Relationship Between Ankle-Brachial Index and Left Ventricle Ejection Fraction in Patients on Hemodialysis

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Introduction. Ankle-brachial index (ABI) is a noninvasive test which employs as a diagnostic marker of atherosclerotic peripheral vascular disease in hemodialysis patients. This study aimed to investigate the association between ABI and left ventricular ejection fraction (LVEF) in patients on hemodialysis.
Materials and Methods. Eighty-six patients with end-stage renal disease undergoing hemodialysis and 100 patients referred for echocardiography without apparent kidney disease were included. Ankle-brachial index was calculated by dividing the highest ankle pressure (the left and right dorsalis pedis and posterior tibial) by the brachial systolic blood pressure on the arm with no arteriovenous fistula. The relationship between ABI and LVEF was investigated.
Results. The hemodialysis patients were older on average than the control group ($P = .004$). The total average of ABI in the hemodialysis group was less than 0.9 in 20 patients (23.3%) and 0.9 to 1.3 in 66 (76.7%). These were 11 (11%) and 89 (89%), respectively, among the controls ($P = .02$). The mean LVEF was 49.7 ± 8.6% in the hemodialysis patients and 53.8 ± 9.5% in the controls ($P = .003$). There was a significant correlation between LVEF and ABI in the hemodialysis patients ($r = 0.06$; $P = .001$), and ABI could predict the LVEF with sensitivity and specificity of 90% and 94.1%, respectively (positive predictive value, 34.6%; negative predictive value, 48.5%).
Conclusions. These findings show that ABI may be applied in predicting the presence of left ventricular systolic dysfunction in hemodialysis patients. Further studies are recommended to confirm this association.

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INTRODUCTION

End-stage renal disease is a life-threatening disease in the world and in our nation, which puts social and economic burden on individuals and the society. Patients with end-stage renal disease require renal replacement therapy, ie, kidney transplantation and dialysis, in order to survive.[1] Cardiovascular disease is one of the major causes of mortality and morbidity in patients undergoing hemodialysis, which is mainly due to increasing risk factors of atherosclerosis. Therefore, it is advisable to identify hemodialysis patients with high cardiovascular risk for employing further prevention and interventional measures.[2] On the other hand, there is growing body of evidence that shows aggravation of atherosclerosis after starting hemodialysis which means that hemodialysis may play a role in acceleration of atherosclerosis.[3]

Ankle-brachial index (ABI) is a simple noninvasive test reflecting the ratio of the ankle systolic blood pressure to the brachial systolic blood pressure. An abnormally low ABI, below 0.9, is a powerful independent marker of cardiovascular risk.[4] Ankle-brachial index is a measuring tool for detecting peripheral vascular disease. Despite close association between left ventricular systolic dysfunction with coronary artery disease,[5] not much data support ABI-attributed structural and functional left ventricular dysfunction. Recently, low ABI values have been associated with left ventricular hypertrophy, which is a known risk factor for left ventricular dysfunction and heart failure[6]; an ABI less than 0.9 is able to detect angiographic-proven peripheral vascular disease with a sensitivity of 95% and a specificity of 100%.

It has been reported that peripheral vascular disease is common in hemodialysis patients (16.5 %) and affects the mortality rate.[7] Ankle-brachial index is normally above 1 because arterial pulse amplitude changes from central aorta to peripheral vasculature which in turn may increase peripheral systolic blood pressure.[8] Left ventricular ejection fraction (LVEF) may affect the reflective feature of arterial wave, and therefore, it has been postulated that ABI can reflect left ventricular systolic function and atherosclerosis, as well.[9] According to the above facts, it can be seen that the determination of cardiac function in hemodialysis patients has an important role in the future management of their disease. The aim of this study was to investigate the association of the ABI with LVEF in patients undergoing hemodialysis.

