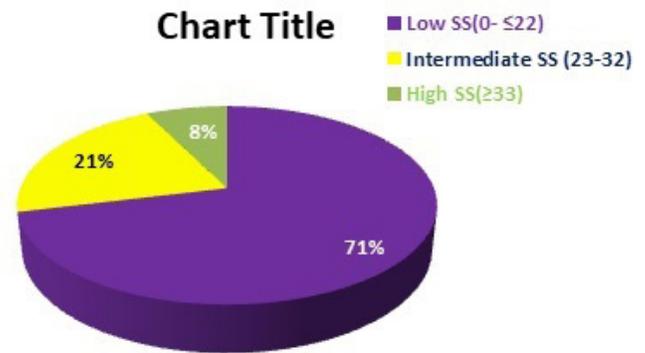**Table 6:** Comparison of SS groups in the group with low ABI Vs the

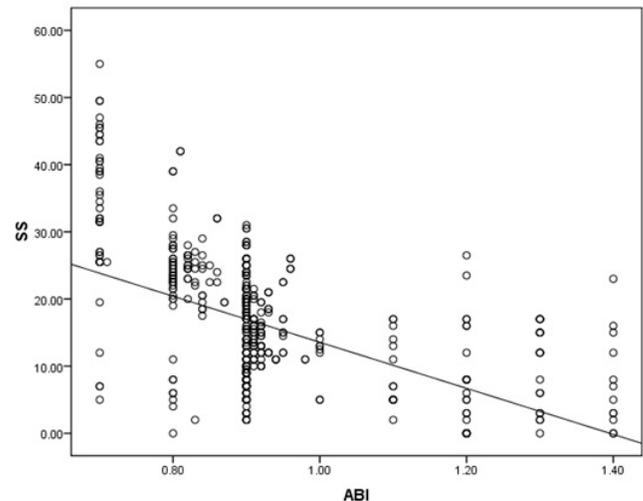**Figure 3:** Distribution of SSI in the study patients.

Figure 4: Correlation of ABI and SSI in the study patient.

Discussion

The most important finding in our study is the highly significant negative correlation between ABI and SS1 r = - 0.5 P<0.001 (Figure 4), the highly significant increase in mean SS1 in the group with low ABI as compared to the reference group (p<0.001) (Table 5) and the highly significant difference in the prevalence of low, intermediate and high SS1 in the group with low ABI versus the group with high ABI P<0.001 (Table 6). These results indicate that the value of ABI is a simple non-invasive clinical test that predicts the severity of CAD, help in decision making regarding patient selection for coronary angiography and can be combined with SS1 to predict the outcome of percutaneous coronary intervention as suggested in SHINANO Registry [11] in Japan. Our results are in agreement with the results of to Sebastianski et al. [12], in a study of 814 patients, 8% had PAD (ABI <0.90), which concluded that patients with PAD were more likely to have high SYNTAX scores (>33), with an odds ratio of 4.3 (95% confidence interval 1.2 to 14.9), compared with those with normal ABIs after adjustment for traditional cardiovascular risk factors. Also, several studies had demonstrated that ABI correlates with the presence and severity of coronary atherosclerosis [6,13-19].

The prevalence of patient with low ABI< 0.9 was 25% which

was nearly similar to the results of most previous studies. As Rotterdam study [17] in a population <55 years of age had a low ABI prevalence of 19%. Also, PARTNERS program which studied the population aged between 50 years and 69 years found a prevalence of 29% [4] however, our results are higher than that found in Edinburgh Artery Study [18] with the age between 55 years and 74 years and found a prevalence of 9% and Kim et al. [6] who found PAD in 12.8%.

The higher prevalence of low ABI in our study than in the above mentioned studies may be explained by the method of selection as we chose a high risk patients referred to coronary angiography. Also, our Egyptian population may have a high cardiovascular risk profile as Egypt is considered as one of the high risk countries by ESC [19].

In the present study 78.6% of the patients were males with significant lower mean age than females' P<0.001 Table 1 however no significant correlation was found between age and ABI (Figure 2). These findings are consistent with most previous studies that showed the prevalence of PAD, either symptomatic or asymptomatic, is higher in men than women [16,18] Whereas in the study of Taylor-Piliae et al. [20] in Arizona, the prevalence of low ABI was similar in both sexes.

However, Meijer et al. in Rotterdam Study [17] found a higher prevalence rate among women (20.5%) than for men (16.9%). Also, Sadrzadeh Rafie et al. [21] in USA found a higher prevalence of PAD in female in patient referred for coronary angiography.

