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ORIGINAL ARTICLE

Relation of Ankle Brachial Index and Severity of Coronary Artery Disease

Ahmed Elzyat[1], Abd Elfattah Frere[1], Ahmed S. Eldamanhory[1], Osama kamal[1*]

[1]Cardiology department, Faculty of Medicine, Zagazig University, Zagazig, Egypt

***Corresponding author:**
Osama Kamal Saad Mansour
Cardiology department, faculty of medicine, Zagazig University.
E-mail:
osama.kamal.mans@gmail.com

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ABSTRACT

Background: The ankle brachial index (ABI) has been used for the diagnosis of lower-extremity peripheral artery disease, which is mainly caused by Atherosclerosis which also causes coronary artery disease (CAD), So ABI can be used as a marker for CAD.

Methods: This is a cross-sectional study from November 2018 to July 2019, including 160 male and female patients. Patients who had non-obstructive coronary artery disease like coronary ectasia, slow flow and corkscrew coronary arteries were excluded. The 160 cases had been divided according to SYNTAX score into three groups (low, intermediate and high score). Another division according to ABI into two groups (abnormal<1, normal≥1). We measured ABI using a handheld Doppler device (bistos BT-200V), fingertip pulse oximeter (ConTec CMS50D) then patients underwent coronary angiography. The CAD severity had been estimated using SYNTAX score, Gensini score and number of diseased vessels. The aim of this work is to investigate the relationship between ABI and CAD severity in Egyptian patients with chronic coronary syndrome(CCS). We use three measures: SYNTAX score, Gensini score and number of diseased vessels.

Results: Coronary artery disease severity increased significantly in cases with abnormal ABI (P<0.001) for all. We also found a significant negative correlation of SYNTAX, Gensini scores with ABI (P<0.001 for SYNTAX scores, P<0.001 for Gensini). We also measured ABI with the photoplethysmograpgy (PPG) method, which can be considered a new innovative method for ABI calculation.

Conclusions: We concluded that ABI can predict CAD severity in CCS Egyptian cases, ABI (PPG) method had very good accuracy compared to the ABI Doppler method.

keywords: Ankle brachial index; Coronary artery disease; Chronic coronary syndrome; SYNTAX score

INTRODUCTION

Atherosclerosis is a systemic disease that increases the risk of fatal, non-fatal cardiovascular (C.V) events. A serious cause of morbidity and mortality worldwide is coronary artery disease, which is mainly caused by atherosclerosis [1]. The ankle brachial index was initially proposed for the diagnosis of lower-extremity peripheral artery disease(PAD) as a noninvasive method [2]. After that, ABI was shown to be a prognostic marker for cardiovascular events even in asymptomatic PAD. This is because ABI is an indicator of atherosclerosis, which is a systemic disease that always affects many vascular sites [3]. Atherosclerosis is a disease that affects medium, large sized arteries which is characterized by lipids, inflammatory cells accumulation within the arterial wall and scar tissue development that is covered by a fibrous cap. Adults over the age of 60 years are usually affected by cardiovascular disease(CVD) which includes cerebrovascular, coronary heart disease(CHD), peripheral arterial disease (PAD), and abdominal arteries atherosclerosis. The CHD lifetime risk at age 40 was 49 % in males and less in females 32% in the Framingham Heart study [4]. Atherosclerosis is a multifactorial disease with marked individual variability regarding which vessels are affected and the severity of affection. Many cardiovascular risk assessment models have been introduced. These models have provided good discrimination of cardiovascular disease(CVD) risk in high-risk individuals but not in low- and intermediate-risk individuals. For these individuals with unidentified CVD risk, imaging techniques have developed as risk modifiers like carotid Intima Media

Thickness(cIMT), Coronary Artery Calcium score(CAC), Ankle--Brachial Index(ABI) and flow mediated dilation(FMD) [5].

Winsor first introduced the ankle-brachial index(ABI) in 1950 as the number given by dividing the systolic blood pressure(SBP) measured at the ankle by the SBP measured at the arm [6]**.** There is an association between peripheral artery disease(PAD) and coronary artery disease(CAD) as they are mainly caused by atherosclerosis, so they share similar risk factor profiles. Many studies have identified a PAD correlation with increased cardiovascular events. The ABI is used to diagnose PAD with around 90% sensitivity and specificity compared to gold standard invasive angiography. The ABI has the advantage of being a noninvasive, inexpensive measurement and could be used as an indirect measure of CAD severity [3].

ABI less than 0.9 is associated with 2-3 folds of increased risk of C.V and total mortality. Also, ABI more than 1.4 is also associated with higher C.V events and mortality **[**7].

European peripheral arterial disease guidelines in 2017 suggested that ABI should be considered for purposes of cardiovascular risk assessment [8]. Recently published European chronic coronary syndrome guidelines in 2019 stated that ABI might be considered as a risk modifier in cardiovascular risk assessment [9].

METHODS

The study was conducted in cardiology department at Zagazig University and Al Agoza specialized hospitals from November 2018 to July 2019. One hundred and sixty cases with chronic stable CAD were included in the current prospective cross-sectional study in whom coronary angiography had been indicated. Written informed consent was obtained from all participants. The study was approved by the research ethical committee of faculty of Medicine, Zagazig University. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Cases with stable CAD undergoing coronary angiography due to one or more of the following criteria were included in this study: uncontrolled symptoms on optimal guideline-directed medical therapy, high risk stress testing, low left ventricular ejection fraction, and equivocal diagnosis to determine the cause. Cases with one or more of the following conditions were excluded from this study: congenital heart disease, valvular heart disease, atrial fibrillation, chronic renal failure on dialysis, severe limb ischemia with ulcerative leg lesions, and high cardiac output state.

All cases were subjected to the following: clinical history taking, physical examination with special stress on CAD risk factors, Blood biochemistry(fasting, postprandial blood glucose, lipid profile, serum creatinine, complete blood count), resting 12 lead ECG analysis for ST, T wave changes indicating ischemia, previous MI, ischemic LBBB, stress ECG in whom resting ECG had non-conclusive, atypical angina pectoris, those with intermediate probability of CAD, Resting transthoracic echocardiography with special stress on LV internal dimensions in end diastole, end systole, presence of LVH, wall motion abnormalities, wall motion score index,

Invasive coronary angiography was performed via a femoral approach according to Judkins technique. We used three common measures for estimating the severity of coronary artery disease.

SYNTAX score calculated using an online SYNTAX calculator (http://www.syntaxscore.com) [10],

Gensini score is a scoring system used to assess the severity of the coronary disease in angiography with a numerical value for the degree of stenosis in a coronary artery. For each lesion detected in coronary angiography, there is a number that correlates to the degree of stenosis and another number for the site of the lesion known as weight factor as weight of myocardium at risk then these two numbers is multiplied by each other to get score for one lesion. The Gensini score is the sum of all lesions scores as below. The number represents the degree of coronary artery lumenal stenosis (1 for 1% to 25% stenosis, 2 for 26% to 50% stenosis, 4 for 51% to 75% stenosis, 8 for 76% to 90% stenosis, 16 for 91% to 99% stenosis, and 32 for total occlusion).These numbers had then multiplied by a weight factor which is a number that resembles the site of the lesion's in the coronary arterial tree (5 for the left main coronary artery, 2.5 for the proximal left anterior descending coronary artery, proximal left circumflex coronary artery (3.5 if left circumflex coronary artery had dominant),1.5 for the mid region of the left anterior descending coronary artery, 1 for the distal left anterior descending coronary artery, the first diagonal, the proximal, mid region, distal region of the right coronary artery, the posterior descending, the mid region, distal region of the left circumflex coronary artery(2 for both of them if left circumflex coronary artery had dominant), the obtuse margin, 0.5 for the second diagonal, the posterolateral branch) . The Gensini score is the sum of scores for all lesions [11]. The Gensini score formula: Gensini score = $\sum$ (points for each segment x weighing factor*)* [11].

The number of diseased vessels was defined by coronary angiography as one of the following: single vessel disease, two vessels disease and three or multiple vessel disease.

A handheld Doppler device (bistos BT-200V) and a fingertip pulse oximeter (ConTec CMS50D) were used to calculate the ankle brachial index. All patients had been examined supine following ten minutes of rest. All measurements were done by an unblinded single examiner.

