TEHRAN HEART CENTER

Original Article

# Agreement Between ABI (Ankle Brachial Index) and USD (Ultrasound Duplex Scanning) in Symptomatic Peripheral Arterial Disease Patients

Seyed Mahmood Sadr, MD, Seyedeh Mahdieh Namayandeh, MD*, Mansoor Rafiei, MD, Seyed Mostafa Baghaei Poor, MD, Maryam Aflatoonian, MD, Monireh Modares Mosadegh, PhD, Seyed Khalil Foroozannia, MD

*Cardiovascular Research Center, Afshar Hospital, Shahid Sadooghi Medical University, Yazd, Iran.*

Received 15 July 2007; Accepted 10 October 2007



## Abstract

***Background:*** *Atherosclerosis of the peripheral arteries occurs in 12% of individuals at 65 years of age or older. At least 28% of these patients suffer from coronary heart diseases and 10% of them are afflicted with cerebrovascular diseases. To calculate the agreement between two diagnostic tests for peripheral arterial disease (PAD), namely ankle brachial index (ABI) and ultrasound duplex scanning (USD).*

***Methods:*** *Forty symptomatic PAD patients were enrolled in this study, and their demographic characteristics, risk factors, and symptoms as well as their ABI and USD measurements were recorded. On the basis of the symptoms and ABI and USD findings, the patients were divided into four groups and comparisons were made between them so that the associations between the findings could be analyzed.*

***Results:*** *The study population included 32 (80%) men at a mean age of 62.9+12.8 years (26-90). Smoking (75%) and hypertension (100%) were the most common risk factors in the men and women, respectively, followed by diabetes in both genders. Whereas the agreement between ABI and USD findings in the men was significant (Kappa=0.28, P=0.02), it was not significant (Kappa=-0.91, P=0.68) in the women. Additionally, there was a significant correlation between symptoms and ABI findings (Kappa=0.21, P=0.04), while that between symptoms and USD measurements was not significant (Kappa=0.09, P=0.3)*

***Conclusion:*** *The correlation between ABI findings and symptoms, especially in the men, was better than that between ABI findings and USD measurements. ABI could, therefore, be considered an appropriate tool for the initial screening of arterial stenosis and lower extremity circulation.*

*J Teh Univ Heart Ctr 1 (2008) 35-38*

***Keywords:*** *Peripheral arterial disease • Ultrasound Duplex scanning • Intermittent claudication*

## Introduction

Atherosclerosis is the most common cause of the chronic arterial occlusive diseases of the lower limbs. As a reduced blood flow, a spectrum of symptoms occurs that is dependent on the severity of stenosis. Thus, symptoms may range from

*Corresponding Author: ***Mahdieh Namayandeh,*** *Research Manager of Cardiovascular research and clinic center, Afshar Hospital, Jomhoori Blv, Yazd, Iran. 8917945556. Fax: +98 351 5253335. Tel: +98 351 5255011. Email: Mnamayandeh@yahoo.com.*

intermittent claudication to pain at rest.[1] Epidemiologic studies indicate that up to 5% of men and 2.5% of women at 60 years of age or older suffer from intermittent claudication. The prevalence rises by three folds when sensitive tests are applied. At least 10% of patients with lower extremity arterial diseases have cerebrovascular diseases and 28% have coronary diseases. The rate of mortality in patients suffering from peripheral arterial diseases (PAD) with claudication is to three times higher than that in age and sex-matched controls.[1-2] Consequently, PAD is a presentation of disseminated atherosclerosis and it is a systemic disease that involves heart, brain, Kidneys, or intestines.[2] The probability of myocardial infarction in these patients is increased by two to three folds.[1-3]

PAD is diagnosed based on 3 criteria: 1- history of intermittent claudication or pain at rest, 2- circulatory impairment on physical examination, and 3- ankle brachial index (ABI) < 0.9. PAD diagnosis cannot be ruled out based on the absence of one of these criteria.[3] It is noteworthy that intermittent claudication is seen only in 30% of PAD patients. PAD can be diagnosed via invasive and noninvasive tests; the latter include ABI and ultrasound duplex scanning (USD), two sensitive and specific tests reliably employed for the confirmation and follow-up of PAD progression.[2-3]

ABI with 95% sensitivity and 99% specificity is considered a good screening test for PAD[2] that it is known as a predictor of all-cause mortality.[1] ABI, however, is not diagnostic in patients with arterial wall calcification, which is normally the case with diabetes, old age, and renal failure. Furthermore, ABI sometimes fails to detect aortic lesions and iliac stenosis. In these conditions, other noninvasive tests such as USD should be used.