Regarding the relation between cardiovascular disease risk factors and ABI our study revealed a significantly higher prevalence of hypertension, cigarette smoking and dyslipidemia in patients with low ABI as compared to patient with normal ABI but non-significant difference in the prevalence of diabetes mellitus. On logistic regression analysis, the most independent predictors of ABI < 0.9 were smoking (AOR 0.89 95% CI 1,14 - 3.13 P = 0.03) and dyslipidemia (AOR 0.68 955 CI 1.56-4.6 P<0.001) table 4. Our results regarding hypertension are similar to many previous studies [22,23] but contradictory to those of Reunanen et al. [24] who showed that hypertension was not significantly related to PAD. Also, higher prevalence of smoking was reported by many previous studies [18,25,26]. The relation of dyslipidemia to PAD was confirmed by many authors [27,28].

Although the higher prevalence of diabetes in patient with PAD in many studies [25,29-31], a non-significant difference was observed in our study. This may be explained by population difference, small sample size and the evidence that diabetic patients may have abnormally high ankle BP and consequently a false higher ABI [32].

The most important limitations of present study are small sample size in single center and lack of follow up which makes investigation into the prognostic value of ABI on cardiovascular outcome is not possible.

Overall conclusions of the present study are:
- A high overall presentation of low ABI in our patients with suspected IHD 25%.
- Higher prevalence of males especially younger males, hypertension, cigarette smoking and dyslipidemia in patients with low ABI.
- A strong negative correlation between ABI and SS1 that signify the positive relation between the severity of PAD and CAD and the value of ABI as a simple noninvasive clinical test that can be used for prediction of severity of CAD and selection of patient for coronary angiography.

References

1. Sadeghi M, Heidari R, Mostanfa B, et al. The relation between ankle-brachial index (ABI) and coronary artery disease severity and risk factors: an angiographic study. Atherosclerosis Journal. 2011; 7: 68-73.
2. Abbasnezhad M, Aliasgarzadeh A, Aslanabadi H, et al. Relation of Ankle Brachial Index to Left Ventricular Ejection Fraction in Non-Diabetic Individuals. Journal of Cardiovascular and Thoracic Research. 2011; 3: 109-112.
3. Sodhi HS, Shrestha SK, Rauniyar R, et al. Prevalence of peripheral arterial disease by ankle-brachial index and its correlation with carotid intimal thickness and coronary risk factors in Nepalese population over the age of forty years. Kathmandu University Medical Journal. 2007; 5: 12-15.
4. Sarangi S, Srikant B, Dayasagar V, et al: Correlation between peripheral arterial disease and coronary artery disease using ankle brachial index—a study in Indian population. Indian Heart Journal. 2012; 3: 64-65.
5. Hirsch AT, Haskal Z, Hertzer M, et al. ACC/AHA 2005 Practice Guidelines for the Management of Patients With Peripheral Arterial Disease (Lower Extremity, Renal, Mesenteric, and Abdominal Aortic): Executive Summary. Circulation. 2006; 11: 1474-1547.
6. Kim EK, Song PS, Yang JH, et al. Peripheral artery disease in Korean patients undergoing percutaneous coronary intervention: prevalence and association with coronary artery disease severity. J Korean Med Sci. 2013; 5: 87-92.
7. Amer M , Tawfik H, Mohamed A, et al. Correlation Between Ankle Brachial Index and Coronary Artery Disease Severity in Elderly Egyptians, Angiology 2013; 65: 891-895.
8. Madeira S, Raposo L, Brito J, et al. Potential Utility of the SYNTAX Score 2 in Patients Undergoing Left Main Angioplasty. Arq Bras Cardiol. 2016; 106: 270-278.
9. Jaff M. Lower extremity arterial disease Diagnostic aspects. Cardiol Clin. 2002; 20: 491-500.
10. Crawford F, Welch K, Andras A, et al. Ankle brachial index for the diagnosis of lower limb peripheral arterial disease. Cochrane Database of Systematic Reviews. 2016; 9: CD010680.
11. Uekie Y, Miura T, Miyashita Y. et al. Predictive Value of Combining the Ankle-Brachial Index and SYNTAX Score for the Prediction of Outcome After Percutaneous Coronary Intervention (from the SHINANO Registry), Am J Cardiol. 2016; 117: 179-185.