ABI by Doppler method (ABI D)*:* Brachial blood pressure has been measured using 8 MHz continuous wave Doppler probe and sphygmomanometer with cuff around the upper arm and it's lower edge one inch above the antecubital fossa. After palpating the brachial artery, layer of ultrasonographic gel was applied then the Doppler probe had positioned over it. When a good audible signal had been obtained, the pressure cuff was inflated until the signal had disappeared, then slow deflation of the cuff, When the signal reappeared this was considered the systolic pressure. The two brachial arteries have been measured and the highest pressure was used in calculations of the ABI. Ankle blood pressures had been measured by pressure cuff placed above ankle and the Doppler probe placed over the posterior tibial and measured the SBP then the Doppler probe is placed over the dorsalis pedis arteries and do the same then greater of the two had been used to calculate the ABI for one leg then did the same to the other leg [12]. In PAD assessment, each leg has its own ABI but as for cardiovascular risk stratification, the lower ABI of both legs is used. [8]. ABI by photoplethysmograpgy method (ABI P)*:* ABI P was measured using a sphygmomanometer and a pulse oximeter (PO). The PO probes had been placed each time over the nails of index fingers for brachial pressure and the great toes for ankle pressure Then when a good signal waves had been obtained on the pulse oximeter screen (without artifacts, good O2 saturation above 96%). The pressure cuffs had been placed around the arm for brachial pressure and just above the ankle for ankle pressure. Then pressure cuff had been inflated until the signal disappeared. Then gradual deflation of the cuff till the pulse signal waves reappeared on pulse oximeter screen. The systolic blood pressure is the pressure at which the signal waves reappeared. Measurements were done in both legs, both arms and the greater of two brachial was used to calculate ABI for each leg [12]. Then the lower ABI of both legs was used as its recommended to be used in cardiovascular risk stratification [8]

STATISTICAL ANALYSIS

Data collected throughout history, basic clinical examination, laboratory investigations and outcome measures were coded, entered, analyzed using Microsoft Excel software. Data had then been imported into Statistical Package for the Social Sciences (SPSS version 20.0) software for analysis. According to the type of data qualitative represent as number, percentage, quantitative continues group represent by mean± SD, the following tests had been used to test differences for significance, difference, association of qualitative variable by Chi square test(X^2). Differences between quantitative independent groups by t test, multiple by ANOVA, correlation by Pearson's correlation. P value had set at > 0.05 for non-significant results, <0.05 for significant results, <0.01 for high significant results &<0.001 for very high significant result.

RESULTS

The 160 cases had been divided according to SYNTAX into Low SYNTAX score group (≤ 22) comprised 101 cases, intermediate SYNTAX score group (23-32) comprised 35 cases and high SYNTAX score group (≥33) comprised 24 cases. The 160 cases had also been divided according to their ABI D values into abnormal ABI with ABI D (<1) comprised 36 cases and **normal ABI** with ABI D (≥1) comprised 124 cases.

Mean values of age in low, intermediate and high SYNTAX score groups were 56.52±7.9, 54.6±9.6 and 61.33±8.4 years respectively. Statistical analysis showed significant (<0.05) higher age in higher SYNTAX score group compared with other SYNTAX score groups. There were 39 females and 62 males in low SYNTAX score group, 13 females and 22 males in intermediate score group and 8 females and 16 males in high score group. Statistical analysis showed no significant difference regarding gender in-between SYNTAX score groups. Regarding the history of previous MI there were 26 (25.8%) in low SYNTAX score group, 16 (45.8%) in intermediate score group and 16 (66.7%) in high score group. Statistical analysis showed high significant association with higher SYNTAX score (P < 0.001).

The mean values of ABI D in low, intermediate and high SYNTAX score groups were 1.08±0.1, 1.05±0.11 and 0.96±0.15 respectively. Statistical analysis showed a very highly significant(P<0.001) decrease in ABI D in high SYNTAX score group compared to other groups. The mean values of ABI P in low, intermediate and high SYNTAX score groups were 1.06±0.14, 1.04±0.12 and 0.97±0.15 respectively. Statistical analysis showed a very highly significant(P<0.001) decrease in ABI P in high SYNTAX score group compared to other groups (Table 1).

Patients with abnormal ABI D in low, intermediate and high SYNTAX score groups were 12 cases out of 101(11.9%), in 11 cases out of 35(31.4%) and in 13 cases out of 24(54.2%) respectively (table 2). Statistical analysis showed a very highly significant(P<0.001) association of

abnormal ABI D with high SYNTAX score. The sensitivity and specificity of abnormal ABI D for detection of high SYNTAX score were 4.2% and 83.1% respectively (table 2). The mean values SYNTAX score in normal ABI D group and abnormal ABI D groups were 16.14±5.4 and 26.33±8.2 respectively. Statistical analysis showed a very highly significant(P<0.001) increase in SYNTAX score in abnormal ABI D group (figure 1). The mean values of Gensini score in normal ABI D group and abnormal ABI D groups were 50.97±17.9 and 94.04±31.2 respectively. Statistical analysis showed a very highly significant(P<0.001) increase in Gensini score in abnormal ABI D group (table 3).

Multiple vessels disease had been found in 61 cases (49.1%) out of 124 and in 26 cases (72.2%) out of 36 in normal ABI D group and abnormal ABI D group respectively. Statistical analysis showed significant association(P<0.05) with abnormal ABI D group.

LM disease had been found in 23 cases (18.6%) out of 124 and in 11 cases (30.6%) out of 36 in normal ABI D group and abnormal ABI D group respectively. Statistical analysis showed nonsignificant association (P >0.05) with abnormal ABI D group.

There was a highly significant negative correlation between ABI D and both SYNTAX score (r=-0.337, p<0.001, figure 2) and Gensini score (r=-0.378, p<0.001) There was a highly significant negative correlation between ABI P and both SYNTAX score (r=-0.261, p<0.001) and Gensini score (r=-0.274, p<0.001). There was a highly significant positive correlation between ABI D and ABI P (r=0.864 p<0.001) (table 4).

There was highly significant(P<0.001) association and agreement between ABI D and ABI P. The sensitivity, specificity, positive prediction, negative prediction value and accuracy were 94.4%, 99.1%, 97.1%, 98.4% and 98.1% respectively. The mean value of ABI D and ABI P in the whole study population (160 cases) were 1.0577±0.121 and 1.0478±0.145 respectively. Statistical analysis showed no significant (P >0.05) difference between ABI D and ABI P (table 5).

Table (1) : ABI comparative analysis among SYNTAX score groups

	SYNTAX score							
	Low (N=101)	Intermediate (N=35)	High (N=24)	F	P	P1	P2	P3
ABI D (mean±SD)	1.08±0.1	1.05±0.11	0.96±0.15	10.283	<0.001	>0.05	<0.001	<0.001
ABI P (mean±SD)	1.06±0.14	1.04±0.12	0.97±0.15	4.740	<0.01	>0.05	<0.001	<0.001

ABI D ankle brachial index by Doppler, ABI P ankle brachial index by photoplethysmography

Table (2) : Abnormal ABI association with Syntax score

		SYNTAX score			X^2	
		Low	Intermediate	High		
Abnormal ABI	N	12	11	13	22.7	<0.001
	%	11.9%	31.4%	54.2%		
Total	N	101	35	24		
	%	100.0%	100.0%	100.0%		

ABI: ankle brachial index

Table (3): SYNTAX and GENSINI scores comparative analysis in between ABI groups:

	ABI D			
	Normal (N=124)	Abnormal (N=36)	T	P
SYNTAX (mean±SD)	16.14±5.4	26.33±8.2	-4.950	<0.001
GENSINI (mean±SD))	50.97±17.9	94.04±31.2	-5.257	<0.001

Table (4): Correlations coefficient between ABI, SYNTAX score, Gensini score :

		SYNTAX	ABI D	ABI P
ABI D	R	-0.337	1	0.864
	P	<0.001		<0.001
ABI P	R	- 0.261	0.864	1
	P	<0.001	<0.001	
GENSINI	R	0.843	-0.378	-0.274
	P	<0.001	<0.001	<0.001

