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Research Article

Comparison of colour Doppler ultrasound and ankle-brachial pressure index measurements in peripheral vascular disease in type 2 diabetic patients with foot infections

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ABSTRACT

Background: Peripheral vascular disease is diagnosed by definitive history of intermittent claudication or if one or more of peripheral pulses are absent in one or both lower limbs. Diagnostic testing for peripheral vascular disease must be accurate, inexpensive, widely accessible, easy to perform and preferably non-invasive. A variety of non-invasive techniques are available to detect the presence of peripheral vascular disease as well as to localize areas of stenosis, assess severity of disease and follow patients for disease progression or response to therapy. In this study we compare the specificity and sensitivity of ankle brachial pressure index with colour Doppler ultrasound for diagnosis of peripheral vascular disease in type 2 diabetes.

Methods: This prospective study was carried out in the department of General surgery, GMCH, Udaipur, Rajasthan, India, from September 2014 to February 2016 after taking the permission from institutional ethical committee. A total of 50 patients were selected. The selected patients were evaluated by detailed clinical history, physical examination, local examination, ankle brachial pressure index (ABPI), colour doppler study and other relevant investigations. The ABPI ratio was calculated in every patient and an ABPI less than 0.9 in either foot was defined to have PVD. Colour duplex ultrasound was done in all selected patients. Imaging of peripheral arteries of the lower limbs was done using high resolution colour duplex ultrasound. PVD was diagnosed if the stenosis in the artery was greater than 50% or presence of occlusion.

Results: Total 50 patients having type 2 diabetes mellitus with foot infection were included and most of the patients were between 40-60 years of age (68%) with males preponderance. In our study 12 (24%) patients had normal ABPI of 1.0 to 1.29 and 22 (44%) patients were in the range of mild to moderate PVD with ABPI between 0.41 to 0.90. Colour doppler was used as a standard diagnostic test for PVD & out of 50 patients, 36 (72%) showed involvement of arteries and among them both anterior and posterior tibial arteries were involved in 12 (24%) patients. In our study colour doppler ultrasound was used as standard diagnostic method for PVD. The sensitivity, specificity, positive predictive value and negative predictive value of ABPI against colour duplex ultrasound were calculated.

Conclusions: In our study it's concluded that ABPI is a good initial screening tool for peripheral vascular disease, but some patients with significant stenosis or in whom collaterals have developed in lower extremity would be missed, if ABPI measurement alone is used for diagnosis of peripheral vascular disease.

Keywords: Peripheral vascular disease, Diabetes, Foot infections, Colour doppler ultrasound, Ankle-brachial pressure index

INTRODUCTION

Diabetes is known for its micro and macro vascular complications like retinopathy, neuropathy, nephropathy, cardiovascular and peripheral vascular diseases and infections.

The major risk factors leading to diabetic foot ulcer is poor diabetes control, which results in neuropathic and vascular changes. Currently, foot problems are an important cause of morbidity in diabetes. Foot ulceration precedes the majority of amputation in diabetics. Diabetes accounts for up to 50% of non-traumatic leg amputations and 1% of diabetic people have undergone amputation.

Prevention and early treatment of foot ulcers require multidisciplinary teamwork from nurses, chiropodiatrists and doctors, preferably at primary care level. Rapid assessment and timely intervention can make the difference between limbs salvage and limb loss.

The diabetic foot is mainly because of peripheral neuropathy, arteriopathy and superimposed infection. Peripheral vascular diseases are a group of common degenerative (organic) and vasospastic (functional) disease processes that result in significant morbidity and are strong predictors of subsequent mortality.

Gangrene of the lower extremities as a result of advanced vascular disease is about 100 times more common in diabetics than non-diabetics. The primary cause of mortality in patients with PVD is myocardial infarction (60%), stroke (12%) and other complications of diabetes. A significant cause of morbidity in patients with peripheral vascular disease in diabetics is ischemic limb loss. Approximately 2% of non-diabetic patients with intermittent claudication require amputation. This rate increases to 7% for patients with diabetes mellitus.

According to American Diabetes Association revised criteria diabetes is diagnosed by.[1]

Criteria for the diagnosis of diabetes mellitus

- Symptoms of diabetes plus random blood glucose concentration ≥11.1 mmo1/L (200 mg/dL) or
- Fasting plasma glucose ≥7.0 mmo1/L (126 mg/dL) or
- A1C >6.5% or
- Two-hour plasma glucose ≥11.1 mmo1/L (200 mg/dL) during an oral glucose tolerance test.

