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The importance of community screening of asymptomatic elderly for peripheral arterial disease by Doppler ultrasound and ankle-brachial index

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Abstract

Background: Peripheral arterial disease is an atherosclerotic disease characterized by an increase in morbidity and mortality. For these reasons early diagnosis of peripheral arterial disease is important. Ankle-brachial systolic pressure index measurement is frequently used in screening studies. Evaluating waveforms of distal lower extremities with Doppler ultrasound can be used as a screening program and provides more accurate information on peripheral arterial disease. **Aim:** We investigate the prevalence of peripheral arterial disease, compare the efficacy of Doppler ultrasound evaluation of distal lower extremity waveforms and ankle-brachial systolic pressure index measurement in screening programs, and discuss the importance of early diagnosis of asymptomatic cases. **Material and methods:** A total of 457 patients over the age of 65 (between 65 and 94, mean age: 71.4) including 270 males and 187 females were examined with Doppler ultrasound, had ankle-brachial systolic pressure index measurement taken and were screened for peripheral arterial disease. The correlation between Doppler ultrasound findings and ankle-brachial systolic pressure index was examined. **Results:** According to the Doppler ultrasound findings, in the aortoiliac ($r = 0.648$) and femoropopliteal ($r = 0.564$) area, there is a medium level of correlation between severe stenosis and occlusions and a low ankle-brachial systolic pressure index value, and a low level of correlation between such abnormalities in the tibioperoneal region ($r = 0.116$) and a low ankle-brachial systolic pressure index value. Therefore, while the sensitivity of ankle-brachial systolic pressure index increases in proximal stenosis, it decreases in distal stenosis. **Conclusion:** Despite the fact that ankle-brachial systolic pressure index is a diagnostic test commonly used in screening studies, evaluation of distal arteries by means of Doppler ultrasound provides more accurate information in terms of the identification of peripheral arterial disease.

Introduction

The investigation of peripheral arterial disease (PAD) with Doppler ultrasound is an easily accessible, relatively inexpensive and completely noninvasive method compared to other radiological methods. While providing information about the morphology of blood vessels, it also evaluates blood flow. The restrictions of Doppler ultrasound are that the results are dependent on the user, it is difficult to distinguish high grade stenosis from occlusion, evaluate the iliac vascularity in obese cases with intensive abdominal gas and evaluate sequential layout lesions, and it does not allow for vascular lumen imaging of calcified plaques⁽¹⁾.

The ankle-brachial systolic pressure index (ABI) is a simple, noninvasive and effective method for screening asymptomatic patients, diagnosing symptomatic patients, and monitoring follow-up. The highest ankle pressure is compared to the highest arm pressure, and patients with values under 0.9 are diagnosed with PAD⁽²⁾. Based on ABI, the severity of PAD is divided into mild (ABI = 0.7–0.9), moderate (ABI = 0.5–0.69) and severe (ABI < 0.5) cases⁽³⁾. The diagnostic results of ABI may be affected by insufficient compression of the cuff, as the compression capability of the vessel wall will be reduced in diabetes and other diseases that cause diffuse arterial wall calcification, where ABI may be over 0.9⁽⁴⁾. ABI with values over 1.4 indicates that the patient's arteries can be only weakly compressed because of diffuse wall calcification associated with atherosclerosis⁽⁵⁾.

For these reasons, even though ABI is a diagnostic test frequently used in screening studies, evaluation of the flow velocity and waveform in the distal arteries by means of Doppler Ultrasound provides more accurate information in terms of the detection of PAD according to the results of our study.

In this study, we investigate the frequency of PAD by using Doppler ultrasound and ABI measurement in people who are 65 years and older, compare the efficacy of Doppler ultrasound and ABI measurement in screening

programs, and discuss the importance of diagnosing asymptomatic cases in the early period of the disease.