Table (5): Validity of ABI P vs ABI D

			ABI D		Total	X^2	P	Kappa Agreement
			Normal	Abnormal				
ABI P	Normal	N	123	2	125	144.93	<0.001	0.96
		%	99.1%	5.6%	78.1%			
	Abnormal	N	1	34	35			
		%	0.9%	94.4%	21.9%			
Total		N	124	36	160			
		%	100.0%	100.0%	100.0%			

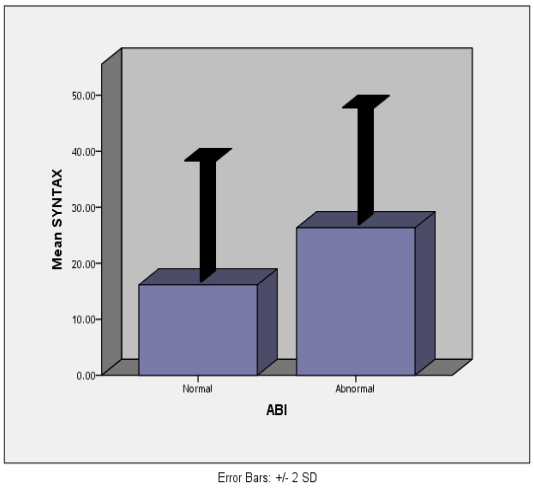

Figure 1: Mean SYNTAX score difference inbetween groups of normal and abnormal ankle brachial index measured by Doppler method (ABI D)

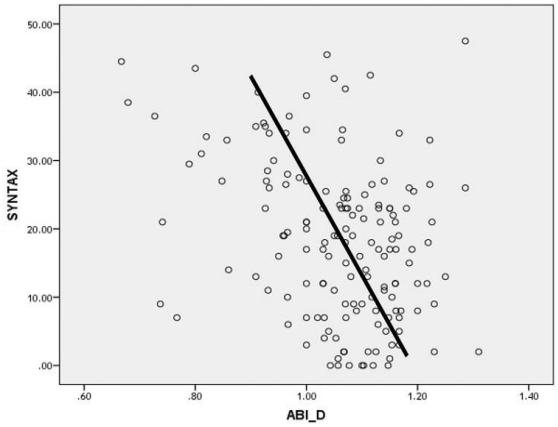

Figure 2: Correlation between SYNTAX score and ABI D (R -0.337, P<0.001)

DISCUSSION

In many studies, an association between peripheral artery disease(PAD) and coronary artery disease(CAD) has been identified. They are mainly caused by atherosclerosis, so they share the same risk factors and pathogenesis. PAD has been identified in many studies to correlate significantly with worse cardiovascular outcomes. The ABI has

been introduced to diagnose PAD with high sensitivity and specificity compared against invasive angiography. Being non-invasive, inexpensive and easy to measure, the ABI could be used as indirect assessment of CAD severity [3].

SYNTAX score is used to risk stratify patients undergoing invasive coronary angiography using objective measurement and also encourages cooperation between surgeons and interventional cardiologists. The SYNTAX score is an independent prediction factor of MACE after PCI [13].In a trial to find out the relation between ABI and the severity of CAD as reflected by SYNTAX score, Gensini score and number of diseased vessels, 160 cases with chronic stable CAD were included in the current study.

We found that advanced age was associated with a higher SYNTAX score while there was a nonsignificant association between sex and grade of SYNTAX score. Although the rate of atherosclerosis varies markedly among individuals, advanced age is usually associated with severe atherosclerosis, calcification, more prevalent myocardial infarction and total coronary artery occlusion, which explains the higher SYNTAX score at higher age.

We found a significant association between a history of myocardial infarction and a higher grade of SYNTAX score. This result could be attributed to a higher rate of coronary artery occlusion, hence the higher SYNTAX score.

In the present study, cases in the group with a high SYNTAX score had an abnormal ABI while those with low and intermediate SYNTAX scores had normal ABI. Moreover, there was a highly significant association between abnormal ABI and a high SYNTAX score. The ABI had a sensitivity of 54% and a specificity of 83% to predict high SYNTAX score.

It has been reported to have a sensitivity of 34%, specificity of 87% of ABI<0.9 in predicting coronary artery involvement [14].

This means that ABI could serve as a prognostic marker for cardiovascular events even in asymptomatic PAD. Other investigators found that ABI less than 0.9 was associated with more doubling of 10 years' morbidity and mortality [15].

Petracco et al. (2017) compared the ABI value with CAD severity using SYNTAX score in 101 cases with ACS, they found that cases with ABI<0.9 showed no association with CAD complexity determined by higher SYNTAX score. However, in their study they chose to take the measure at the left leg only because its measured after cardiac catheterization had done for all cases through right femoral access, Also the SBP had measured manually while in our study hand held Doppler ultrasound probe had been used to measure systolic BP which is more reliable and accurate [16]

Regards to Gensini score, number of diseased vessel and presence of LM disease comparison inbetween SYNTAX score groups, We found a highly significant higher Gensini score in higher grade of Syntax score and a significant association between presence of Multivessel and left main CAD with higher SYNTAX score.

In cases with abnormal ABI, the SYNTAX and Gensini scores tended to be significantly higher than those with normal ABI, reflecting the increased severity and complexity of CAD.

In the present study, multivessel CAD showed a significant association with abnormal ABI while LM disease did not. The lack of a significant relationship between abnormal ABI and LM disease could be explained by the fact that ABI is a physiological parameter rather than an anatomical parameter like SYNTAX score.

In 2016, Tripathi V. et al. studied the relationship between ABI and the severity of CAD. The study included 100 cases of stable CAD in whom angiography had been indicated. There had been a significant correlation between low ABI and the presence of triple vessel disease in comparison to the presence of single or double vessel disease, which had been non-significant. There was a significant correlation between a high SYNTAX score and low ABI, which had a non-significant Correlation with low and intermediate SYNTAX score. So the presence of low ABI signifies the presence of high SYNTAX score, triple vessel disease in cases with stable CAD [17].

Amer M, etal.(2014) investigated the association between ABI and CAD severity in elderly Egyptians using three different measurements. They used SYNTAX score, Jeopardy score and number of diseased vessels for assessment of coronary artery disease severity, which increased significantly in cases with PAD. They found that all the 3 measures had a strong negative correlation with ABI. They concluded that PAD could reflect the severity of CAD [18].

As regards to the validity of ABI P vs ABI D, we validated ABI determined by PPG vs ABI determined by Doppler. We found that ABI by PPG had a highly significant association and agreement with ABI D. The sensitivity, specificity, positive, negative predictive and accuracy were 94.4%, 99.1%, 97.1%, 98.4% and 98.1% respectively.

Moreover, a highly significant positive correlation has been found between ABI D and ABI P. Furthermore, comparison between ABI P and ABI D in the whole study population showed no significant difference.

ABI measured by PPG and hand held Doppler ultrasound probe had been used to assess PAD. ABI D has shown a sensitivity of 95% and specificity of 99% compared to invasive angiography. However, it is relatively time-consuming to find adequate signal by Doppler probe and requires adequate training. There are also other limitations with ABI D in cases with heavy arterial calcification resulting in incompressible arteries in diabetic, renal and older cases, which prevent calculations of ABI, so PPG can be used in these cases to measure the Teo brachial index (TBI) by PPG. PPG offers a new promising method to calculate ABI for the diagnosis of PAD. PPG is a low cost non-invasive, simple to use, fast to perform and based on peripheral pulse waveform analysis, ABI P has shown good sensitivity and specificity for diagnosis of PAD when compared to ABI D. However, this technology in general practice had not been used for this purpose [19]

Correlation coefficient had been done, we found a highly significant positive correlation between ABI D value and left ventricular EF and a highly significant negative correlation between ABI D value and Gensini, SYNTAX scores and higher age. These results go hand in hand with Amer M, et al. (2014) who reported a highly significant correlation between SYNTAX score, number of diseased vessels, as well as Jeopardy score [18].

Limitation of the study:

First, it was a single-center study. Second, the small number of cases with high SYNTAX scores Finally, the inclusion of cases with previous MI causes heterogeneity.

CONCLUSIONS

In cases with CCS, abnormal ABI was associated and correlated with higher Gensini, high SYNTAX scores and multivessel CAD. In cases with CCS, abnormal ABI predicted a high SYNTAX score with a sensitivity of 54% and specificity of 83%. There was a highly significant negative correlation between ABI and both the SYNTAX score and the Gensini score. ABI P showed excellent association, agreement, and positive correlation with the gold standard, ABI D

Conflict of interest: no conflict of interest to be reported.

