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Original Research Article

Doppler study of peripheral blood flow in lower extremity of diabetic patients with or without ischemic symptoms in tertiary centre

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ABSTRACT

Background: Doppler ultrasonic velocity detector which is least expensive and most versatile instrument. This technique is particularly helpful to establish the diagnosis of vascular insufficiency in clinically suspected cases of vascular disease and to predict the therapeutic results and follow up.
Methods: The present study was conducted in MLN Medical College and SRN Hospital, Allahabad, Uttar Pradesh, India. Patients of either sex suffering from diabetes with or without ischemic symptoms, who presented themselves. Study consisted of 50 subjects, which were matched by age, sex and all physical characteristics. Among the 50 subjects, 20 were suffering from diabetes and had ischemic symptoms like intermittent or rest pain and gangrene. Another set of 20 patients in this study group were of diabetes without any ischemic symptoms. Remaining 10 patients were controls i.e., they were comparable in physical characteristics like age, sex, height and weight. They had never smoked neither had any vascular disease.
Results: In this study, peak incidence of diabetic foot lesion was 6th decade and about 20% of female patient had foot lesion. In this study, the mean duration of disease in diabetic with ischemic symptoms was 9.6 years, while in asymptomatic group it was 6.9 years. It showed that as duration of disease increases, there is more probability for appearance of ischemic symptoms and foot involvement.
Conclusions: In diabetics without ischemic symptoms, most of the doppler wave patterns are triphasic and biphasic, while in diabetics with ischemic symptoms biphasic and monophasic waves are predominantly seen.

Keywords: Doppler, Diabetes, Ischemia, Non-ischemia

INTRODUCTION

The incidence of diabetic foot as a diabetic complication is more than the combined incidence of retinopathy, nephropathy, myocardial infarction and stroke. The seriousness of problem is further abetted by concurring peripheral neuropathy, infection and peripheral arteriopathy resulting in loss of limb creating, preventable, social and vocational handicaps. 15% diabetics will suffer from foot ulcer in their life time. Indeed about 14-24% of people with a foot ulcer will require an amputation.[1] Diabetic patients with peripheral vascular disease have a six to seven-fold increase in extremity gangrene compared to the patients who are only diabetics (Rhodes BA et al).[2] More than 10% of all admissions for diabetes are primarily for foot management at the Indian Institute of Diabetes in Bombay, India.[3] More than 70% required surgical

intervention and in more than 45% of these interventions were a toe or limb amputation. It has been forced upon me to think that diabetic gangrene is not heaven sent but earth born Joslin 1934.[4] Here in this work, author have tried to identify these high-risk patients those who are prone to develop foot lesion. Author have used Doppler ultrasonic velocity detector which is least expensive and most versatile instrument.[5] This technique is particularly helpful to establish the diagnosis of vascular insufficiency in clinically suspected cases of vascular disease and to predict the therapeutic results and follow up.

METHODS

The present study was conducted in MLN Medical College and SRN Hospitals, Allahabad, Uttar Pradesh, India of duration of one-year July 2017 to June 2018. Patients of either sex suffering from diabetes with or without ischemic symptoms, who presented themselves at diabetic clinic or surgical Outdoor Patient Department of surgery were selected. Study consisted of 50 subjects, which were matched by age, sex and all physical characteristics. Among the 50 subjects, 20 were suffering from diabetes and had ischemic symptoms like intermittent or rest pain and gangrene. Another set of 20 patients in this study group were of diabetes without any ischemic symptoms. Remaining 10 patients were controls i.e. they were comparable in physical characteristics like age, sex, height and weight. They had never smoked neither had any vascular disease. Informal consent of all the patients participating in this study was taken. These subjects were classified into two groups.

- Patients
    - Symptomatic (20) in which diabetic patients with ischemic symptoms,
    - Asymptomatic (20) in which diabetic patients without ischemic symptoms.
- Controls
    - Nonsmoker healthy individuals comparable with age, sex and physical characterizes.

Clinical history

A detailed history was recorded, particular attention was given to the onset and duration of diabetes, method of diabetes control and it was also recorded that patients were taking regular medicine or not.