Materials and methods

A total of 457 patients (914 lower extremities), over the age of 65 (between 65 and 94, mean age: 71.4) including 270 males (mean age: 71.52) and 187 females (mean age: 71.29), who had presented to our department for various reasons, were enrolled in this study. 330 of those who were included in the study (72.2%) were 65–74 years old, 119 of them (26.0%) were 75–84 years old, and 8 of them (1.8%) were 85 years old and over. The risk factors of the participants by sex are presented in Tab. 1.

Patients were provided with detailed information about the procedures and they signed written consent forms. The approval of the ethics committee was obtained before the initiation of the study.

After questioning the patients as to whether or not they had pain in their legs as they walked, how many meters after the beginning of the walk the pain started and whether or not they had leg pain during rest, both lower extremities were evaluated in terms of the presence of ulceration that was not cured, and the existence of trophic changes in the legs. Based on the findings, the patients' lower extremities were divided into two groups as asymptomatic and symptomatic with respect to PAD, results reported per extremity.

The ankle-brachial index was calculated by measuring the blood pressure in the ankles and arms. ABI was calculated by comparing the highest ankle pressure on both legs measured on the dorsalis pedis and tibialis posterior arteries to the highest pressure on both arms.

Two radiologists experienced in Doppler ultrasound evaluated the patients' lower extremities. The results were evaluated together by consensus. Duplex ultrasound imaging was carried out with the help of the

Risk factor	Male		Female		All	
	Count	Percentage	Count	Percentage	Count	Percentage
Diabetes	75	27.8%	56	29.9%	131	28.0%
Tobacco	151	55.9%	28	15.0%	179	39.2%
Alcohol	57	21.1%	2	1.1%	59	12.8%
Hyperlipidemia	125	46.3%	114	61.0%	239	52.3%
Coronary artery disease	102	37.8%	58	31.0%	160	35.0%
Hypertension	145	53.7%	136	72.7%	281	61.5%
Cerebral vascular disease	60	22.2%	30	16.0%	90	19.7%
Obesity	157	58.1%	135	72.2%	292	63.9%

Tab. 1. Risk factors and sex distribution of patients

Aplio (Toshiba, Japan) device, using a 7.5 MHz linear transducer and a 3 MHz convex transducer.

With Doppler ultrasound, the flow velocities and waveforms in the distal arteries of the lower extremities (a. dorsalis pedis and a. tibialis posterior) were evaluated. A detailed lower extremity Doppler ultrasound was performed on the patients with detected pathology in the distal artery flows (a monophasic, post-stenotic wave decrease in the flow velocities), and pathologic segments were investigated. For the assessment of the arterial system of the lower extremities, the abdominal aorta and the iliac arteries were imaged using a low-frequency convex probe, while high-frequency linear probes were used in the peripheral parts. Both common and external iliac arteries and common, superficial and deep femoral arteries were imaged in the sagittal and axial planes while the patients were in the supine position. The popliteal arteries were assessed in the supine position, with the knees slightly bent and the lower extremity in external rotation and abduction. The anterior tibial artery was distally followed until the dorsalis pedis artery. The tibioperoneal trunk, posterior tibial artery and the peroneal arteries were followed until the distal aspects as long as they were visible. The flow velocities and waveforms were assessed for arterial stenosis and obstruction using gray-scale, color duplex and spectral analysis criteria. Doppler ultrasound findings of PAD were characterized by a disturbance in the distal waveforms in at least one lower extremity. A detailed lower extremity arterial Doppler ultrasound was performed on the patients with a monophasic flow found in the waveforms in their distal arteries in order to detect pathological segment or segments.

In lower extremity arterial Doppler ultrasound, the arteries have been divided into 3 main areas: the aortoiliac area (infrarenal abdominal aorta, main iliac artery and external iliac artery), the femoropopliteal area (main femoral artery, superficial femoral artery and popliteal artery) and the tibioperoneal area (tibioperoneal trunk, anterior tibial artery, posterior tibial artery and peroneal artery). These anatomical regions have been divided into three groups according to their grey scale,

colored and spectral review findings as group 1 – normal findings, 2 – intimal thickening, wall calcifications and plaques which do not cause a meaningful stenosis in the lumen (under 50%) and 3 – meaningful stenosis in the lumen (over 50%) and total occlusions.