MATERIALS AND METHODS

Eighty-six patients with end-stage renal disease undergoing maintenance hemodialysis and 100 patients who were referred for echocardiography without apparent kidney disease were included in the study. Hemodialysis patients were recruited from the hemodialysis units of Shahid Madani and Sina Medical and Training Center and the Nephrology Clinic of Emam Reza Medical and Training Center, all affiliated to Tabriz Medical University of Medical Sciences. To determine the sample size, we used the results reported by Rizvi and colleagues,[10] and considering a of 0.05, a power of 80%, and a difference of 5, the sample size of 73 was calculated for each group. We extended the sample sizes t 86 and 100 participants in the hemodialysis and control groups, to ensure collection of complete data in enough number of participants.

We included patients who did not have acute cardiovascular disease, cerebrovascular accident, diabetic foot ulcer, or deep vein thrombosis. From March 2012 to March 2013, all basic information was collected and patients' clinical evaluation and data analysis were carried out. Demographic and clinical data were obtained using patients' records. In the control group, data were obtained during the interview and examination.

Participants were given a supine rest for at least 10 minutes, and then, ankle systolic blood pressure was measured in the arteries of the right and the left dorsalis pedis, as well as the posterior tibial and brachial systolic blood pressure on the arm without arteriovenous fistula, by means of a Hunt Leigh Doppler ultrasonography device (Addison, IL, USA). The ABI was calculated by dividing the highest ankle pressure (the left and right dorsalis pedis and posterior tibial) on brachial systolic blood pressure. Results were categorized as low ABI (less than 0.9 in one leg) and normal ABI (between 0.9 and 1.3 in both legs). All of the participants also underwent transthoracic echocardiographic assay. Echocardiography was performed after hemodialysis session in the patients group. Left ventricular dimensions were measured with M mode images. Left ventricular ejection fraction was measured using both the Eyeball and Simpson methods, and the average value was recorded. An LVEF greater than 50% was considered normal.

Statistical Analysis

The obtained results are expressed as mean ± standard deviation or frequency (percentage). SPSS version 16 statistical software program was used for statistical purposes. Normal distribution of data was evaluated by Kolmogorov-Smirnov test. The *t* test was used for comparison of quantitative variables in independent groups and the chi-square test or the Fisher exact test was used for qualitative variables. Results of logistic regression analysis were used for investigation of the associating factors with low ABI. The Pearson or Spearman correlation coefficient test was used for the evaluation of correlation between quantitative variables. A *P* value of less than .05 was considered significant.

RESULTS

The mean age of the participants was 52.9 ± 15 years (range, 20 to 88 years). The mean age was significantly greater in the hemodialysis patients than that in the control group ($P = .004$). In total, 101 patients (54.3%) were men and 85 (45.7%) were women. A higher percentage of patients were men in the hemodialysis group than the control group ($P = .04$). Demographic data and symptoms of peripheral artery disease are shown in Table 1.

The duration of hemodialysis was less than 1 year in 12 patients (14%) and was 1 year and more in 74 (86%). The mean hemodialysis vintage was 63.1±56.0 months. Two patients (2.3 %) were on hemodialysis once weekly; 35 (40.7%), twice weekly; and in 49 (57%), three times weekly.

The right lower limb pulse was felt with 1+ strength in 41 patients (47.7%) and 2+ strength in 43 (50%) in the hemodialysis group, while it was pulseless in 2 (2.3%). In the control group, the right lower limb pulse was felt with 1+ and 2+ strength, and was felt at all in 27 (27.0%), + 72 (72.0%), and 1 (1.0%), respectively ($P = .01$). The pulse strength for the left lower limb was 1+, 2+, and nil in 41 (47.7%), 42 (48.8%), and 3 (3.5%) patients on hemodialysis, and in 35 (35.0%), 63 (63.0%), and 2 (2.0%) participants in the control group, respectively ($P = .08$). The total average of ABI in the hemodialysis group was less than 0.9 in 20 patients (23.3%) and 0.9 to 1.3 in 66 (76.7%). The total average of ABI in the control group was less than 0.9 in 11 participants (11%) and 0.9 to 1.3 in 89 (89%). The difference between the two groups was significant ($P = .02$).

