

# A Doppler-Based Evaluation of Peripheral Lower Limb Arterial Insufficiency in Diabetes Mellitus

Riffat Shaheen and Saba Sohail

## ABSTRACT

**Objective:** To determine the frequency, level and flow patterns of lower limb arterial insufficiency in diabetic patients on Doppler ultrasound study.

**Study Design:** Cross-sectional study.

**Place and Duration of Study:** Radiology Department, Civil Hospital, Karachi, from February 2007 to September 2008.

**Methodology:** One hundred adult diabetic patients with suspected peripheral vascular insufficiency irrespective of gender were included. Demographic data, presenting complaints, treatment history, and level of HbA1c were recorded. Doppler evaluated arterial status and ankle brachial index (ABI) were recorded on proforma. Statistical analysis were done on SPSS version 12.

**Results:** The mean HbA1c was  $8.4 \pm 1.4$  gm/dl, a majority of 77% having a controlled level of  $< 10$  mg/dl. Arterial insufficiency on Doppler ultrasound was documented in 62% ( $p=0.016$ ) and the dorsalis pedis artery was the predominant site of stenosis (24%). Spectral broadening and biphasic flow were salient features. The mean value of resistive index in stenotic cases was  $0.563 \pm 0.16$  with a mean velocity difference of  $0.37 \pm 0.29$  m/s ( $p < 0.001$ ) at the site of stenosis.

**Conclusion:** Peripheral vascular insufficiency was a significant finding in patients having diabetes for an average of 9.8 years, even in the presence of controlled HbA1c. The dorsalis pedis was the commonest site of involvement. The insufficiency was moderate with a biphasic flow pattern in a majority of cases. Difference in resistive index and flow velocities at and above the site of stenosis provided an important clue to the diagnosis of level of stenosis that helps in planning limb salvage management.

**Key words:** Peripheral arterial insufficiency. Diabetes mellitus. Doppler ultrasound. Lower limb.

## INTRODUCTION

Diabetes mellitus is a common pathological condition of the present times,<sup>1</sup> with a higher prevalence rate in developing countries.<sup>2</sup> Pakistan is included among the countries with the highest prevalence of diabetes.<sup>3</sup>

Diabetes mellitus has a marked impact on the quality of life due to the acute and long-term complications secondary to the involvement of micro and macro vasculature with the progression of the natural history of disease.<sup>4</sup>

Peripheral arterial disease (PAD) is a condition characterized by occlusive changes in the lower extremities arteries. PAD is markedly frequent among individuals with diabetes. Peripheral ischemic event rates are higher in diabetic individuals with PAD than in non-diabetic and even atherosclerotic populations.<sup>5,6</sup> PAD is an important contributory factor to diabetic foot ulceration and gangrene leading to lower-extremity amputation in diabetes mellitus.<sup>7</sup> Spectral Doppler (Duplex) sonography is well accepted as a noninvasive imaging

modality to be used as a diagnostic test for detecting and grading the presence and severity of arterial disease.<sup>8</sup>

Diagnosis of PAD in diabetic patients is of great clinical significance in order to determine the subset of patients that may be at a high risk of subsequent myocardial infarction or stroke regardless of the presence or absence of symptoms of PAD and to treat the symptoms of PAD, which can lead to limb loss and functional disability.<sup>9</sup> Thus, regular screening is essential as a part of aggressive management to reduce the impact of comorbidities on the affected person.

The evaluation of the state of peripheral arteries of the lower limb in terms of stenosis (percentage) if any, and its association with patient symptomatology is important. This can act as a basis for regular follow up of the cases at the risk of arterial disease and early intervention to salvage the limb if vascular insufficiency is detected at an early stage. Doppler ultrasound provides the basis for non-invasive and objective measurements of the spectrum and velocity of flow in arteries that can be serially monitored. Local studies have not evaluated Doppler scanning as a means of evaluating vascular complications in diabetics. The objective of this study was to determine the frequency, level and patterns of lower limb arterial insufficiency in diabetic patients on a Doppler-based evaluation.