USD shows the severity of stenosis and anatomy of arteries better than ABI does. USD is also utilized for the follow-up of patients after angioplasty or bypass surgery.[1-2] Angiography, a gold standard for the diagnosis of PAD, is preformed only in severe diseases that need invasive treatments in order to illustrate lesion characteristics and arterial anatomy.[4] Although peripheral arterial angiography is a safe method, it has some complications such as pseudoaneurysm, arteriovenous (AV) fistula, hematoma, acute contrast renal failure, and atheroemboli or microemboli, which limit its indications.

This study was carried out to compare the results of ABI and USD with clinical symptoms of PAD so that the agreement between these results could be calculated.

## *Methods*

Forty consecutive patients with clinically confirmed symptoms of PAD were referred by cardiologists to the USD ward and enrolled in the study.

Before UDS, the patients' demographic characteristics, PAD risk factors [i.e. diabetes mellitus, hypertension, dyslipidemia, smoking, and obesity (BMI>30)], and symptoms were collected via questionnaires and face-to-face interviews. ABI and USD measurements were taken by a trained general physician and a radiologist, respectively.

The blood pressures of all four limbs at the brachial artery and posterior tibialis or dorsalis peddis arteries were measured with continuous wave Doppler with a hand-held sensor (Smartart model 450 Htz) and a pneumatic cuff, employing a standardized method.

The highest pressure was recorded. ABI was calculated by dividing the greatest systolic blood pressure of the lower limb arteries (posterior tibialis or dorsalis peddis arteries) by the greatest systolic blood pressure of the brachial arteries of the hands. ABI was calculated for each side of the body, using a lower index.

All the participants underwent USD [Mitsubishi Doppler Sonography (CP 700)] for an evaluation of the extent of stenosis. The peaks of systolic velocities were compared in all the segments of the arteries from the abdominal aorta to the distal of the popliteal artery in both sides of the body.

The severity of stenosis was estimated based on the following criteria:

1- Triphasic wave containing 0-49% stenosis,

2- (50-74%) Stenosis: A twofold increase in peak systolic velocity from one segment to another,

3- Critical stenosis (75-99%): A minimum of threefold increase in peak systolic velocity from one segment to the next, and

4- 100% Stenosis (occlusion): No flow detection.

Color Doppler scanning was used as a rough index of the severity of stenosis, employing the following criteria:

1- Normal: Triphasic response,

2- Stenosis above >50%: Post-stenotic turbulence and presence of a bruit at the site of the narrowing, and

3- Total occlusion: A complete absence of color and evidence of collateral arteries proximal to the site of obstruction.

Color Doppler scanning was utilized for the evaluation of the entire arteries of the lower limbs. A spectral analysis through quantifying the peak systolic velocity of stenosis was thereafter applied to estimate the severity of stenosis.[5-6]

The participants were divided into four groups based on their symptoms, ABI findings, and USD measurements.

Based on their symptoms, the patients were grouped into 4 stages:

Stage I: No symptom
Stage II: Intermittent claudication
Stage III: Pain at rest
Stage IV: Necrosis or gangrene

According to the ABI findings, the patients were classified into 4 stages:

Stage I- ABI: (0.85-1)
Stage II- ABI: (0.4-0.84)
Stage III- ABI: (0.2- 0.39)
Stage IV- ABI: (<0.2)

On the basis of the USD measurements, the patients were categorized into 4 stages:

Stage I: 0-49% stenosis

Stage II: 50-74% stenosis

Stage III: 75-99% stenosis

Stage IV: 100% stenosis

The patients' demographic data, ABI findings, USD measurements, and symptoms were analyzed with SPSS Software version 11.5, employing chi-square tests and regression models. To compare the tests and evaluate their agreements, the kappa index was used. Kappa<0.4, 0.4-0.75, and >0.75 was considered poor, moderate to strong, and strong agreement, respectively. P<0.05 was considered significant.

## Results

Of the 40 PAD patients with clinical symptoms enrolled in this study, 80% were men at a mean age of 62.9±12.8 (26-90) years. The average age of the women was 67±11 (59-79) years. The total prevalence of risk factors was as follows: smoking 60%, diabetes 52.5%, hypertension 40%, history of ischemic heart disease 37.5%, dyslipidemia 27%, and family history15%.

The most prevalent risk factors among the men and women were smoking (75%) and hypertension (100%), respectively. Hypertension, diabetes, and dyslipidemia were significantly more prevalent among the women (P<0.05).