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SUPPLEMENTARY FILES

Table S1 : Age and sex comparative analysis among SYNTAX score groups :

			SYNTAX score							
			Low (N=101)	Intermediate (N=35)	High (N=24)	F	P	P1	P2	P3
AGE			56.52±7.9	54.6±9.6	61.33±8.4	4.694	<0.05	>0.05	<0.05	<0.05
SEX	Female	N	39	13	8	0.66	>0.05			
		%	38.7%	37.1%	33.4%					
Total		N	101	35	24					
		%	100.0%	100.0%	100.0%					

P1 : low vs intermediate P2 : low vs high P3 : intermediate vs high

Table S2: CAD Risk factors comparative analysis among SYNTAX score groups:

		SYNTAX score			X2	P	P1	P2	P3
		Low	Intermediate	High					
Obesity	N	81	32	21	1.39	>0.05			
	%	80.2%	91.4%	87.5%					
DM	N	51	21	16	1.79	>0.05			
	%	50.5%	60.0%	66.7%					
HTN	N	56	21	17	1.38	>0.05			
	%	55.5%	60.0%	70.8%					
DYSLP	N	95	35	23	1.33	>0.05			
	%	94.1%	100.0%	95.8%					
Smoke	N	25	13	9	2.31	>0.05			
	%	24.8%	37.1%	37.5%					
Hx MI	N	26	16	16	14.1	<0.001	<0.05	<0.001	<0.05
	%	25.8%	45.8%	66.7%					
Total	N	101	35	24					
	%	100.0%	100.0%	100.0%					

CAD coronary artery disease, DM diabetes mellitus, HTN systemic hypertension, DYSLP dyslipidemia, HX MI history of myocardial infarction

P1: low vs intermediate P2: low vs high P3: intermediate vs high

Table S3 : ABI , ECHO and GENSINI score comparative analysis among SYNTAX score groups :

	SYNTAX score							
	Low (N=101)	Intermediate (N=35)	High (N=24)	F	P	P1	P2	P3
ABI D	1.08±0.1	1.05±0.11	0.96±0.15	10.283	<0.001	>0.05	<0.001	<0.001
ABI P	1.06±0.14	1.04±0.12	0.97±0.15	4.740	<0.01	>0.05	<0.001	<0.001
LVIDd mm	52.23±5.8	54.02±6.83	55.16±8.28	2.414	>0.05			
LVIDs mm	35.19±7.5	38.14±8.52	40.45±9.3	4.879	<0.01	<0.05	<0.05	>0.05

	SYNTAX score							
EF %	58.93±9.97	55.34±14.4	52.16±11.2	3.988	<0.05	<0.05	<0.05	<0.05
GENSINI	35.69±11.8	85.37±24.5	127.14±38.7	95.968	<0.001	<0.00 1	<0.001	<0.001

LVIDd left ventricular internal diameter diastole, LVIDs left ventricular internal diameter systole, EF % left ventricular ejection fraction
P1: low vs intermediate P2: low vs high P3: intermediate vs high

Table S4 : Abnormal ABI association with Syntax score

		SYNTAX score			X2	P
		Low	Intermediate	High		
Abnormal ABI	N	12	11	13	22.7	<0.001
	%	11.9%	31.4%	54.2%		
Total	N	101	35	24		
	%	100.0%	100.0%	100.0%		

Table S5 : ECG changes , LVH and diseased vessels affected association with Syntax score:

			SYNTAX score			X2	P	P1	P2	P3
			Low	Intermedi ate	High					
ECG		N	68	29	23	8.07	<0.05	<0.05	<0.001	>0.05
		%	67.4%	82.9%	95.8%					
LVH		N	31	11	10	0.89	>0.05			
		%	30.7%	31.4%	41.7%					
Dis Vessel	Single	N	38	5	0					
		%	37.6%	14.3%	0.0%					
	Double	N	23	5	2	25.22	<0.001	<0.05	<0.001	<0.001
		%	22.7%	14.3%	8.3%					
	>2	N	40	25	22					
		%	39.6%	71.4%	91.7%					
LM		N	10	8	16	35.88	<0.001	<0.001	<0.001	<0.001
		%	9.99%	22.9%	66.7%					
Total		N	101	35	24					
		%	100.0%	100.0%	100.0%					

ECG electrocardiography , LVH left ventricular hypertrophy ,
Dis Vessel; diseased vessels number , LM left main disease
P1: low vs intermediate P2: low vs high P3: intermediate vs high

Table S6 : Age and sex comparative analysis inbetween ABI groups:

			ABI D			
			Normal (N=124)	Abnormal (N=36)	t	P
AGE			56.01±8.6	59.87±8.18	-2.203	<0.05
SEX	Female	N	38	22		
		%	30.6%	61.2%	10.31	<0.001
Total		N	124	36		
		%	100.0%	100.0%		

Table S7: CAD Risk factors comparative analysis in between ABI groups:

		ABI D		X2	P
		Normal	Abnormal		
OBESITY	N	100	34	2.82	>0.05
	%	80.7%	94.4%		
DM	N	62	26	4.43	<0.05
	%	50.0%	72.2%		
HTN	N	65	29	8.05	<0.05
	%	52.5%	80.6%		
DYSLP	N	117	36	0.91	>0.05
	%	94.4%	100.0%		
Smoke	N	40	7	2.53	>0.05
	%	32.3%	19.4%		
Hx MI	N	39	19	5.16	<0.05
	%	31.5%	52.8%		
Total	N	124	36		
	%	100.0%	100.0%		

CAD coronary artery disease, DM diabetes mellitus, HTN systemic hypertension, DYSLP dyslipidemia, HX MI history of myocardial infarction

Table S8 : ECHO, SYNTAX and GENSINI scores comparative analysis inbetween ABI groups:

	ABI D			
	Normal (N=124)	Abnormal (N=36)	T	P
LVIDd mm	52.61±6.3	54.66±7.11	-1.650	>0.05
LVIDs mm	35.83±7.9	39.44±8.7	-2.339	<0.05
EF %	58.62±10.3	51.97±13.8	3.122	<0.05
SYNTAX	16.14±5.4	26.33±8.2	-4.950	<0.001
GENSINI	50.97±17.9	94.04±31.2	-5.257	<0.001

LVIDd left ventricular internal diameter diastole , LVIDs left ventricular internal diameter systole , EF % left ventricular ejection fraction

Table S9 : ECG ,LVH and diseased vessels association with ABI :

			ABI D		X2	P
			Normal	Abnormal		
ECG		N	88	32	4.65	<0.05
		%	71.0%	88.9%		
LVH		N	35	17	4.06	<0.05
		%	28.3%	47.2%		
Dis Vessel	Single	N	40	3		
		%	32.2%	8.3%		
	Double	N	23	7	7.47	<0.05
		%	18.5%	19.4%		
	>2	N	61	26		
		%	49.1%	72.2%		
LM		N	23	11	2.1	>0.05
		%	18.6%	30.6%		
Total		N	124	36		
		%	100.0%	100.0%		

LVH left ventricular hypertrophy , Dis Vessel diseased vessels number , LM left main disease

Table S 10 : Validity of ABI P vs ABI D :

			ABI D		Total	X2	P	Kappa agreement
			Normal	Abnormal				
ABI P	Normal	N	123	2	125	144.93	<0.001	0.96
		%	99.1%	5.6%	78.1%			
	Abnormal	N	1	34	35			
		%	0.9%	94.4%	21.9%			
Total		N	124	36	160			
		%	100.0%	100.0%	100.0%			

Table S 11 : Correlations coefficient between ABI , SYNTAX score , Gensini score , EF and age :

		SYNTAX	ABI D	ABI P
ABI_D	R	-0.337	1	0.864
	P	<0.001		<0.001
ABI_P	R	- 0.261	0.864	1
	P	<0.001	<0.001	
AGE	R	0.160	-0.227	-0.242
	P	<0.05	<0.01	<0.01
EF	R	-0.275	0.198	0.179
	P	<0.001	<0.05	<0.05
GENSINI	R	0.843	-0.378	-0.274
	P	<0.001	<0.001	<0.001