*Department of Radiology, Dow University of Health Sciences and Civil Hospital, Karachi.*

**Correspondence:** Dr. Riffat Shaheen, B-13, Block A, Kazimabad, Model Colony, Karachi-75100.

E-mail: [docriffat@yahoo.com](mailto:docriffat@yahoo.com)

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## METHODOLOGY

This study was conducted from February 2007 to September 2008 at the Department of Radiology, Dow University of Health Sciences and Civil Hospital, Karachi with patient's referral from both the medical and surgical units. One hundred patients were included in this study by purposive non-randomized sampling. Inclusion criteria were adult diabetic patients (aged 18 years or above) irrespective of type of diabetes and gender with suspected peripheral vascular insufficiency or complaints of numbness, discoloration of periphery or ulceration. Patients with a previous history of trauma to the arterial vasculature, those suffering from other causes of peripheral arterial insufficiency like hypertension, vitamin deficiency, and known atherosclerotic disease, and those who underwent arterial graft procedures were excluded.

Demographic data was collected regarding identification, gender, age, address, presenting complaints, treatment history and level of Hb A1c (when available).

Doppler ultrasound (U/S) was done by a convex linear array probe of 11.5 MHz on Toshiba Nemio-17. Color and spectral Doppler technique were used to identify the affected vessel. Mapping of the lower limb arterial tree was done, from common iliac up to the dorsalis pedis artery. Doppler assessment of the site of stenosis was based on a peak systolic velocity in cm/sec, comparison of mean velocity at and 1-2 cm above the level of stenosis, spectral waveform for phasicity and resistive index (RI) determination by getting the ratio of systolic to diastolic velocity on spectral waveform. Presence of significant ischemia was confirmed with the measurement of ankle to brachial index ratio (ABI), involving the measurement of peak systolic flow velocities in the ankles (dorsalis pedis and posterior tibial arteries), and arms (brachial artery) by using a handheld Doppler and then calculating a ratio, with an ABI of 0.9-1.3 indicating normal flow, 0.6-0.9 indicating mild ischemia, 0.4-0.6 indicating moderate ischemia and < 0.4 severe ischemia.

Descriptive and inferential statistics were applied using SPSS version 12. Frequency, mean, and standard deviation were determined for age, gender, presenting complaints and Doppler findings. Mean velocity difference at and above the site of stenosis were compared using a t-test, while the chi-square test was used to compare proportions of the presence of vascular disease or otherwise and sites of stenosis among the affected and non-affected groups with 0.05 level of significance.

## RESULTS

The study comprised of 100 known diabetic patients with a mean age of  $55 \pm 7.9$  years ranging from 45 to 75 years. The male to female ratio was found to be 1.5:1 (61% males and 39% females). The mean duration of

diabetes was  $9.8 \pm 6.32$  years ranging from 6 months to 30 years. Type-I diabetes mellitus was present in 37% and type-II was in 60% cases. Three (3%) patients regardless of the type were using homeopathic medicines. Other co-morbidities like coexistent hypertension and coronary artery disease were present in 42%. Hypertension alone was found in 29%, coronary artery disease alone was found in 6% and liver disorder alone was present in 3% cases. Claudication was the main presenting symptom in 64% cases and ulcers and frank gangrene was observed in 39% cases. HbA1c indicating glycemic control during last two to three months was available among 68% cases. With a mean value of  $8.4 \pm 1.4$  gm/dl, fifty-three cases (77%) had shown a controlled blood sugar level i.e. HbA1c < 10 gm/dl and 15 cases (22%) had shown uncontrolled blood sugar levels i.e. > 10 gm/dl.