Symptoms and risk factors of patients were evaluated. A considerable number of the hypertensives, smokers, and diabetics were at stage II of symptoms (37.9%, 58.3%, and 47.6%, respectively).

Table 1 illustrates the severity of PAD according to symptoms, ABI findings, and USD measurements in the men and women. ABI findings, and USD measurements was analyzed based on sex. Fifty percent of the men were at stage II of symptoms, 43.8% at stage III of ABI findings, and 62.5% at stage III of USD measurements. 50% of the women were at stage III of symptoms, 50% at stage III of ABI findings, and 50% at stage II of USD measurements. In comparison with the men, the women had more severe symptoms, lower ABI, and less stenosis in USD.

Agreement of ABI, USD, and symptoms in the PAD patients was evaluated. Table 2 shows agreement between clinical stage and Ankle Brachial Index (KAPPA=0.214 P=0.02). The overall agreement between USD and ABI in both sexes was poor. Kappa was 0.28 (P=0.02) and 0.09 (P=0.63) for the men and women, respectively. Table 3 shows agreement between ultrasound duplex scanning (USD stages) and Ankle Brachial Index (ABI stages) (KAPPA=0.19 P=0.09). Also, the agreement between USD and clinical stages was not significant (Kappa=0.09, P=0.3).

The relationship between ABI findings and USD measurements was tested by using linear regression models. The following model showed that USD can be estimated by the following formula:

Stenosis via USD(%)=93.43-(21.83×ABI)

[P-value: (constant)=0.00, (ABI)=0.024]

The mean of stenosis in stages II, III, and IV of ABI was 79%, 82%, and 95%, respectively (estimated by the USD findings)(P=0.036), and 79%, 87%, and 86% in stages II, III, and IV of clinical symptoms, respectively (P=0.004).

Table 1. PAD severity based on ABI, UDS and symptoms findings according to sex of patients*

| PAD severity | Male | Female | Total |
|---|---|---|---|
| Clinic stages | | | |
| I | - | - | - |
| II | 16(50) | 3(37.5) | 19(47.5) |
| III | 5(15.6) | 4(50) | 9(22.5) |
| IV | 11(24.4) | 1(12.5) | 12(30) |
| ABI stages | | | |
| I | - | - | - |
| II | 13(40.6) | 2(25) | 15(37.5) |
| III | 14(43.8) | 4(50) | 18(45) |
| IV | 5(15.6) | 2(25) | 7(17.5) |
| Doppler stages | | | |
| I | - | - | - |
| II | (21.9) | 4(50) | 11(27.5) |
| III | 20(62.5) | 2(25) | 22(55) |
| IV | 5(15.6) | 2(25) | 7(17.5) |

*Number in Parenthesis Show the related percentages

PAD, peripheral arterial disease; ABI, Ankle Brachial Index; UDS, Ultrasound duplex scanning

Table 2. Agreement between clinical stages and Ankle Brachial Index(ABI)

| Agreement of tests | | Clinical stages % | | |
|---|---|---|---|---|
| | | II | III | IV |
| ABI stages | II | 40 | 47 | 13 |
| | III | 28 | 61 | 11 |
| | IV | 0 | 57 | 43 |

Kappa, 0.214; P value, 0.02

Table 3. Agreement between ultrasound duplex scanning (UDS stages) and Ankle Brachial Index (ABI stages)

| Agreement of test | | USD stages % | | |
|---|---|---|---|---|
| | | II | III | IV |
| ABI stages | II | 80 | 20 | 0 |
| | III | 38 | 17 | 45 |
| | IV | 0 | 43 | 57 |

Kappa, 0.19; P value, 0.09

## Discussion

Earlier studies have shown that the prevalence of PAD

increases by age. For example, the prevalence of PAD among individuals aging 70-75 years is twice greater than that among those at the age range of 50-55 years. PAD is observed in 9% of people at 50-55 years of age and in 57% of those aging 85-89 years.[3] This study showed that 50% of the symptomatic PAD patients were 65 years and older, while 25% of them were older than 75 at a mean age of 63.7±12 (26-90). It should be noted that the mean age in an Indian study was 59±10.[4] Valentine and co-workers demonstrated that PAD in smokers was 11.2 times more prevalent than that among non-smokers. The current study revealed that smoking was the most common risk factor.[7]

15% of our patients had premature PAD (i.e. the onset of disease occurs before 45 years of age). The most prevalent risk factors among those with premature PAD were smoking, diabetes, and hyperlipidemia. None of whom had hypertension, but smoking was more prevalent in the patients with premature PAD than the ones above 45 years of age ($P<0.05$).