12. Sebastianski M, Narasimhan S, Graham M, et al. Usefulness of the Ankle-Brachial Index to Predict High Coronary SYNTAX Scores, Myocardium at Risk, and Incomplete Coronary Revascularization. Am J Cardiol. 2014; 114: 1745-1749.

13. Moussa ID Ja, MR, Mehran R, et al. Prevalence and prediction of previously unrecognized peripheral artery disease in patients with coronary artery disease: the peripheral artery disease in interventional patients study. Catheter Cardiovasc Interv. 2009; 73: 719-1197.

14. Korkmaz L, Adar A, Erkan H, et al. Ankle-brachial index and coronary artery lesion complexity in patients with acute coronary syndromes. Angiology 2012; 63: 495-499.

15. Benyakorn T, Kuanprasert S , Rerkasem K. A, et al. Correlation Study between Ankle Brachial Pressure Index and the Severity of Coronary Artery Disease. The International Journal of Lower Extremity Wounds. 2012; 11: 120-123.

16. Amer M, Tawfik H, Abd Elmoteleb A, et al. Is SYNTAX Score more accurate than Jeopardy Score and number of diseased vessels when correlating Ankle Brachial Index to Coronary Artery Disease severity in elderly Egyptians? Middle East Journal of Age and Ageing 2014; 11: 1-3.

17. Meijer T, Hoes A, Rutgers D, et al. Peripheral Arterial Disease in the Elderly The Rotterdam Study. rterioscler Thromb Vasc Biol. 1998; 18: 185-192.

18. Fowkes FG, Housley E, Cawood EH, et al. Edinburgh Artery Study: prevalence of asymptomatic and symptomatic peripheral arterial disease in the general population Int J Epidemiol. 1991; 20: 384-92.

19. Catapano A, Grahan I, De Backer G, et al. 2016 ESC/EAS Guidelines for the Management of Dyslipidaemias, European Heart Journal. 2016; 37: 2999-3058.

20. Taylor-Piliae RE, Fair JM, Varady AN, et al. Ankle brachial index screening in asymptomatic older adults. Am Heart J. 2011; 161: 979-985.

21. Sadrzadeh Rafie AH, Stefanick ML, Sims ST, et al. Sex differences in the prevalence of peripheral artery disease in patients undergoing coronary catheterization. Vasc Med. 2010; 15: 443-450.

22. Johnston KW et al. An atherosclerosis risk factor assessment program for patients with peripheral arterial occlusive disease. Ann Vasc Surg. 1988; 2: 101-107.

23. Binaghi F et al. Prevalence of peripheral arterial occlusive disease and associated risk factors in a sample of southern Sardinian population. Int Angiol. 1994; 13: 233-245.

24. Reunanen A, Takkunen H, Aromaa A. Prevalence of intermittent claudication and its effect on mortality. Acta Med Scand. 1982; 211: 249-256.

25. Agarwal AK, Singh M, Arya V, et al. Prevalence of Peripheral Arterial Disease in Type 2 Diabetes Mellitus and its Correlation with Coronary. Artery Disease and its Risk Factors. J Assoc Physicians India. 2012; 60: 28-32.

26. Norman P.E, Davis W.A, Bruce D.G, et al. Peripheral arterial disease and risk of cardiac death in type 2 diabetes. Diabetes Care. 2006: 29: 575-580.

27. Ridker PM, Stampfer MJ, Rifai N. Novel risk factors for systemic atherosclerosis: a comparison of C-reactive protein, fibrinogen, homocysteine, lipoprotein(a), and standard cholesterol screening as predictors of peripheral arterial disease. JAMA 2001; 285: 2481-2485.

28. Kumbhani DJ, Steg PG, Cannon CP, et al. Statin therapy and long-term adverse limb outcomes in patients with peripheral artery disease: insights from the REACH registry. Eur Heart J. 2014; 35: 2864-2872.

29. Janka H.U, Standl E, Mehnert H. Peripheral vascular disease in diabetes mellitus and its relation to cardiovascular risk factors screening with Doppler. Dia-betes Care. 1980; 3: 207-213.

30. Walter D.P, Gatting W, Mullee M.A, et al. The prevalence of diabetics and non-diabetic subjects in an English community. Diab Medicine.1992; 9: 710-715.

31. Marinelli M.R, Beach K.W, Glass M.J, et al. Non-Invasive testing vs clinical evaluation of arterial disease, a prospective study. JAMA. 1997; 241: 2031-2034.

32. Marso S and Hiatt W. Peripheral Arterial Disease in Patients with Diabetes. J Am Coll Cardiol. 2006; 47: 921-929.