- General Examination
- Systemic Examination

Central nervous system

- Cardiovascular system

Gastrointestinal system

- Autonomic nervous system

Examination of leg and foot

Examined for all sensory modalities, e.g. touch, pain, temperature and motor deficit e.g. wasting, weakness of muscles, jerks and thinning of skin, hair loss, loss of subcutaneous fat, trophic changes of nails, cellulitis, abscess, superficial ulcers, gangrene, autoamputation.

Palpation of blood vessels

- Dorsalis pedis artery was felt,
- Posterior tibial artery was felt behind the medial malleolus against pulsation of popliteal artery was felt.

Investigations

- Hemogram,
- Diabetic profile - Fasting blood sugar (F.B.S.), Post prandial blood sugar (P.P.B.S),
- Renal profile - serum urea

X-ray chest

Plain X of foot and lower part of leg of affected side.

Doppler study of lower limbs was done. All the diabetics and controls were subjected to doppler ultrasound for determination of blood velocity of popliteal, posterior tibial and dorsalis pedis arteries. Peak flow velocity, acceleration, deceleration were the parameters taken.

Instrumentation

LOGIQ 400 MD color doppler machine (GE Medical Systems) was used, with a 6-13 MHZ. Linear probe on all diabetics and controls. Gray scale imaging, color flow imaging and pulse imaging analysis was done.

RESULTS

This study was carried out in MLN Medical College and associated group of hospitals over a period of one year from July 2017 to June 2018. Forty patients suffering from diabetes mellitus of varied duration with or without ischemic symptoms, peripheral blood flow studies were done. They all were subjected to noninvasive method with the help of color Doppler recorder to know the vascular status of the feet.

In diabetic patients with ischemic symptoms

Total number of patients were 20 and age of the patients ranged from 25 to 75 years. The mean age being 51.3

years. There were 14 males and 6 females giving a percentage of 70 and 30 respectively (Table 1).

Table 1: Age and sex distribution of diabetic patients with or without ischemic symptoms.

Age group (years)	With symptoms		Without symptoms	
	Male	Female	Male	Female
20-40	1	-	2	-
41-60	11	6	10	6
>61	2	-	1	1
Total	14(70%)	6 (30%)	13(65%)	7 (35%)

In diabetic patients without ischemic symptoms

Total number of patients were 20 and age of the patients ranged from 30 years to 62 years. The mean age being 48.2 years. Maximum number of patients (80%) were between 40-60 years. There were 13 males and 7 females patients giving percentage of 65 and 35 respectively (Table 1).

In controls

The total number of controls studied were 10. The age of control ranged from 25 to 62 years. The mean age being 51.8 years. There were 6 males and 4 females in the group (Table 2).

Table 2: Age and sex distribution of controls.

Age group in years	Male	Female
20-40	1	0
40-60	3	3
>61	2	1
Total	6 (60%)	4 (40%)

Age and duration of diabetes in diabetic patients

Two patients were diagnosed as diabetic at the time of presentation of foot lesion, rest all were known diabetics. The maximum duration of disease was 16 years. The mean duration of disease being 9.6 years. One patient, 25 years old had juvenile diabetes (Table 3).

Table 3: Age and duration of diabetes in diabetic patients with ischemic symptoms.

Age group (yrs)	Diagnosed at the time of foot lesion presentation	Duration of disease		
		<5 (yrs)	5-10 (yrs)	>10 (yrs)
20-40	0	0	1	1
41 -60	2	1	4	9
>61	0	0	2	0

In this group maximum duration of disease was 12 years and minimum duration being 1.5 years. The mean duration of disease being 6.4 years. 65% patients had diabetes for more than 5 years of duration and 35% for less than 5 years of duration (Table 4).

Table 4: Age and duration of diabetes in diabetic patients without ischemic symptoms.

Age group (years)	Duration of disease (years)		
	<5	5-10	>10
20-40	1	1	-
41-60	6	5	5
>61	-	2	-

Type of treatment (regular or irregular) of diabetic patients

As shown in the Table 5, 16 patients were taking regular treatment in asymptomatic group as compared to symptomatic group where only 3 patients were taking regular treatment.

In control group, there was no history of familial diabetes and smoking.