Risk factors for the development of diabetic peripheral vascular disease are genetic predisposition, age, duration of diabetes, smoking, hypertension, hypertriglyceridemia, hypercholesterolemia, truncal obesity, hyperinsulinemia, proteinuria, dialysis and drugs (β-blockers, ionotropic agents). Among them most important are age, duration of diabetes, genetic predisposition and smoking. Peripheral vascular disease is diagnosed by definitive history of intermittent claudication or if one or more of peripheral pulses are absent in one or both lower limbs. The absence of pedal pulses in the presence of a palpable popliteal pulse is a classic finding in diabetic arterial disease because of the selective involvement of the tibial arteries below the knee.

Diagnostic testing for peripheral vascular disease must be accurate, inexpensive, widely accessible, easy to perform and preferably noninvasive. A variety of noninvasive techniques are available to detect the presence of peripheral vascular disease as well as to localize areas of stenosis, assess severity of disease and follow patients for disease progression or response to therapy.

These are:

- ABPI test.
- Doppler ultrasonography and color flow imaging.
- MRI and MR angiography.
- CT angiography.

The ankle-brachial pressure index (ABPI) is the ratio of systolic pressure at the ankle to that in the arm. The highest pressure in the dorsalis pedis, posterior tibial or peroneal artery serves as the numerator, with the highest brachial systolic pressure being the denominator.[2]

According to American College of Cardiology and American Heart Association, ABPI ratios are interpreted as follows:

>1.30: Non-compressible vessels
1.00 to 1.29: Normal
0.91 to 0.99: Borderline (equivocal)
0.41 to 0.90: Mild to moderate PVD
0.00 to 0.40: Severe PVD[3]

The recent ACC/AHA practice guidelines for PVD management recommend that a resting ABPI should be obtained for the following group of patients:

- Individuals with suspected PVD due to exertional leg symptoms or non-healing wounds.
- Individuals aged 70 years or old.
- Individuals between 50 and 70 years of age who have a history of tobacco use or diabetes.
- Individuals with diabetes who are younger than 50 years and who have additional risk factors for PVD such as smoking, hypertension, hyperlipidemia or diabetes of >10 yrs duration.

Arterial duplex ultrasonographic examination of the lower extremities can be used to diagnose PVD. It is especially helpful in determining the location of disease and in delineating between stenotic and occlusive lesion, an added benefit when preparing for an intervention. Gray scale imaging is used to characterize the morphology of the vessel, ascertain the presence or absence of plaque & assess plaque calcification and characteristics. Management of diabetic foot includes

improvement of patient's nutrition, correction of anemia and strict glycemic control. Risk factors like smoking, hypertension, hyperlipidemia should be under strict control. The offloading is avoidance of all mechanical stress on the affected limb. The wounds should be swabbed and cultured. The surgical probing, drainage and debridement should be done under antibiotic coverage.

The arterial angioplasty, stenting, endarterectomy or arterial bypass is done for revascularization of diabetic foot. In recent years, several new treatment strategies have been developed to stimulate wound healing in the diabetic foot ulcers. These are topical growth factors, extracellular matrix products, bioengineered human skin, and hyperbaric oxygen therapy, granulocyte macrophage colony stimulating factor and collagen granules.

METHODS

This study was conducted on patients of type 2 diabetes mellitus with foot infection admitted in Geetanjali Medical College & Hospital, Udaipur from September 2014 to February 2016. A total of 50 patients were selected. The selected patients were evaluated by detailed clinical history, physical examination, local examination, ABPI, colour Doppler study and other relevant investigations. The ankle brachial pressure index ratio was calculated in every patient and an ABPI less than 0.9 in either foot was defined to have PVD.

Blood pressure recordings were done on the brachial pulse in the upper limb by palpatory method using the usual sphygmomanometer, cuff and brachial systolic pressure noted. In the lower limb similar recordings were done by using the same cuff around the calf and palpating dorsalis pedis and posterior tibial pulses. The mean of these two readings was taken as the ankle pressure. All readings being done in supine position after ten minutes rest.

ABPI was calculated as:

$$\text{ABPI} = \frac{\text{Systolic ankle pressure}}{\text{Systolic brachial pressure}}$$

Colour duplex ultrasound was done in all selected patients. Imaging of peripheral arteries of the lower limbs was done using high resolution colour duplex ultrasound.

The superficial femoral artery was traced up to the popliteal fossa and the profound was evaluated in its proximal segment. The popliteal vessels, anterior tibial, peroneal, posterior tibial and dorsalis pedis were also evaluated. PVD was diagnosed if the stenosis in the artery was greater than 50% or presence of occlusion.