Echocardiography results are shown in Table 2. The mean LVEF values were compared between the groups by the ABI results (Table 3). As shown, LVEF was distinguishably less than 50% in those with an ABI less than 0.9 ($P = .001$). There was a significant correlation between LVEF and ABI values in the hemodialysis patients ($r = 0.06$; $P = .001$). In this group, ABI could predict the

Table 1. Characteristics of Hemodialysis Patients and Control Participants

Characteristic	Hemodialysis Patients (n = 86)	Control Group (n = 100)	*P*
Mean age, y	56.3 ± 15.1	49.9 ± 14.4	.004
Sex			
Male	53 (61.6)	48 (48.0)	
Female	33 (38.4)	52 (52.0)	.04
Mean body mass index, kg/m^2	24.7 ± 4.5	27.4 ± 5.4	< .001
Smoking habit	16 (18.6)	21 (21.0)	.41
Hypertension	67 (77.9)	41 (41.0)	< .001
Hyperlipidemia	26 (30.2)	31 (31.0)	.51
Ischemic heart disease	16 (18.6)	11 (11.0)	.10
Diabetes mellitus	27 (31.4)	17 (17.0)	.50
Intermittent leg claudication	6 (7.0)	3 (3.0)	.18
Limb hair loss	58 (67.4)	17 (17.0)	< .001
Nail deformity	1 (1.2)	0	.46

Table 2. Echocardiographic findings in Hemodialysis Patients and Control Participants

Parameter	Hemodialysis Patients (n = 86)	Control Group (n = 100)	*P*
Mitral valve regurgitation score			
None	54 (62.7)	62 (62.0)	
1	25 (29.1)	34 (34.0)	
2	6 (7.0)	3 (3.0)	
3	1 (1.2)	1 (1.0)	.59
Aortic valve insufficiency score			
None	76 (88.3)	88 (88.0)	
1	8 (9.3)	11 (11.0)	
2	1 (1.2)	1 (1.0)	
3	1 (1.2)	0	.72
Ejection fraction, %	49.7 ± 8.6 (25 to 60)	53.8 ± 9.5 (15 to 65)	.003

Table 3. Left Ventricular Ejection Fraction by Ankle-brachial Index in Hemodialysis Patients and Control Participants*

Ankle-brachial Index	Left Ventricular Ejection Fraction, %		*P*
	Hemodialysis Patients (n = 86)	Control Group (n = 100)	
< 0.9	42.2 ± 8.9	34.0 ± 11.5	.03
0.9 to 1.3	52.0 ± 7.2	56.2 ± 5.6	< .001

**P* < .001 for comparisons between low and normal ankle-brachial index groups in both participant groups

LVEF with sensitivity and specificity of 90% and 94.1%, respectively (positive predictive value, 34.6%; negative predictive value, 48.5%).

DISCUSSION

Ankle-brachial index is a simple noninvasive test reflecting the ratio of ankle systolic blood pressure to brachial systolic blood pressure. Low value of ABI (< 0.9) is considered as a benchmark for development of peripheral vascular atherosclerosis in patients over 40 years of age.[4] Gelev and colleagues investigated the ABI values in hemodialysis patients who had no symptoms of peripheral vascular disease.[11] The study demonstrated that older age, diabetes mellitus, lower dialysis adequacy, and a higher dose of prescribed calcium carbonate were frequently presented in patients with low ABI levels. Given the prevailing peripheral vascular disease and atherosclerosis in hemodialysis patients, it was recommended in this study that ABI be used as a diagnostic tool for peripheral vascular disease even if the patients were symptom free.[11] Likewise, the mean age of hemodialysis patients in the current study was higher than that of the control group. In our study, the mean of total calcium level of the patients was 8.5 ± 1.04 mg/dL, but unlike the Gelev and colleagues' survey, we did not examine the correlation between prescribed calcium carbonate and ABI values.

