Research Article

The Relationship between the Ankle-Brachial Index and Glycemic Control in Patients with Diabetes Mellitus

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Abstract

Objective: To determine the relationship between the Ankle-Brachial Index (ABI) and glycemic control in patients with type 2 diabetes mellitus. **Materials & Methods:** This descriptive, cross-sectional, correlational study was completed with 175 patients presenting to the internal diseases clinic of an education and research hospital between April and May 2021, consenting to take part, and meeting the inclusion criteria. Age, gender, Body Mass Index (BMI), antidiabetic therapy used, statin and acetylsalicylic acid use, and biochemistry parameters were evaluated. p values<0.05 were regarded as significant. **Results:** The mean age of the patients in this research was 57.91 years ± 9.10 years (min: 23, max: 79), 58.9% were women, and 73.1 had normal ABI scores (0.9-1.4). Significant associations were observed between gender, retinopathy or hypertension and ABI scores. Cholesterol, Low-Density Lipoprotein (LDL), and systolic and diastolic blood pressures were also significantly higher in the group with normal ABI scores (0.9-1.4). Significant weak, negative correlation was determined between patient ABI values and total cholesterol, LDL, and albuminuria values. **Conclusion:** ABI values in the present study were higher among women and patients with retinopathy and hypertension, while no association was observed with glycemic control. Cholesterol, LDL, and systolic and diastolic blood pressure values increased in individuals with normal ABI scores, and total cholesterol, LDL, and albuminuria decreased as ABI increased.

Keywords: Glucose; HbA1c; ABI

Introduction

Atherosclerotic cardiovascular diseases are the principal cause of death in individuals with Diabetes Mellitus (DM), and are also responsible for the majority of public health costs. [1] Peripheral Artery Disease (PAD) is also an important risk factor for lower extremity amputation in patients with advanced stage DM. It also increases the probability of other vascular events (stroke and myocardial infarction) and cardiovascular disease by one-third. [2] Accompanying hypertension, dyslipidemia, and obesity also cause an exponential increase in these complications. [3]

Although risk factors associated with PAD in patients with DM have not been fully identified, the Ankle-Brachial Index (ABI) is a popular method for the early diagnosis of this complication. [4] Due to its low cost, simplicity of application, and non-interventional nature it is useful in identifying asymptomatic patients. [5] ABI values<0.9 have been linked to increased cardiovascular mortality and morbidity. [6] In addition to low values, high ABI (ABİ>1.4) has also been shown be associated with arterial calcification and arteriosclerosis. [7] Epidemiological studies have generally defined ABI values 0.9-1.5 as normal. [7] The American College of Cardiology/American Heart Association (AHA) have particularly recommended risk factor screening for PAD and cardiovascular disease in asymptomatic diabetic patients aged over 50 or diabetic patients younger than 50. [8] In contrast, the American Diabetes Association (ADA) stated in 2018 that the ABI test should only be applied to Type 2 Diabetes Mellitus (T2DM) patients with signs or symptoms of PAD. [2]

In addition, an increase in the prevalence of DM makes it essential for the main risk factors associated with PAD to be re-evaluated, and to establish whether or not the ABI test will be useful in newly diagnosed diabetic patients, irrespective of age or PAD symptoms. The purpose of this study was therefore to determine the percentage of individuals with high ABI values in T2DM patients, to investigate the relationship between ABI values and glucose regulation and complication status, and to investigate whether metabolic data differ between groups with normal and high ABI values.

Materials and Methods

One hundred eighty-three patients with T2DM presenting to the internal diseases clinic of an education and research hospital

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in Turkey between April and May 2021 were included in this descriptive, cross-sectional, correlational study. The research was concluded with 175 patients (72 men, 103 women, mean age 57.91years ± 9.10 years, range 23years 79 years) meeting the inclusion criteria and agreeing to participate. The participation rate in the study was 95.6%.

Participants underwent a detailed physical examination, and duration of diabetes, smoking status, oral antidiabetic or insulin use, and history of coronary artery disease were recorded.

ABI was defined as the ratio of the highest systolic blood pressure in the ankle to the highest systolic blood pressure in the arm. Ankle systolic blood pressure was measured from the posterior tibial artery using a hand-held Doppler device. ABI values were calculated by dividing the highest ankle systolic blood pressure by the highest brachial systolic blood pressure. [9]

Patients were also referred to the ophthalmology clinic for fundus examination by a specialist ophthalmologist. The presence of retinopathy was recorded as a result of that examination. Patients were also referred to a neurologist for neuropathy evaluation, and the presence of neuropathy was recorded accordingly. Histories of coronary artery and cerebrovascular disease were also noted. Fasting plasma glucose, total cholesterol, triglycerides, High-Density Lipoprotein (HDL) cholesterol, Low-Density Lipoprotein (LDL) cholesterol, and Hemoglobin A1c (HbA1c) were measured after approximately 18 hours fasting. Twenty-four-hour urine was collected for albuminuria investigation. Glomerular Filtration Rate (GFR) and creatinine levels were calculated using the Modification of Diet in Renal Disease (MDRD) method for age and gender.