Doppler evidence of vascular abnormality in lower limbs was seen in 62% of the cases while 38% were normal. Vascular insufficiency was noted bilaterally in 11 cases (17.7%), the right limb was involved in 30 cases (48%  $p < 0.001$ ) and left limb involvement was seen in 21 cases (33%). The most frequent site of stenosis was the dorsalis pedis artery (Figure 1) found in 15 cases (24%,  $p < 0.001$ ), followed by superficial femoral (Figure 2) and distal femoral arteries in 11 cases (17%) each. Stenosis was seen in the popliteal artery in 9 cases (14.5%), posterior tibial with dorsalis pedis artery in 9 cases (14.5%), posterior tibial artery alone in 6 cases (9.6%), popliteal artery alone in 3 cases (4.8%), distal part of superficial femoral alone in 3 cases (4.8%) and occlusive disease of whole limb extending from common iliac to dorsalis pedis was noted in 3 cases (4.8%) (Table I).

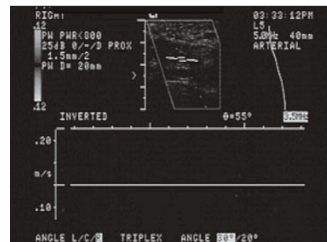


Figure 1: Dorsalis pedis artery Doppler scan showing absence of flow compatible with occlusion.

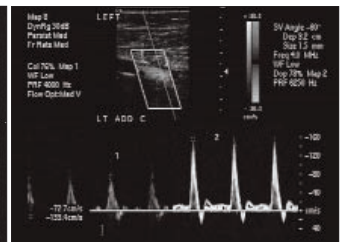


Figure 2: A femoral artery Doppler scan showing moderate (50%) ischemia with spectral broadening and biphasic flow.

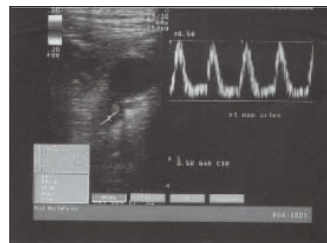


Figure 3: A popliteal artery triplex Doppler scan showing moderate ischemia with spectral broadening and biphasic flow.

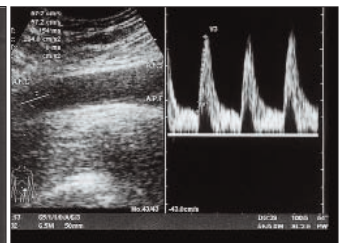


Figure 4: A left common femoral artery Doppler scan showing post-occlusive monophasic flow.

**Table I:** Patterns of arterial involvement (n=62).

Artery involve in stenosis	Number of cases (n)	Percentage of cases
Dorsalis paedis alone	15	24.2%
Superficial femoral and distal femoral	11	17.7%
Popliteal artery and distal arterial branches	9	14.5%
Posterior tibial with dorsalis paedis artery	9	14.5%
Anterior and Posterior tibial with dorsalis paedis artery	3	4.8%
Posterior tibial artery alone	6	9.6%
Popliteal artery alone	3	4.8%
Distal part of superficial artery alone	3	4.8%
Common iliac and distal arterial branches	3	4.8%

Normal arterial blood flow with a normal triphasic pattern of spectral waveform was observed in 38 cases. Broadening of the spectral waveform (Figure 3) was noted in 41 cases with mild stenosis in 15 cases (24%), moderate in 21 cases (33.8%) and severe in five cases (8%). Biphasic flow pattern was observed in 15 cases (36%) and a monophasic flow (Figure 4) was seen in 26 cases (63.4%). Among the recorded velocities, the ratio of velocity above (1-2 cm) and at the site of stenosis was mild (ratio of 1.5-2:1) in 15 cases (36%), moderate (2-4:1) in 21 cases (51%) and severe (> 4:1) in 5 cases (12%) measuring a higher velocity at the site of stenosis. The mean value of the resistive index among the cases with stenosis (N=62) was found to be  $0.563 \pm 0.16$  with a mean velocity difference of  $0.37 \pm 0.29$  m/s at the site of stenosis ( $p < 0.001$ ). The mean value of the resistive index among the cases without any stenosis was found to be  $0.89 \pm 0.20$  ( $p < 0.001$ ). The ankle brachial index (ABI) was normal (0.9-1.3) in 39 cases, mildly ischemic (0.6-0.9) in 9 cases, moderately ischemic (0.4-0.6) in 11 cases and severe ischemic changes (< 0.4) were seen in 3 cases. The presence of peripheral calcification hindered the recording of ABI index in 23 cases.