Symptoms analysis of diabetic patients with is ischemic symptoms

In symptoms analysis, it was found that among ischemic symptoms ulcer was commonest symptoms (55%) followed by intermittent Claudication and gangrene (40%) each.

Table 5: Diabetic patients according to type of treatment (regular or irregular).

Duration of diabetes (yrs)	Without symptoms			With symptoms		
	No. of patients with			No. of patients with		
	Regular Tt.	Irregular Tt	Total no.	Regular Tt.	Irregular Tt.	Total no.
< 5 yrs	5	2	7	-	1	1
5-10 yrs.	6	2	8	1	6	7
>10 yrs.	5		5	2	8	1 0

Most common associated neurological symptoms were burning sensation of feet (65%) followed by numbness (40%) (Table 6).

Table 6: Distribution of diabetic patients (with ischemic symptoms) according to symptoms present (no. of patients = 20).

Symptoms present	No. of patients	%
Ulcer	11	55.00
Gangrene	7	35.00
Intermittent claudication	8	40.00
Rest pain	2	10.00
Numbness	8	40.00
Burning sensation of feet	13	65.00
Gangrenous changes with numbness	3	15.00
Gangrenous changes with burning sensation of feet	4	20,00
Gangrene with auto amputation	1	5,00

Duration of foot lesion

Among symptomatic group only 12 patients had foot lesion rest 8 were without foot lesion but symptoms of ischemia were present. Maximum patients presented with more than 4 weeks duration of foot lesion (Table 7).

Table 7: Distribution of patients according to duration of foot lesion (no, of patients = 12).

Duration	No. of patients	Percentage
<4 weeks	2	16.60
4-8 weeks	5	41.50
>8 weeks	5	41.50

Analysis of peripheral pulses

In controls

In all controls, popliteal, tibialis posterior and dorsalis pedis arterial pulsations were felt on palpation as well as recorded by doppler.

In diabetics without ischemic symptoms

Pulsations in all the three arteries were felt on palpation as well as recorded by doppler.

In diabetics with ischemic symptoms

Popliteal artery pulsations were present in all patients, on palpation as well as recorded by Doppler.

Clinically tibialis posterior was not palpable in two patients, one on right side and in another on left side, one was confirmed by doppler. Clinically Dorsalis pedis was absent in 6 patients, in 4 patients on right side and in 2 patients on left side, 4 cases could be detected by doppler.

Blood sugar analysis

Table 8: Blood sugar in diabetics with ischemic symptoms (no. of patients=20).

Fasting blood sugar (mg%)	No. of patients	%
120-180	2	10.00
181-240	4	20.00
241-300	9	45.00
>300	5	25.00

As shown in the above table in symptomatic group, most of the patients (45%), blood sugar levels were between 241-300 mg% and then 25% were having >300 mg% and 20% were in between 181-240 mg% (Table 8).

Table 9: Blood sugar in diabetics without ischemic symptoms (no. of patients=20).

Fasting blood sugar (mg%)	No. of patients	%
120-180	3	15.00
181-240	12	60.00
>240	5	25.00

As shown in above table, in most of the patients (60%) blood sugar level was between 181-240 mg%, 25% patients era having more than 240 mg% and 15% were having in between 120-180 mg%. In controls, fasting blood sugar level was within normal limits. It ranged from 76 mg% to 90 mg% (Table 9). Doppler wave form recording was analyzed in the form of peak forward velocity, acceleration and deceleration. For qualitative analysis, wave patterns were analyzed, which may be monophasic, biphasic or triphasic.

Table 10: Doppler wave pattern in control and diabetics without symptoms (right side).

Artery	Wave pattern	Control		Diabetics	
		No.	%	No.	%
Popliteal	Monophasic	-	-	1	5.00
	Biphasic	2	20.00	11	55.00
	Triphasic	8	80.00	8	40.00
Dorsalis pedis	Monophasic	-	-	1	5.00
	Biphasic	2	20.00	14	70.00
	Triphasic	8	80.00	4	20.00
Tibialis posterior	Monophasic	-	-	1	5.00
	Biphasic	3	30.00	15	75.00
	Triphasic	7	70.00	4	20.00

In controls, mostly wave was triphasic, while in diabetics without symptoms there were biphasic and triphasic (Table 10).