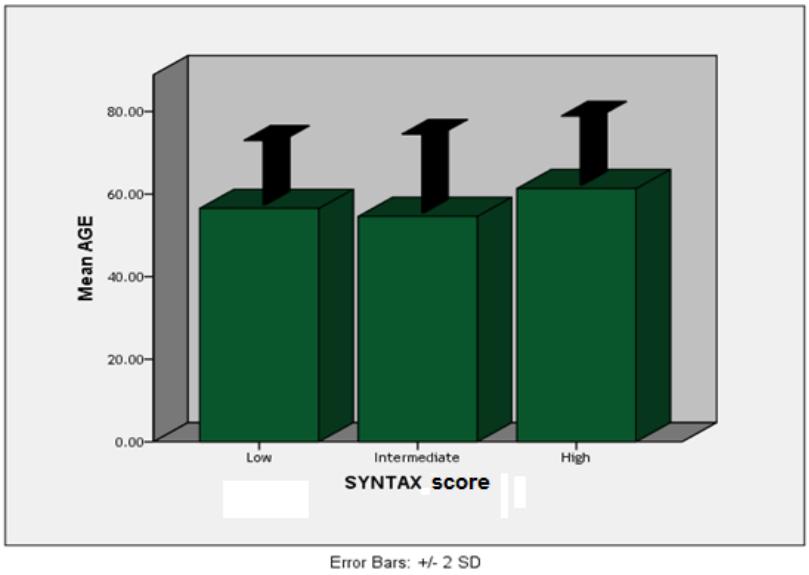

Figure S1 : Age among SYNTAX score groups
P1 : >0.05 P2 : <0.05 P3 : <0.05

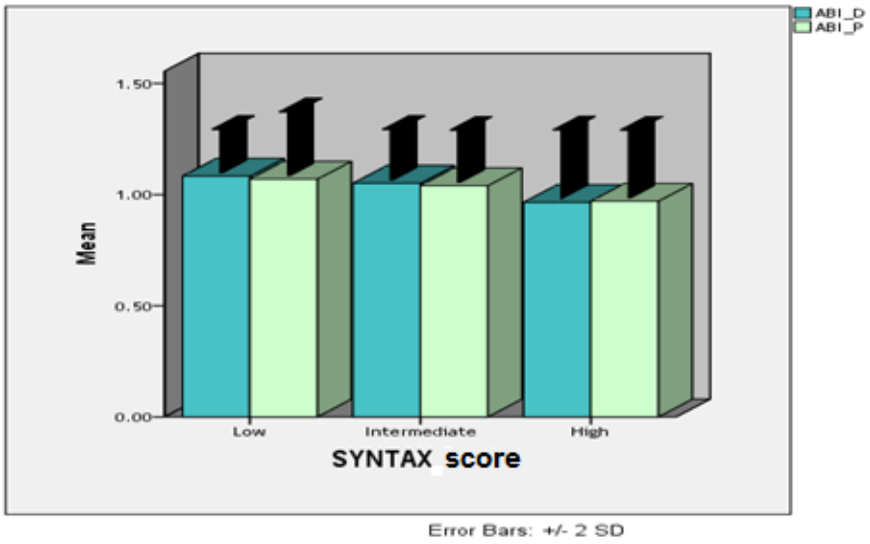

Figure S2: ABI D and ABI P among SYNTAX score groups
P1 : >0.05 P2 : <0.001 P3 : <0.001

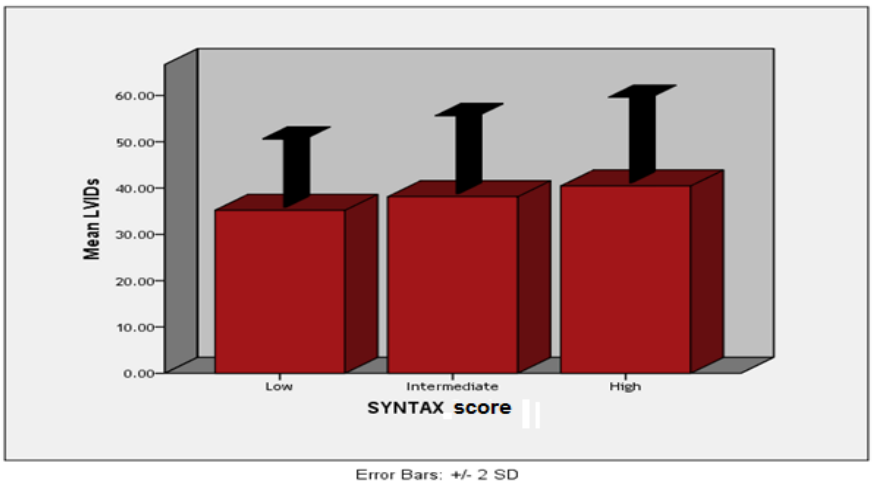

Figure S3 : LVIDs mm among SYNTAX score group
P1 : <0.05 P2 : <0.05 P3 : >0.05

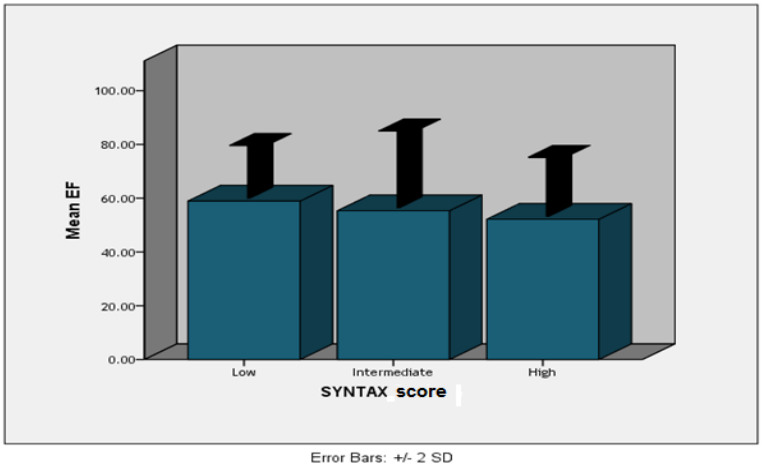

Figure S4 : LV ejection fraction among SYNTAX score groups
P1 : <0.05 P2 : <0.05 P3 : <0.05

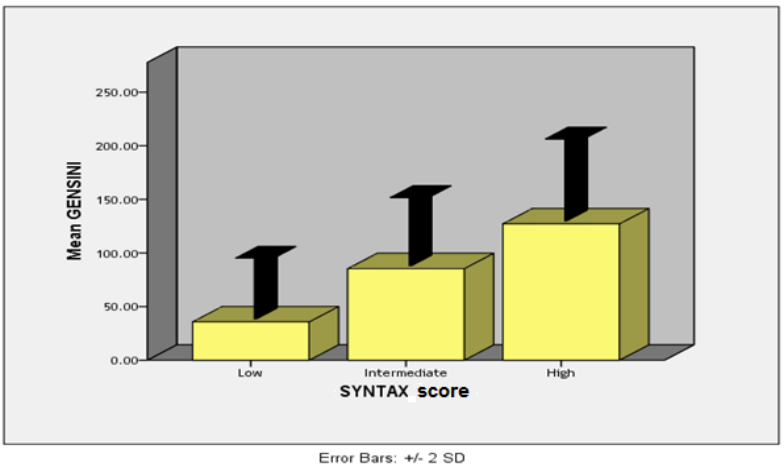

Figure S5 : Gensini score among SYNTAX score groups
P1 : <0.001 P2 : <0.001 P3 : <0.001