Further examinations (CT/MRI Angio, DSA) and evaluations for endovascular and/or surgical treatment were recommended to the patients with meaningful stenosis detected in their lower extremities with Doppler ultrasound.

Evaluation of the data and statistical analysis

Statistical analysis was performed using PASW 18 (SPSS/IBM, Chicago, IL, ultrasoundA) and the level of significance was established at the 0.05 level (two-sided). Primarily, the descriptive statistics related to the variables were evaluated. The variables were expressed in terms of the mean, minimum and maximum values and standard deviations. These were observed to be supported by cross reference tables and frequency tables. Since the majority of the data related to the variables was categorical, the Chi-square test was employed for the analysis of these variables. This test was performed on two groups of variables comprising dependent and independent variables where we searched for a relationship. Also, the influence of the independent variables on the dependent variables was assessed through logistic regression analysis. In all the tests we used a 95% significance level (α).

In addition, correlations were assessed with Pearson coefficients.

Results

Doppler ultrasound findings of PAD were characterized by a disturbance in only distal waveforms in at least one lower extremity. A monophasic, post-stenotic wave decrease in flow velocities were observed in 57 (12.47%)

Region	Doppler ultrasound	ABI ≥ 0.9	ABI 0.7–0.9	ABI 0.5–0.69	ABI < 0.5
Aortoiliac	Normal	24 (42.1%)	9 (15.8%)	0 (0%)	0 (0%)
	Stenosis below 50%	3 (5.3%)	12 (21.1%)	4 (7.0%)	0 (0%)
	Stenosis over 50%	0 (0%)	3 (5.3%)	1 (1.8%)	1 (1.8%)
Femoropopliteal	Normal	19 (33.3%)	4 (7.0%)	0 (0%)	0 (0%)
	Stenosis below 50%	5 (8.8%)	8 (14.0%)	2 (3.5%)	0 (0%)
	Stenosis over 50%	3 (5.3%)	12 (21.1%)	3 (5.3%)	1 (1.8%)
Tibioperoneal	Normal	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Stenosis below 50%↓	26 (45.6%)	23 (40.4%)	4 (7.0%)	1 (1.8%)
	Stenosis over 50%↑	1 (1.8%)	1 (1.8%)	1 (1.8%)	0 (0%)

Tab. 2. Lower extremity arterial Doppler ultrasound findings and ABI correlation

of 457 patients (47 (17.4%) males, 10 (5.3%) females). 47 (82.5%) of the 57 patients with detected PAD were males, 10 of them (17.5%) were females, and the higher rate of PAD in males was found to be statistically significant ($p < 0.05$). When detailed lower extremity arterial Doppler ultrasound was performed in these 57 patients, 50% or more stenosis or occlusions were observed sonographically in at least one proximal segment of an artery (aortoiliac area or femoropopliteal area in the lower extremity) in 21 (36%) patients. The mean age of those with PAD was found to be higher than those without PAD, and a significant relationship was found between increased age and PAD ($p < 0.05$). In our study, the prevalence of PAD at 65–74 years was $\sim 10.6\%$ and at 75 years and over $\sim 17.3\%$.

ABI of 43 patients (9.4%) who took part in the study was 0.9 and below. In 36 of these patients (7.9%), ABI was consistent with mild PAD of 0.7–0.9, in 6 of them (1.3%) with medium PAD of 0.5–0.6 and in 1 of them (0.2%) severe of less than 0.5. When patients with ABI values of less than 0.9 were evaluated, there were 26 patients (60.4%) of 65–74 years of age, 15 patients (34.9%) of 75–84 years of age, and 2 patients (4.7%) over 85 years of age. 29 (59.1%) of these 43 patients were males with a low ABI value, and 14 of them (40.9%) were females. The frequency of PAD in men was found to be higher.