Statistical analysis

Statistical analyses were performed on Statistical Package for Social Sciences for Windows version 23.0 software, in addition to descriptive statistical methods (mean, standard deviation, median, frequency, and ratio), the Mann Whitney U test and Spearman correlation analysis were applied in the analysis of non-normally distributed data. The results were assessed at a 95% confidence interval, with p values<0.05 being regarded as statistically significant.

Ethical approval

Approval for the study was granted by the Bakırköy Education and Research Hospital local ethical committee (No. 2021/97), and written informed consent was obtained from all patients. The study was conducted in compliance with the principles of the Declaration of Helsinki.

Results

The mean age of the patients in this research was 57.91 ± 9.10 years (min: 23, max: 79), 58.9% were women, and 73.1% had normal ABI scores (0.9-1.4). No significant difference was observed between the normal ABI score (0.9-1.4) and high ABI score (>1.4) groups in terms of age, smoking status, diabetes treatment, statin and ASA use, albuminuria, or presence of coronary artery disease (p>0.05). However, significant differences were observed between ABI score groups in terms of gender, and presence of retinopathy and hypertension (p<0.005) [Table 1].

No significant differences were observed between ABI scores and glucose, HbA1c, triglyceride, HDL, GFR, creatinine,

Table 1: A comparison of patients' demographic and clinical characteristics between ABI groups.

Characteristics	Ankle-brachial index		
	Normal (0.9-1.4)	High (>1.4)	p
Age (years) mean ± SD	57.91 ± 9.10	55.47 ± 8.44	0.119
Gender			
Female	85(82.5)	18(17.5)	0.001
Male	43(59.7)	29(40.3)	
Smoking status			
Never smoked	88(75.9)	28(24.1)	0.52
Quit	10(66.7)	5(33.3)	
Active smoker	30(68.2)	14(31.8)	
Diabetes treatment			
OAD	69(67)	34(33)	0.087
OAD+Insulin	34(81)	8(19)	
Insulin	25(83.3)	5(16.7)	
Statin use			
Used	78(74.3)	27(25.7)	0.676
Not used	50(71.4)	20(28.6)	
ASA use			
Used	42(77.8)	12(22.2)	0.355
Not used	86(71.1)	35(28.9)	
Albuminuria			
Present	64(79)	17(21)	0.104
Not present	64(68.1)	30(31.9)	
Retinopathy			
Present	35(85.4)	6(14.6)	0.044
Not present	93(69.4)	41(30.6)	

Coronary artery disease			
Present	27(75)	9(25)	0.778
Not present	101(72.7)	38(27.3)	
Neuropathy			
Present	60(75)	20(25)	0.611
Not present	68(71.6)	27(28.4)	
Hypertension			
Present	104(77)	31(23)	0.033
Not present	24(60)	16(40)	

Table 2: A comparison of patients' metabolic data between the ankle-brachial index groups.

	Ankle-brachial index						
Characteristic	**Normal (0.9-1.4)**			**High (>14)**			**p**
	Mean ± SD	**Median**	**Min-Max**	**Mean±SD**	**Median**	**Min-Max**	
Glucose	170.95 ± 63.89	151	81-378	165.70 ± 79.11	137	78-467	0.128
Hemoglobin A1c (%)	7.87 ± 1.79	7.33	5.10-14.80	7.72 ± 2.08	7.02	5.16-13.19	0.231
Total cholesterol	206.52 ± 51.18	209	85-384	189.00 ± 53.99	182	81-324	0.014
Triglyceride (mg/dL)	192,45 ± 116,38	162	21-888	181,57 ± 132,3	144	31-741	0.167
HDL(mg/dL)	46.24 ± 12.55	44	25-100	44.98 ± 12.07	42	28-86	0.529
LDL(mg/dL)	122.91 ± 41.07	122	40-270	109.64 ± 40.45	106	28-204	0.036
GFR	87.00 ± 21.65	88.9	34-168	90.94 ± 17.38	91.2	64-144	0.46
Creatinine	0.80 ± 0.19	0.76	0.49-1.50	0.810 ± 0.153	0.82	0.55-1.21	0.462
Albuminuria	347.19 ± 609.1	145	5.79-400	271.84 ± 760.6	120	29-500	0.018
Systolic blood pressure	149.24 ± 21.67	133	100-220	127.09 ± 17.56	127	89-153	<0.001
Diastolic blood pressure	88.17 ± 15.44	87.5	60-140	80.26 ± 10.03	80	57-100	0.002
Duration of diabetes mellitus (months)	99.80 ± 53.73	96	12-240	81.79 ± 31.46	72	24-156	0.071

Table 3: Correlations between ankle-brachial index and metabolic data.