Hypertension, as an independent risk factor for PAD,[8] was observed in 100% of the women and 25% of the men ($P=0.00$). PAD in hypertensive patients must be considered as end organ damage, and blood pressure must be controlled in these patients aggressively.[9] Hypertension was the third most common risk factor in the present study.

Diabetes, which correlates with PAD in various studies,[1-3] was the second most common risk factor in the current study. None of the patients had ABI >0.9 (normal range), and all of them had M≥50% stenosis based on USD measurements.

In the present study, the sensitivity of ABI for the diagnosis of PAD according to USD was calculated to be 100%. In other studies, the sensitivity and specificity of ABI according to USD was estimated to be 70.6% and 88.5%, respectively,[4] and the overall agreement between ABI and USD was poor (Kappa=0.28), (Kappa=0.2).[4] USD with 96.9% sensitivity and 96.2% specificity can be used for the confirmation of the diagnosis of PAD via ABI or clinical symptoms. It could also be used to determine the severity and location of stenosis and the anatomy of arteries.[1]

In one study, only 30% of the patients with ABI <0.9 had intermittent claudication;[8] and the relationship between intermittent claudication and ABI was elsewhere reported to be poor Kappa=0.21 ($P=0.003$).[3] In the present study, the mean severity of stenosis in the various stages of symptoms was not significantly different; the severity of symptoms was, therefore, not correlated with the severity of stenosis. However, all of these patients had stenosis above 50%. Since intermittent claudication symptoms are also observed in the spinal cord stenosis, degenerative diseases, and peripheral neuropathy, ABI measurements are recommended for the confirmation of PAD and USD for the detection of the severity of lesions.[4] ABI and the peak velocity of walking and walking endurance have a significant relationship.[8] In this study, ABI and severity of symptoms had a direct association, but this relationship was not observed between the severity of stenosis based on USD and clinical symptoms. ABI findings can reveal, in addition, the function of lower limbs.

## Conclusion

The correlation between ABI findings and symptoms, especially in the men, was better than that between ABI findings and USD measurements. ABI is an appropriate tool for the initial screening of arterial stenosis and lower extremity circulation.

## Acknowledgement

This study has been supported by Yazd University of Medical Sciences. We thank Ms. Ghasemi and Ms. Lesan for the ABI measurements and Ms. Bather for typing the manuscript. Thanks are also due to all our PAD patients for their cooperation.

## References

1. Waits JI, Byrne J, Clagett P, Farkouh ME, Porter JM, Saclett DL, Strandenss DE, Taylor LM. Diagnosis & treatment of chronic arterial insufficiency of the lower extremities. A critical review. Circulation, 1996;94:3026-3049.
2. McDermott MM. The ankle brachial index in the evaluation of peripheral arterial disease. In: Barunwald E, ed. Harrison's advanced in cardiology. New York/Chicago/San Francisco/Lisbon/London: McGraw-Hill; 2003. p. 570-574.
3. Jaff MJ, Hiatt WR. Clinical and vascular laboratory evaluation of peripheral arterial disease. In: William R, ed. Peripheral Arterial Disease Handbook. Boca Raton/London/New York/Washangton: CRC press; 2001. p. 57-117.
4. Premalatha G, Ravikumar R, Sanjay R, Deepa R, Mohan V. Comparison of colour duplex ultrasound and ankle-brachial pressure index measurements in peripheral vascular disease in type 2 diabetic patients with foot infections. J Assoc Physicians India 2002;50:1240-1244.
5. Thrush A, Sharne TH. Doppler ultrasound. In: Law M, ed. Peripheral vascular ultrasound. Edingerg/London/ New York/ Philadelphia/ST Louis/Sydney/Toronto: Churchill Livingstone; 1999. p. 1-130.
6. Coffi SB, Ubbink DT, Zwiers I, vans Gurp AJ, Legemate DA. The value of the peak systolic velocity ratio in the assessment of the haemodynamic significance of subcritical iliac artery stenoses. Eur J Vasc Endovasc Surg 2001;22:424-428.
7. Valentine RJ, Guerra R, Stephan P, Scoggins E, Clagett GP, Cohen J. Family history is a major determinant of subclinical peripheral arterial disease in young adults. J Vasc Surg 2004;39:351-356.
8. Michael R, Sanjay R. Lower extrimity evaluation. In: Sanjay R, ed. Peripheral Vascular Disease. Philadelphia/ London/Torento/ Montreal/Sydney/Tokyo: W.B. Saunders. 2002. p. 521-523.
9. Jaff MR. Diagnosis of peripheral arterial disease: utility of the vascular laboratory. Clin Cornerstone 2002;4:16-25.