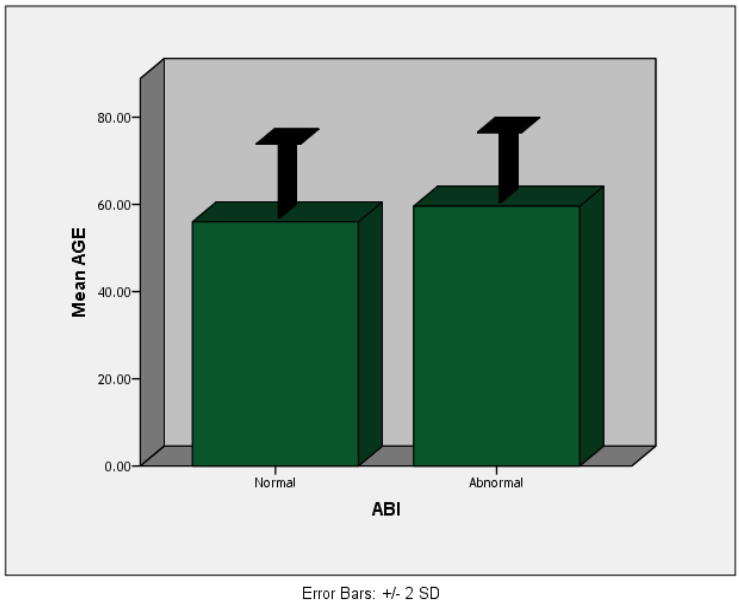

Figure S6 : Age in-between ABI D groups P <0.05

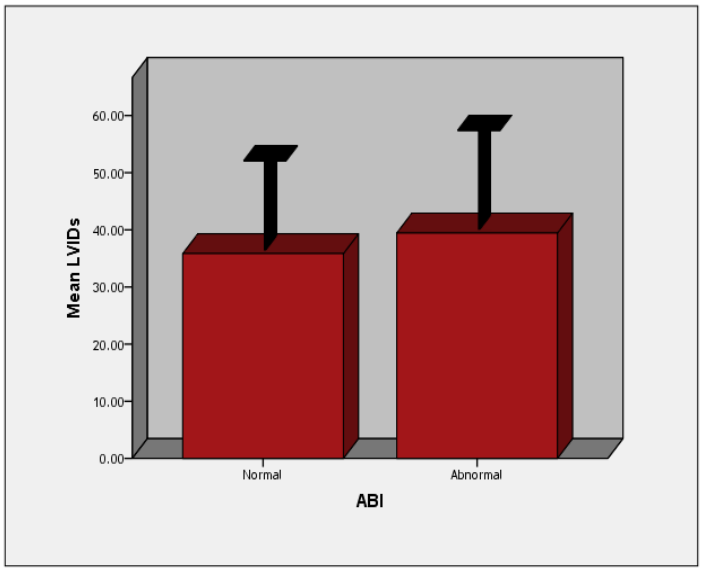

Figure S7: LVIDs in-between ABI D groups P <0.05

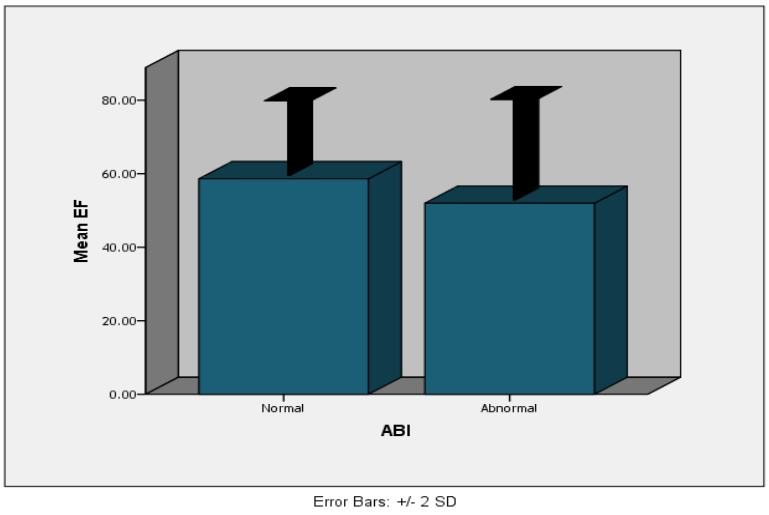

Figure 13 : LV ejection fraction in-between ABI D groups P <0.05

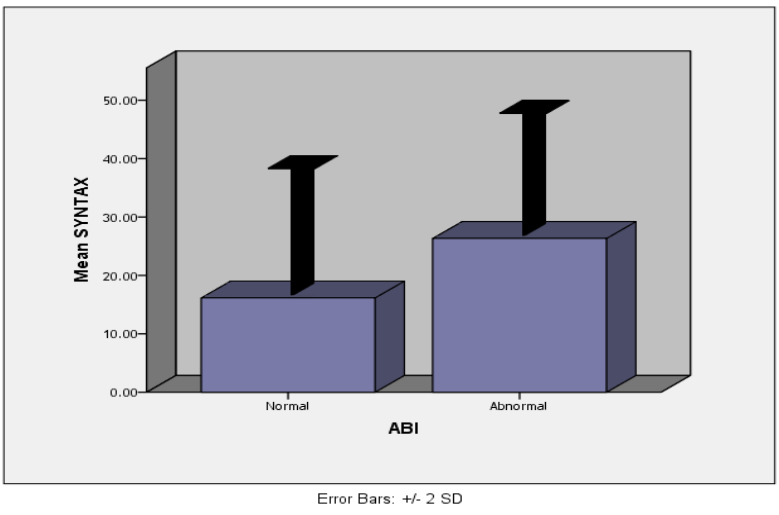

Figure S8: SYNTAX score in-between ABI D groups P <0.001