	Ankle-brachial index	
Characteristic	**r**	**p**
Glucose	-0.115	0.128
Hemoglobin A1c (%)	-0.091	0.232
Total cholesterol	-0.186	0.014
Triglyceride (mg/dL)	-0.105	0.168
HDL (mg/dL)	-0.048	0.53
LDL (mg/dL)	-0.159	0.035
GFR	0.056	0.462
Creatinine	0.056	0.463
Albuminuria	-0.18	0.017

albuminuria, or duration of diabetes mellitus (p>0.05). However, cholesterol, LDL, and systolic and diastolic blood pressure were significantly higher in the normal ABI score group (p<0.05) [Table 2].

Weak, significant negative correlation was found between ABI values and total cholesterol, LDL, and albuminuria values (p=0.014 r=-0186; p=0.035, r=-0.15; and p=0.017, r=-0.180, respectively) [Table 3].

Discussion

The first studies involving ABI described a value <0.90 as a significant early marker of mortality, particularly for cardiac patients. However, subsequent studies suggested that ABI >1.40 and ABI <0.90 possessed similar power in terms of mortality rates.

The results of the present study showed that approximately one in four patients had high ABI values. Resnick et al. identified almost twice as many individuals with high ABI compared to the low value category, suggesting that individuals with high ABI are not uncommon, and that the effect on health of high ABI may be greater than that of low ABI. High ABI may be particularly significant in populations with a high prevalence of diabetes, such as the elderly. [7] An increase in atherosclerosis occurs with aging, leading to arterial stiffness, which tends to increase ABI values in diabetes-related PAD. [10]

Glucose and HbA1c values were higher in the normal ABI group (0.9-1.4) compared to the high ABI group (>1.4). We attributed this to individuals having better diabetes regulation in the recent past compared to the more distant past. Dziemidok et al. investigated 175 patients with type 2 diabetes and found high ABI in 37%. [11] HbA1c values in the present study were 8.25% in the low ABI group and 8.01% in the high ABI group, but were higher, at 8.35%, in the normal ABI group (p<0.005). High blood glucose values are also known to be associated with micro and macro vascular complications, together with atherosclerosis. [12,13]

No association was determined in the present study between ABI values and HbA1c or plasma fasting glucose. Another study reported no association between ABI and HbA1c values in individuals with type 2 diabetes, while a positive relationship was determined between ABI and fasting plasma glucose and white blood cell count. [14]

Makhdoomi et al. classified ABI values into three groups, <0.9, 0.9-1.4, and >1.4, and reported micro albuminuria rates of 72.8% in the high ABI group, 57.1% in the low ABI group, and 17.1% in the normal ABI group (p<0.001). Not only low ABI values, but also high values are therefore significant in the follow-up of patients with diabetes. [15]

Higher ABI values in this study were observed in women, and in individuals with retinopathy and hypertension. Significant associations were determined in the high ABI group between ABI and Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP). Escobedo et al. reported that low ABI values in men were significantly associated with SBP and DBP, although low ABI in women was significantly associated only with SBP. [16-19] However, Bozkurt et al. observed no statistically significant difference between men and women in terms of ABI. [20] No statistically significant relationships were detected between ABI values and glucose, HbA1c, triglyceride, HDL, GFR, creatinine, albuminuria, or duration of diabetes mellitus. Significant weak, negative correlation was determined between ABI values and total cholesterol, LDL-cholesterol, and albuminuria values. We attributed this to some patients using lipid-lowering drugs. In another study from Brazil, Monteiro et al. determined no significant difference in total cholesterol levels between PAD and non-PAD groups. [17-19] However, HDL cholesterol levels in this study were lower in patients in the low ABI group compared to the normal ABI group.

In conclusion, HbA1c values were lower in the high ABI group. No relationship was determined between ABI values and recently established glycemic control. High ABI values, in addition to low values associated with vascular rigidity, are also important for diabetic patients. ABI is a more valuable tool for the early detection of PAD that blood sugar levels since it requires no specific laboratory or additional test and can be easily applied even at the primary health service level. [20]

The principal limitations of this study are that it involved a single type of diagnosis and was conducted in a single center.

Conclusion

ABI values were higher in women and in individuals with retinopathy and hypertension in this study, while no relationship was observed with glycemic control. Cholesterol, LDL, SBP, and DBP values increased in individuals with normal ABI scores, while total cholesterol, LDL, and albuminuria decreased as ABI increased. Further studies involving larger samples and different biochemical parameters are now needed to increase awareness.

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