## DISCUSSION

This study focused on a Doppler-based evaluation of the vascular ischemia occurring in diabetics, which is an under-utilized modality in local practices. The WHO predicts that by the end of 2025 there will be a marked increase from the current diabetic population of 130 million people to 300 million.<sup>10-11</sup> Type 1 Diabetes is characterized by an acute onset and requires insulin treatment. Type II diabetes appears insidiously and is treated in a variety of ways, including a dietary regimen, oral hypoglycemic agents, insulin, or a combination of these. The mean age of diabetic patients in this study was  $55 \pm 7.9$  years corresponding with Zafar *et al.*,<sup>12</sup> with a predominance of male patients and type-II Diabetes mellitus as reported by William *et al.*<sup>13</sup> The mean duration of illness was  $9.87 \pm 6.32$  years. The chronic

nature of the illness favours the development of vasculopathic changes leading to peripheral vascular insufficiency. This is twice as common in diabetics than in their non-diabetic counterparts as diabetic patients are 20 times more prone to amputation than the rest of the population.<sup>14,15</sup>

Claudication defined as reproducible pain, weakness, or cramping in muscles occurring during activity due to decreased blood flow is one of the commonest manifestations of peripheral vascular disease,<sup>16</sup> as also seen in this study-(64%) cases. A normal triphasic pattern of flow was observed in 38 cases, even in the presence of claudication in 21 cases, ulcer in 15 cases or gangrene in 6 cases, representing peripheral micro angiopathy, which is an important risk factor for diabetic foot.<sup>13</sup> A large proportion of the patients also had other co-morbidities especially hypertension which is (29%) considered to be an established risk factor for atherosclerotic changes in peripheral vascular insufficiency.<sup>17,18</sup> HbA1C measures the average blood sugar over the past 2 to 3 months and is considered useful for monitoring glycemic control. The presence of chronic hyperglycemia is also considered to be a predisposing risk factor for diabetes-related micro vascular changes.<sup>19</sup> A record of HbA1C was available in 68 cases with a mean value of  $8.4 \pm 1.4$  gm/dl (range 6-11 gm/dl) closer to the values observed in studies conducted at Bangladesh (8.01mg/dl) and India (8.6mg/dl).<sup>20,21</sup> This normal controlled value of HbA1c found in the presence of ischemia suggests that the arteries of diabetics can get affected by a long-term illness despite good glycemic control. The majority of the patients had diabetes for a longer duration with an average duration of illness was 9.8 years.

Non invasive screening tools are being used for the evaluation of peripheral vascular insufficiency in symptomatic or asymptomatic diabetic patients thus making color duplex imaging with spectral waveform analysis an accurate method for grading the severity of arterial stenotic disease.<sup>13</sup> The most frequent site of stenosis found in this study was the dorsalis paedis artery (24%) which contrasts with the findings of Ahluwalia *et al.*<sup>17</sup> The latter found the ileofemoral segment to be the most frequent site of stenosis (36.4%). The presence of biphasic or monophasic flow represent the severity if occlusive arterial disease is found, thus requiring prompt intervention.<sup>13</sup> Resistive index (RI) is a quantitative analysis of the waveform and reflects resistance to blood flow.<sup>22</sup> The resistive index was higher among the normal group ( $0.89 \pm 0.20$ ) and lower in the stenotic group ( $0.563 \pm 0.16$ ) as favoured by Suzuki *et al.*<sup>23</sup>

The main limitation of this study was the lack of a control group. Another limitation was the cross-sectional procurement of data that only showed point-frequency.

## CONCLUSION

The findings of this study suggested vascular insufficiency in 62% of the patients with dorsalis pedis being the commonest site of involvement. The insufficiency was moderate and the flow was biphasic in a majority of the cases. There was a significant difference in resistive index at and above site of stenosis. Most importantly, a majority of the affected patients had a normal glycemic status and the mean duration of disease was almost a decade in patients exhibiting Doppler-documented vasculopathy.

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