34 (59.6%) of the 57 patients with monophasic flow detected in the peripheral arteries of at least one lower extremity in Doppler ultrasound were asymptomatic. In 23 of these 34 patients ABI was higher than 0.9 (40.3%). In 16 (69.56%) of these 23 patients (monophasic flow in Doppler ultrasound but ABI over 0.9) there were common calcified atheroma plaques in the wall of popliteal artery and tibialis posterior artery.

23 (40.3%) of the 57 patients with monophasic flow detected in the peripheral arteries in Doppler ultrasound were symptomatic (18 had walking pain, 5 had resting pain in at least one lower extremity).

In each anatomic region (aortoiliac region, femoropopliteal region, tibioperoneal region) ABI findings were compared with those of Doppler ultrasound. Correlation was searched between the Doppler findings and ABI. In the aortoiliac ($r = 0.648$) and femoropopliteal ($r = 0.564$) region, severe stenosis and occlusions were present; there is a medium level of relationship between this and a low ABI value, and a low level of relationship between such abnormalities in the tibioperoneal region ($r = 0.116$) and a low ABI value (Tab. 2). This is thought to be due to the fact that proximal stenosis reduces the lower extremity pressure to a larger extent than distal stenosis.

Discussion

In order to detect asymptomatic atherosclerotic disease, treat possible complications early and reduce

morbidity and mortality of patients, inexpensive, easy to apply methods with high diagnostic value are needed⁽⁶⁾. Among cardiovascular diseases, while PAD had been ignored before because of the asymptomatic patients, its clinical status has changed in recent years. PAD is a manifestation of atherosclerosis characterized by an increase in the morbidity and mortality incidence. There is a strong association between PAD, CAD and cerebrovascular diseases, and the mortality in patients with PAD is 30% in 5 years, and 50% in 10 years⁽⁷⁾, which makes early recognition of PAD important.

In various epidemiological studies, PAD prevalence was found to be 3–10% in the general population, and 15–20% over 70 years of age^(7,8). In the Edinburgh Artery Study, PAD prevalence was researched by performing ABI measurement and a reactive hyperemia test in participants aged 55–74 years. In this study, intermittent claudication was detected in 4.5% of the population; 24.6% of the patients were found to be asymptomatic, and a low ABI value was detected in 9% of them, absence of distal pulse in 8% of them, and abnormal results of the reactive hyperemia test in 7.6% of them⁽⁹⁾. In our study, the PAD prevalence was 9.4–12.47% (according to the ABI rates 9.4%, according to the Doppler ultrasound findings 12.47%) in patients over the age of 65. The average age of those with PAD was found to be higher than those without PAD, and a meaningful relationship was observed between increased age and PAD ($p < 0.05$).

In screening studies, ABI is a frequently used diagnostic test. ABI's 0.9 and lower values are hemodynamically correlated with distinctive arterial stenosis⁽⁷⁾. In our study, in 23 of the 57 people with monophasic flow detected in the lower extremity arteries in Doppler ultrasound, ABI measured over 0.9 (40.3%), and in 34 patients, ABI measured 0.9 or less, supporting the PAD Doppler ultrasound findings. The potential reasons for why the ABI value was over 0.9 in cases with PAD detected in Doppler ultrasound could be the following:

- Instead of accepting that at least one of the distal extremity arteries with monophasic flow detected in Doppler ultrasound was meaningful with respect to PAD, the highest ankle pressure was used for ABI measurement, that is, the pathological segment with a relatively lower pressure was not taken into account,
- ABI was not assessed after exercise. While ABI measurement during rest may be normal, it may not be upon exertion, which is caused by not meeting the metabolic need that increases after exercise especially in symptomatic people due to vascular insufficiency,
- ABI can measure over 0.9 in PAD cases with common wall calcification because of the insufficient compression of the cuff, as compression capability of the vessel wall will decrease in diabetes and other diseases causing diffuse arterial wall calcification. In our study 16 (69.56%) of 23 patients (monophasic flow in Doppler ultrasound but ABI measuring over

0.9) there were common calcified atheroma plaques in the wall of popliteal artery and tibialis posterior artery.