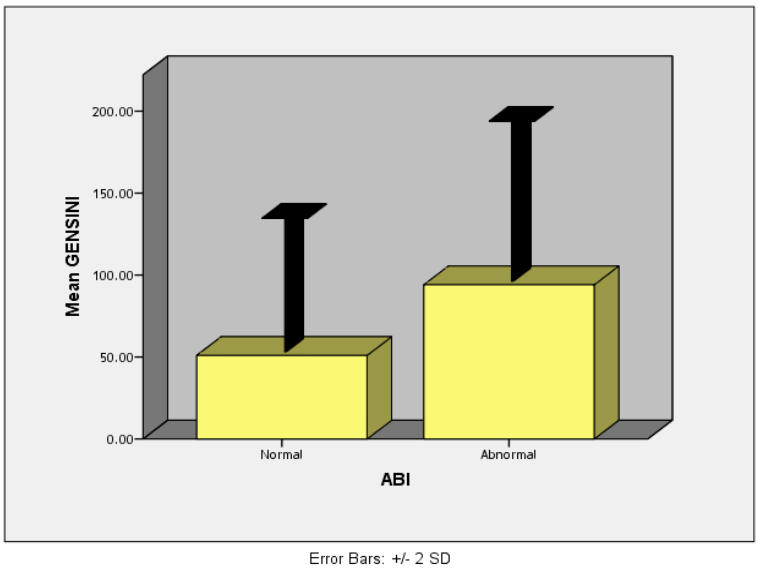

Figure S9: Gensini score in-between ABI D groups P <0.001

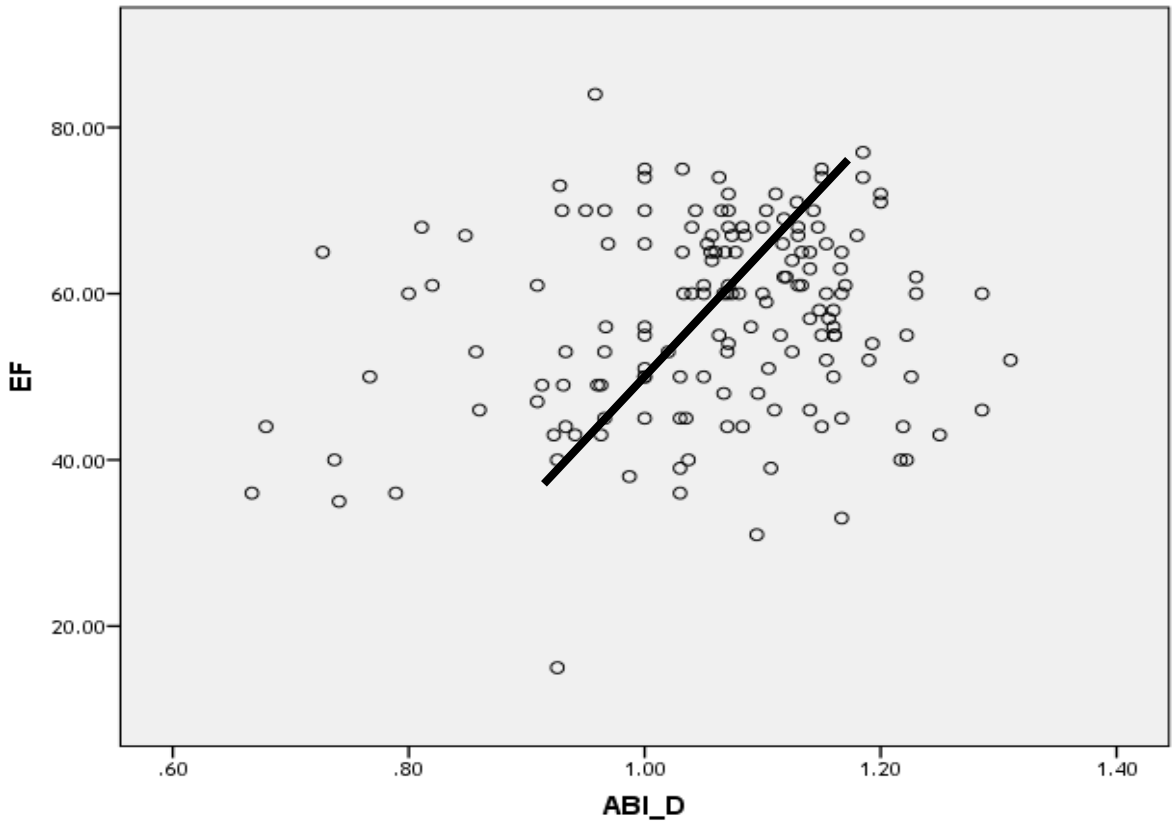

Figure S10: Correlation between LV ejection fraction and ABI D
R 0.198 P <0.05

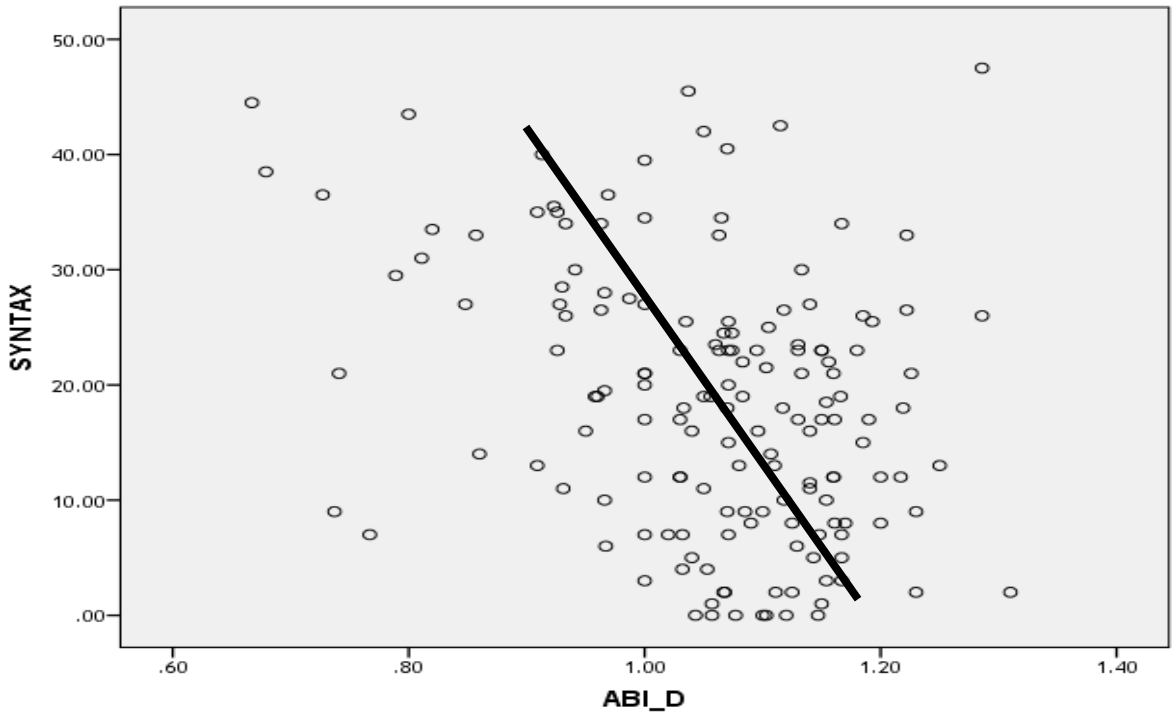

Figure S11: Correlation between SYNTAX score and ABI D
R -0.337 P <0.001

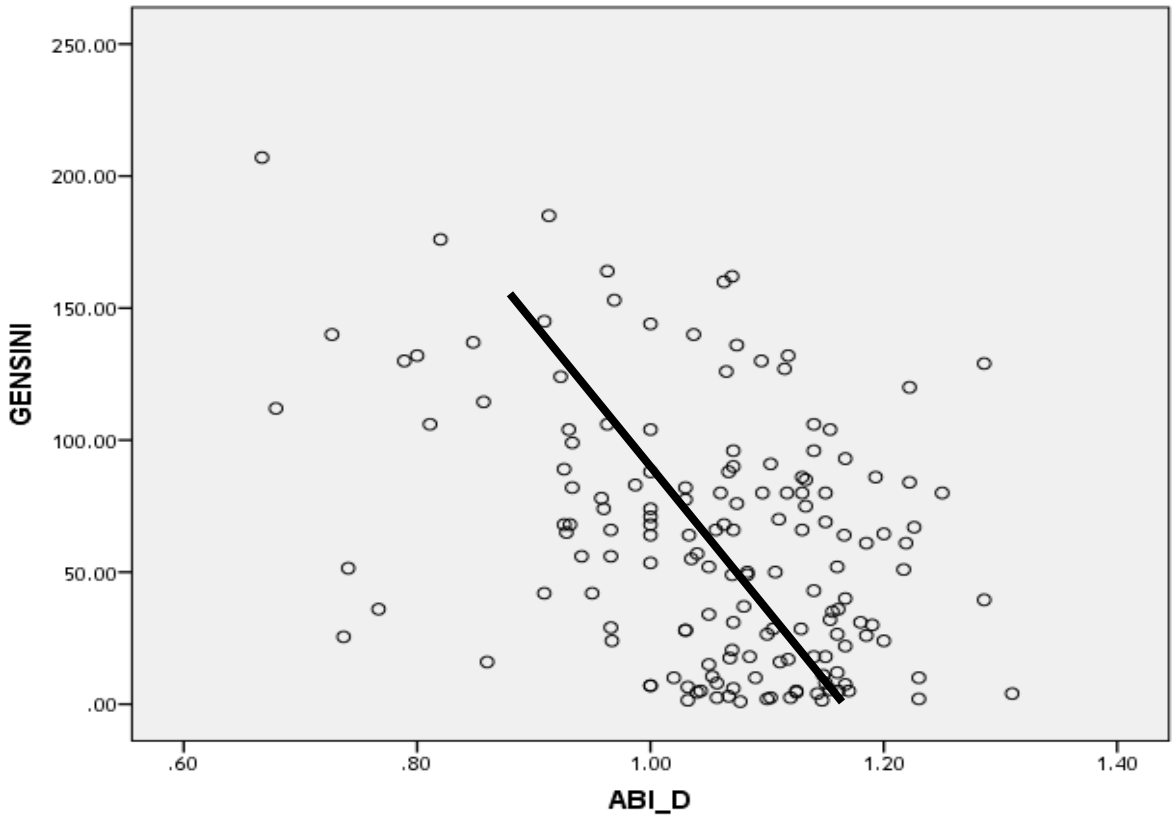

Figure S12: Correlation between Gensini score and ABI D