Statistical analysis

All data were tabulated and statistical analysis was performed. The sensitivity, specificity, positive predictive value and negative predictive value of ABPI against colour duplex ultrasound were calculated. In brief, these were calculated as follow:

$$\text{Sensitivity} = \frac{\text{Number of true positive subjects}}{\text{Total number of subjects diagnosed as PVD by CDU}}$$

$$\text{Specificity} = \frac{\text{Number of true negative subjects}}{\text{Total number of subjects Negative for PVD as diagnosed by CDU}}$$

$$\text{Positive predictive value} = \frac{\text{Number of true positive subjects}}{\text{Total subjects diagnosed as pvd by ABPI}}$$

$$\text{Negative predictive value} = \frac{\text{Number of true negative subjects}}{\text{Total subjects diagnosed as PVD by ABPI}}$$

RESULTS

This study was conducted in Geetanjali Medical College and Hospital, Udaipur, Rajasthan, India. On 50 patients suffering from diabetes mellitus with foot infections.

Age distribution

Out of the 50 patients, 34 (68%) were aged between 40 to 60 years of age, 4 (8%) were aged below 40 years and 12 (24%) patients were aged more than 60 years. Youngest patient was 36 years old & oldest patient was 73 years old (Table 1).

Table 1: Age distribution.

Age (Years)	No. of patients	Percentage
Below 40	04	08
40-60	34	68
Above 60	12	24

Sex distribution

In our study out of 50 patients, 36 (72%) were males & 14 (28%) were females. The male to female ratio was 2.5: 1 (Table 2).

Table 2: Sex distribution.

Sex	No. of patients	Percentage
Male	36	72
Female	14	28

Table 3: Associated factors.

	Yes		No	
	No. of patients	Percentage	No. of patients	Percentage
Walking bare feet	32	64	18	36
H/o smoking	24	48	26	52
H/o ulcer or amputation	18	36	32	64

Associated factors

Out of 50 patients, 32 (64%) patient were in a habit of walking bare feet either at home or at work and 24 (48%) patients were smokers. It shows that walking bare feet was associated with increased incidence of diabetic foot (Table 3).

Ankle Brachial Pressure Index

ABPI in normal patients is between 1.0 to 1.29 and in our study 12 (24%) patients had ABPI of >1.0. ABPI between 0.91 to 0.99 indicates borderline PVD and in our study 10 (20%) patients had ABPI between 0.91 to 0.99. In our study, 22 (44%) patients were in the range of mild to moderate PVD with ABPI between 0.41 to 0.90 (Table 4).

Table 4: ABPI.

ABPI	No. of patients	Percentage
>1.0	12	24
0.91 to 0.99	10	20
0.41 to 0.90	22	44
<0.40	06	12

Colour Doppler study

In our study, colour Doppler was used as standard diagnostic test for PVD. Out of 50 patients, 36 (72%) showed involvement of arteries & 14 (28%) patients showed normal study (Table 5).

Table 5: Colour Doppler study.

Colour Doppler study	No. of patients	Percentage
Involvement of arteries	36	72
Normal study	14	28

Involvement of arteries in colour Doppler study

In our study out of 50 patients colour Doppler shows involvement of arteries in 36 (72%) patients. Out of 36 patients, calf vessel involvement was seen in 27 (54%) patients. Only anterior tibial artery was involved in 9 (18%) patients, posterior tibial in 6 (12%) patients and both anterior and posterior tibial were involved in 12 (24%) patients. Popliteal artery involved in 4 (8%) patients and superficial femoral artery in 5 (10%) patients (Table 6).

Table 6: Involvement of arteries in colour Doppler study.

Involvement of arteries	No. of patients	Percentage
Anterior tibial only	09	18
Posterior tibial only	06	12
Both anterior and post tibial	12	24
Popliteal	04	08
Superficial femoral	05	10

Sensitivity and specificity of ABPI vs colour Doppler ultrasound

In our study, out of 50 patients, ABPI showed PVD in 28 (56%) patients and absence of PVD in 22 (44%) patients. Colour Doppler ultrasound was used as standard diagnostic method for PVD in this study. Colour Doppler showed PVD in 36 (72%) patients. Out of the 36 patients diagnosed to have PVD by CDU, only 26 were categorized as PVD by ABPI. Thus 10 patients would have remained undiagnosed if ABPI alone was used for diagnosis. Conversely 2 patients out of the 28 patients diagnosed as having PVD by ABPI were classified as normal by the CDU. Hence sensitivity of ABPI is 72.22 % & specificity of ABPI is 85.71% in comparison with colour Doppler ultrasound. Positive predictive value of ABPI is 92.85% and negative predictive value of ABPI is 54.54% (Table 7).