Because of these reasons, and according to the results of our study, even though ABI is a diagnostic test frequently used in screening studies, investigations of lower extremity waveforms by Doppler ultrasound give more accurate information about PAD.

In our study, 34 of the 57 people (59.6%) with PAD according to the Doppler findings were asymptomatic, 18 (31.5%) patients had walking pain, 5 patients (8.7%) had resting pain, and a total of 23 patients (40.3%) were found to be symptomatic.

In general, ABI values are lower in those with aortoiliac occlusive disease compared to those with femoropopliteal and infrapopliteal occlusive disease. The same relationship applies to the cases with arterial occlusion compared to those with arterial stenosis, and to those with multiple hemodynamically significant stenosis compared to those with stenosis at a single anatomic level⁽¹⁰⁾. In our study, severe stenosis and occlusions were also present in the aortoiliac and femoropopliteal region, and there was a medium level of relationship between this and a low ABI value, and a low level of relationship between such abnormalities in the tibioperoneal region and a low ABI value. Therefore, while ABI's sensitivity increases in proximal stenosis, it decreases in stenosis in the distal areas. This might occur because stenosis at the proximal level reduces the lower extremity pressure to a larger extent than stenosis at the distal level.

Low ABI is sensitive in detecting the high risk patient; however, normal ABI does not exclude high risk⁽¹¹⁾. Some studies have reported that an ABI below 0.9 may be indicative of subclinical organ damage that determines the total cardiovascular risk and prognosis^(10,11). In our study, patients were evaluated with Doppler ultrasound in addition to the ABI screening test. Patients with monophasic flow in the distal arteries were also more likely to have accompanying cardiovascular disease than those with abnormal ABI values. It is thought that Doppler ultrasound may be useful in the early detection of atherosclerotic diseases.

The main limitation of our study was the small number of patients compared to the studies in the litera-

ture with larger populations. Also, the patient group only included patients who presented themselves to the hospital. In symptomatic patients angiographic or surgical correlation was not investigated, so there was no standard of reference to confirm the sonographic diagnoses. Still, in spite of these limitations, our study was conducted on a heterogeneous population including both symptomatic and asymptomatic patients and Doppler ultrasound diagnosed PAD with higher accuracy compared to ABI measurement. While the sensitivity of ABI increases in proximal stenosis in the diagnosis of PAD, our study indicates that its sensitivity decreases in distal stenosis. In the PAD cases which are diagnosed with Doppler ultrasound, our study shows a statistically significant relationship between PAD and increased age and male gender. Our study, which shows that Doppler ultrasound is an effective method for detecting PAD in high-risk cases, can be a valuable contribution to the literature on the topic.

Conclusion

Our study has shown that Doppler ultrasound can be used as a screening program for PAD in populations with high risk for atherosclerosis who are over 65 years of age. Screening for PAD and comorbid cases can be performed in a short time with Doppler ultrasound which is available in all radiology clinics. Doppler ultrasound is a sensitive, simple, economical, non-invasive and reproducible method for the evaluation of early atherosclerosis.

Apart from ABI measurement, all examinations are already within the scope of radiology, and radiology clinics are ideal environments for screening for PAD. Even though ABI is a diagnostic test commonly used in screening studies, investigating PAD with Doppler ultrasound provides more accurate information according to the results of our study. Distal flow measurements with Doppler ultrasound may be as valuable as ABI measurement; however, comparative studies in large groups are needed on this issue.

Conflict of interest

The authors declare that there are no financial or other relations that could lead to a conflict of interest.

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