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

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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 significant 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).

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

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

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

<table>
<thead>
<tr>
<th>Univariate regression</th>
<th>Multivariate regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>β</td>
<td>P</td>
</tr>
<tr>
<td>HTN</td>
<td>0.80</td>
</tr>
<tr>
<td>Smoking</td>
<td>0.566</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>0.652</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
</tr>
<tr>
<td>Model χ²</td>
<td></td>
</tr>
<tr>
<td>% correctly predicted</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>SS</th>
<th>Ref. group (Normal ABI ≥0.9) (n=373)</th>
<th>Study group (Low ABI &lt;0.9) (n=127)</th>
<th>t-test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SD</td>
<td>12.81 ± 6.82</td>
<td>26.51 ± 10.45</td>
<td>16.86</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Range</td>
<td>0-31</td>
<td>0-55</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>SS</th>
<th>Ref. group (Normal ABI ≥0.9) (n=373)</th>
<th>Study group (Low ABI &lt;0.9) (n=127)</th>
<th>χ²</th>
<th>p- value</th>
</tr>
</thead>
<tbody>
<tr>
<td>N %</td>
<td>N %</td>
<td>N %</td>
<td>N %</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>315 84.5</td>
<td>41 32.3</td>
<td>356 71.2</td>
<td>130.4  &lt;0.001**</td>
</tr>
<tr>
<td>Intermediate</td>
<td>48 12.8</td>
<td>59 46.5</td>
<td>107 21.4</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>10 2.7</td>
<td>27 21.2</td>
<td>37 7.4</td>
<td></td>
</tr>
</tbody>
</table>

**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 SSI r = - 0.5 P<0.001 (Figure 4), the highly significant increase in mean SSI 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 SSI 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 SSI 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, Sadrazadeh 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 95% 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
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.