In controls, mostly waves were triphasic. While in diabetics with symptoms monophasic and biphasic waves were found, except in popliteal artery where mostly waves were biphasic and triphasic.

Table 11: Doppler wave pattern in control and diabetics with symptoms (right side).

Artery	Wave pattern	Control		Diabetics	
		No.	%	No.	%
Popliteal	Monophasic	-	-	4	20.00
	Biphasic	2	20.00	10	50.00
	Triphasic	8	80.00	6	30.00
Dorsalis pedis	Monophasic	-	-	13	72.20
	Biphasic	2	20.00	4	22.22
	Triphasic	8	80.00	1	5.55
Tibialis posterior	Monophasic	-	-	11	55.00
	Biphasic	3	30.00	7	35.00
	Triphasic	7	70.00	2	10.00

In two cases there was complete absence of blood flow in dorsalis pedis artery (Table 11).

Table 12: Doppler wave pattern in control and diabetics with symptoms (left side).

Artery	Wave pattern	Control		Diabetics	
		No.	%	No.	%
Popliteal	Monophasic	-	-	4	20.00
	Biphasic	1	10.00	10	50.00
	Triphasic	9	90.00	6	30.00
Dorsalis pedis	Monophasic	-	-	13	65.00
	Biphasic	3	30.00	7	35.00
	Triphasic	7	70.00	-	-
Tibialis posterior	Monophasic	-	-	13	68.40
	Biphasic	4	40.00	5	26.20
	Triphasic	6	60.00	1	5.26

Table 13: Doppler wave pattern in diabetics without and with symptoms (right side).

Artery	Wave pattern	Without symptoms		With symptoms	
		No.	%	No.	%
Popliteal	Monophasic	1	5.00	4	20.00
	Biphasic	11	55.00	10	50.00
	Triphasic	8	40.00	6	30.00
Dorsalis pedis	Monophasic	2	10.00	13	72.20
	Biphasic	14	70.00	5	22.22
	Triphasic	4	20.00	2	5.55
Tibialis posterior	Monophasic	1	5.00	11	55.00
	Biphasic	15	75.00	7	35.00
	Triphasic	4	20.00	2	10. 00

In control, mostly waves were triphasic, while in diabetics with symptoms monophasic and biphasic waves were found, except in popliteal artery where mostly waves were biphasic and triphasic.

In one case, there was complete absence of blood flow in tibialis posterior artery (Table 12).

In diabetics, without symptoms mostly waves were biphasic and triphasic, while in diabetics with symptoms mostly waves were monophasic and biphasic except in popliteal artery where wave pattern was similar to asymptomatic group. In symptomatic group in two patients there was complete absence of blood flow in dorsalis pedis artery (Table 13).

DISCUSSION

In India, it has been estimated that approximately 2-3% of the population suffers from diabetes. Based on study of 40 diabetic patients, out of which 20 patients were with ischemic symptoms and rest 20 were without ischemic symptoms. 10 subjects were also included as controls who were similar to physical characters of the diseased subjects. In the symptomatic, group male and female ratio was 14:6 giving a percentage of 70% and 30% respectively (Table 1). While in asymptomatic group, male and female ratio was 13:7 giving percentage of 65% and 30% respectively (Table 1). It was found that over all incidence of foot involvement amongst the diabetics was maximum in 6th decade of life (60.3%) (Table 2). There is relatively earlier involvement of the foot amongst the diabetics in our country than westerns. Almost all cases with foot lesion had diabetes of more than 5 years of duration, but in two cases exact duration was not known because at the time of presentation of foot lesion, they were diagnosed as diabetics. Author also observed that foot lesions are commonly seen in known diabetics (Table 4). This is probably due to earlier occurrence of peak incidence of Type 2 diabetes, decreased longevity of diabetics and to a greater exposure of feet to trauma in rural India due to their habit of walking bare foot most of the time. In the west, diabetic foot lesions are more commonly seen beyond the age of 60 years (Oakley et al, Goldenberg et al) and females are conspicuously few (6.6%), this is possibly due to less exposure of females to trauma as they have less outdoor activities.[6,8] In this study in symptomatic group of patients, out of 20 patients 12 had foot lesion in which 3 patients (25%) were female (Table 6). Oakley et al, and Moore et al, havereported the similar findings.[6,7] In this study, peak incidence of diabetic foot lesion was 6th decade and about 20% of female patient had foot lesion. In this study, the mean duration of disease in diabetic with ischemic symptoms was 9.6 years, while in asymptomatic group it was 6.9 years. It showed that as duration of disease increases, there is more probability for appearance of ischemic symptoms and foot involvement. Keiding et al, reported that duration of disease is well established factor in development of ischemic symptoms.[9] Janka JW et al, showed duration seems to be a greater risk factor.[10] In this study, author have also noted that in symptomatic