R - 0.378 P <0.001

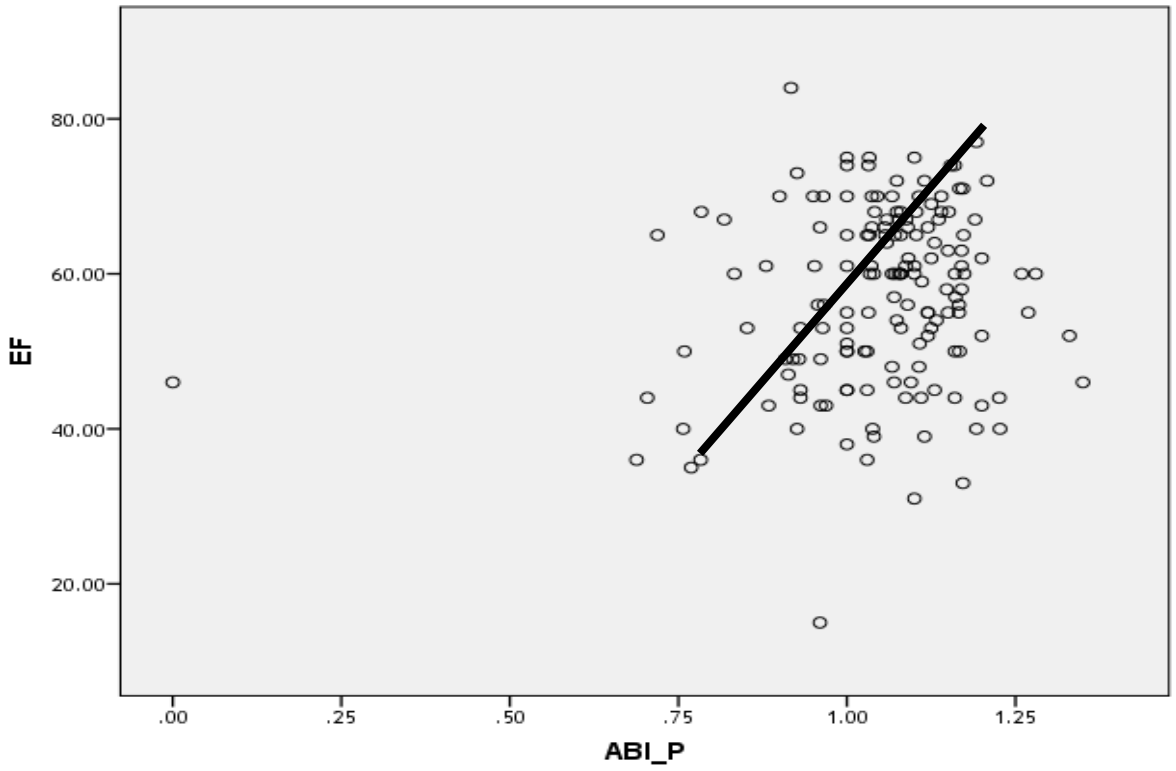

Figure S13 : Correlation between LV ejection fraction and ABI P
R 0.197 P <0.05

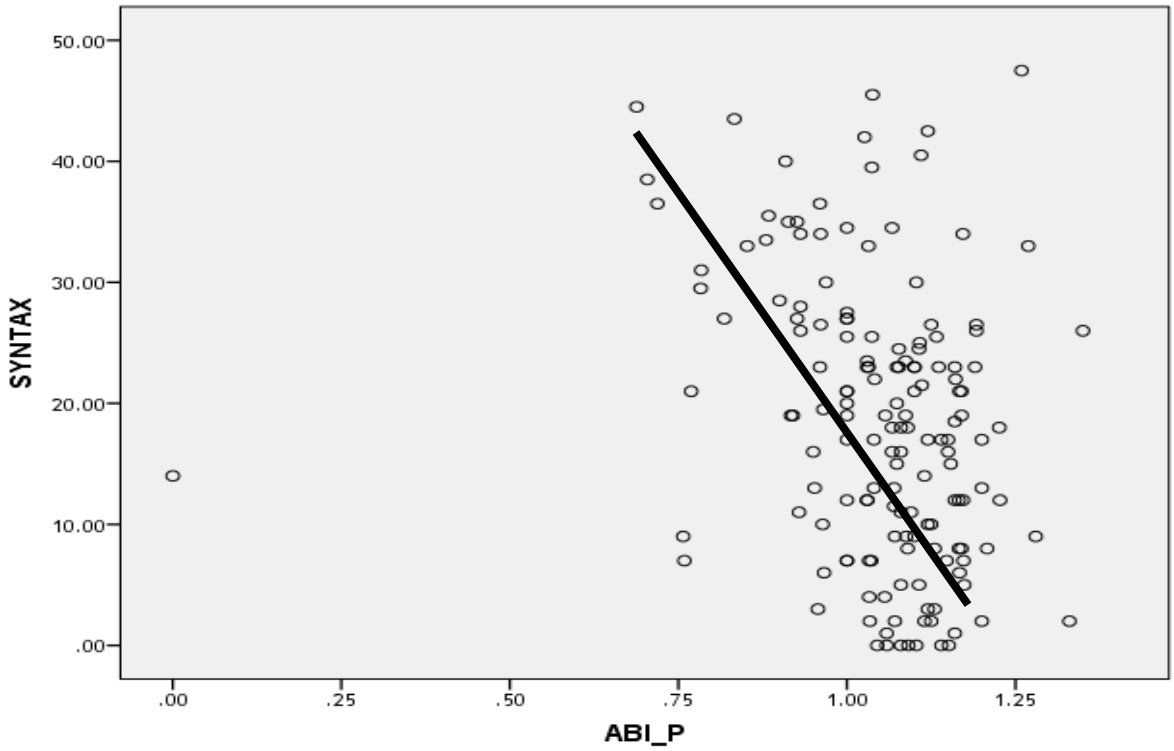

Figure S14: Correlation between SYNTAX score and ABI P
R -0.261 P <0.001

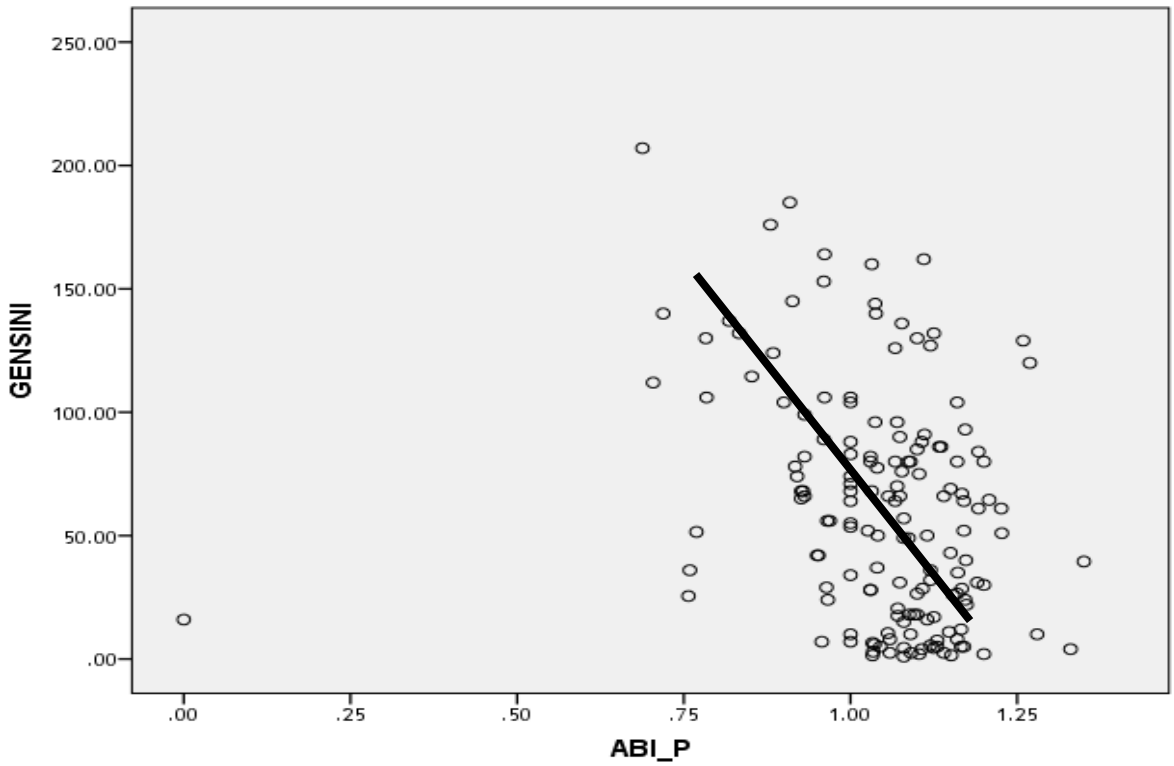

Figure S15: Correlation between Gensini score and ABI P
R - 0.274 P <0.001