Table 7: Sensitivity and specificity of ABPI vs colour Doppler ultrasound.

ABPI	Colour Doppler ultrasound		Total
	Abnormal (+)	Normal (-)	
Abnormal (+)	26	02	28
Normal (-)	10	12	22
Total	36	14	50

Amputation

In this study, out of 50 patients, 17 (34%) patients required amputation, out of which 10 (20%) patients required minor amputation of toes and 7 (14%) required major amputation (Table 8).

Table 8: Amputation.

Amputation	No. of patients	Percentage
Minor	10	20
Minor	07	14
Total	17	34

DISCUSSION

The spectrum of diabetic complication is very wide, and to some extent unpredictable. Advances insulin therapy and oral hypoglycemic agents have led to an increase in the life span of patients affected with diabetes mellitus. This has in turn led to an increase in the incidence of complications of diabetes like retinopathy, neuropathy, vascular diseases and nephropathy. Foot problems are the most common indications for hospital admission in diabetes. They account for approximately 20 percent of all hospital admission in diabetics.

Peripheral vascular disease plays an important role in the pathogenesis of foot ulcer and good circulation is required for early healing. Hence there is a need for early diagnosis of peripheral vascular disease in diabetics with foot infections. The noninvasive tests are of great value in assessing the vascular supply of the foot and evaluating the healing potential of foot ulcers and local amputations. Among these tests ABPI is one of the easiest, most widely reproducible and cost effective method of determining the degree of diminished arterial circulation in lower limb.

Earlier studies by Strandezz DE, Bell JW[4] have suggested ABPI as a reliable method for diagnosis of PVD and ABPI value of <0.9 has 98 % sensitivity compared to angiography. Premalatha et al[5] in their study compared CDU and ABPI measurement in 100 type 2 diabetic patients with foot infections and found that ABPI had sensitivity of 70.6% and specificity of 88.5%. They concluded that ABPI is a good initial screening tool but some patients with significant stenosis would be missed, if ABPI alone is used for diagnosis of PVD.

In our study, ABPI measurement had 85.71% specificity and 72.22% sensitivity as compared to 88.5% and 70.6% in Premalatha et al[5] study (Table 7). The low sensitivity indicates that ABPI measurement would miss some of the patient with PVD. The reason being, there may be higher ABPI values in spite of stenosis probably due to collateral circulation that maintains blood flow to the lower limb beyond the obstruction. Higher ABPI values also suggest calcification of vessels.

If ABPI alone is used, many patients with severe stenosis in the peripheral artery will be diagnosed as normal. But in view of the ease of performing the test and its low cost, ABPI would be a good initial screening test.

If ABPI is abnormal, the diagnosis of PVD is almost certain. If ABPI is normal and the patient is asymptomatic no further testing is required because even if PVD is present it is likely to be clinically insignificant. If however, there are clinical symptoms of PVD and the ABPI is normal, a CDU should be performed before PVD is definitely excluded. CDU however needs more expensive equipment, is technically more difficult, needs a highly skilled radiologist to perform, is not available widely and cannot be carried out at smaller centers.

Venkata et al[6] in his study showed that maximum number (54%) of patients were in the age group of 51-60 years and 65% patients were male. In our study, 34 (68%) patients were between the age of 40 to 60 years and 36 (72%) patients were male patients. Bild et al[7] stated that alteration in foot dynamics due to ulceration or amputation can cause the abnormal distribution of plantar pressures and results in formation of new ulcers. In our study, 18 (36%) of patients had previous history of amputation or ulcers. Also 32 (64%) of patients were in a habit of working bare feet either indoor or outdoor (Table 3).

Logerfo and Coffman[8] stated that the arterial occlusion commonly involves the tibial arteries (calf vessels). In our study, involvements of peripheral arteries were found in 27 (54%) patients (Table 6); out of that involvement of anterior and posterior tibial both were present in 12 (44.4%) patients. In our study, 17 (34%) patients required amputation. In a similar study by Zafar,[9] 17 (36%) patients out of 48 patients required amputation of minor and major types. In Reiber,[10] study out of 50 patients, 20 (40%) required amputation.

CONCLUSION

In our study it's concluded that ABPI is a good initial screening tool for peripheral vascular disease, but some patients with significant stenosis or in whom collaterals have developed in lower extremity would be missed, if ABPI measurement alone is used for diagnosis of peripheral vascular disease.

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