Grenon and colleagues concluded in a similar study on hemodialysis patients in 2009 that ABI can employ as a noninvasive diagnostic tool for peripheral vascular disease.[12] The ABI's sensitivity and specificity in the diagnosis of peripheral arterial disease were reported 90% and 95%, respectively.[12] Chen and coworkers demonstrated that ABI could be applied as a predictive measure of mortality in hemodialysis patients and chronic kidney failure.[7] The results of their study indicated that ABI values below 0.9 in hemodialysis patients were associated with increasing cardiovascular mortality rate. The study has re-emphasized that due to the noninvasive nature of detecting ABI in these patients, one could employ this test for screening purposes.[7] These findings are consistent with Gleve and colleagues'[11] and Grenon and colleagues'[12] reports. Another study showed that ABI was an independent predictive factor of kidney function decline and cardiovascular events in patients involved with chronic kidney failure.[13] Results of the recent study showed a dramatic decline in kidney function and cardiovascular events in patients with stages 3 to 5 of chronic kidney disease who had an ABI less than 0.9. Therefore, it was recommended that ABI be applied as an indicator of systemic and lower extremities vascular atherosclerosis.[13] Suominen and coworkers found in their study that ABI increased by 8.4% and peripheral vascular disease developed in 62.2% of these patients.[14] The result of the study by Jabbari and colleagues showed no significant association between ABI and coronary intima-media thickness. This discrepancy between the results of that study and others may be linked to the limited number of investigated patients.[15] In another study by Makhdoomi and coworkers, there were significant correlations between an ABI less than 0.9 and microalbuminuria and also dyslipidemia in patients with type 2 diabetes mellitus that pointed to the correlation between kidney disease and lower ABI.[16]

More than 67% of patients in case group had also lower limb haring lose when compared with control group that was only 17% (*P* < .001). Thatipelli and colleagues[17] investigated 395 patients (mean age of 69.7 years, 40% women) in terms of ABI compared with dobutamine stress echocardiography.[17] Eighty-six percent had abnormal ABI and 68% had abnormal dobutamine stress echocardiography. During a mean follow-up of 5 years, 27.3% of the patients experienced a cardiovascular event, and 39.4% died. In their study, similar to ours, the mean age of hemodialysis patients was greater than the control group. Also, 38.4% of patients were female in our study. In contrast to Thatipelli and colleagues' study,[17] and due to some limitations, we were unable to follow up our patients in terms of developing cardiovascular events and death for 5 years.

Chen and associates examined the relationship between ABI and fistula failure rate in hemodialysis patients in another study in 2009.[18] Their findings showed a significant lower ABI in 111 patients with vascular access failure in comparison with patients with patent vascular access. They concluded that an ABI less than 0.9 is significantly correlated with increased vascular access failure; therefore, screening hemodialysis patients by means of ABI may help to identify a high-risk group for vascular access failure.[18] Ward and colleagues[19] studied 204 patients with symptomatic peripheral vascular disease and observed that an LVEF less than 55% was more common in patients with low ABI in comparison with those with a normal ABI. In this survey, patients with ABI of 0.9 and lower were more likely to have left ventricular dysfunction (26.7%), an LVEF less than 45% (14.2%), aortic stenosis (5%), and diverse clinical findings (36.7%). Of note, it was observed that peripheral arterial disease was an independent prognostic factor for left ventricular dysfunction.[19] In our study, LVEF was significantly lower in hemodialysis patients. Also, the difference between ABI values among the two groups was significant.

CONCLUSIONS

According to the obtained results and the presence of LVEFs less than 50% in patients with low ABI, it can be concluded that ABI may be used as an indicator for development of atherosclerotic peripheral vascular disease and consequently can predict the cardiac systolic functional decline in hemodialysis patients. Further studies are recommended to confirm this association.

CONFLICT OF INTEREST

None declared.

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