group most of the patients were taking irregular treatment (Table 5). So, the patients with the more than 5 years duration of disease are prone to develop ischemic symptoms especially if irregular treatment is taken. In this study, patients who presented to us with foot lesion, duration varied from 2 weeks to more than 8 weeks. Usually in most of the patient's duration of foot lesion was more than 4 weeks (Table 7). In this study, the involvement of toes and dorsum of foot (66.4%) was commonly observed, toes were involved in 33.2% of cases, sole was involved only in one patient and in three patient's involvement was up to mid foot. On both aspects in one patient involvement was up to ankle. Author have not come across any literature by which author can compare extent of foot involvement. Out of 12 patients with foot lesion, 9 patients (75%) presented as nonhealing ulcer followed by 5 patients (41.5%) with frank gangrene along with ulcer (Table 8). Clinically popliteal artery was palpable in all the diabetic with or without ischemic symptoms. Same findings were also observed on doppler tracings, which also confirms that in diabetics larger arteries were less commonly involved in comparison to smaller arteries. Bell showed in his study that vessels more frequently involved in diabetics are tibialis posterior, dorsalis pedis and peroneal.[11]

Huljev et al, concluded that Doppler's methods are very accurate in way of diagnostical interpretation.[12] Color doppler sonography is an accurate non-invasive method for evaluating the patient with peripheral ischemic disease.[13]

Stasi et al, found in their study that color Doppler ultrasonography is a first-choice instrumental examination for the diagnosis and staging of peripheral arterial occlusive disease in diabetic patients.[14] Finally, the vascular status determines the outcome of ulcer or gangrene. In the symptomatic diabetics, peripheral neuropathy was present in 35% of patients and autonomic neuropathy in 20% of patients. While in asymptomatic group it was 25% and 10% respectively. Calcification of tunica media is common in long standing diabetes and commonly affects the vessels of foot. This is a widely accepted view that the significant degree of nerve damage is likely to occur in uncontrolled or poorly controlled diabetes.

This was corroborated by clinical study of Rudy A et al, they observed that neuropathy is improved by satisfactory control of blood sugar.[16] Indirectly this also supports the findings, history and examination are the most important means of assessing the peripheral vascular disease. Vascular study may give additional information.

Quantitatively calcification is also increased in diabetics. In this study, author have found calcification in 20% of patients in symptomatic diabetics while calcification was not found in asymptomatic group. Here, in symptomatic group family history was present in 9 patients, while asymptomatic cases it was present in 7 cases. Ole et al, used xenon 133 for blood flow assessment and Alexander et al, have used plethysmography for assessment of the fore arm blood flow.[16] Arteriography is another important means of assessing the vascular status and condition of arteries. For the first time Franklin DL et al, described an ultrasonic flow meter based on Doppler effect.[17] Thus, in progressive occlusion gradually all these parameters decrease. The qualitative analysis was done by analyzing the wave patterns (Table 11 to 14). The qualitative wave form analysis showed that in all the three arteries of both limbs, most of the waves were triphasic (80.90%) in control group. While in diabetics without ischemic symptoms mixed patterns of biphasic and triphasic waves were found, however there were more biphasic waves (55.75%) in all three arteries of both limbs. In diabetics with ischemic symptoms mixed patterns of biphasic and monophasic waves were found in dorsalis pedis and tibialis posterior arteries of both the limbs, however there were more of monophasic waves (55-72.2%). In this group in popliteal artery, mostly waves were biphasic (50%) and triphasic (30%) in both limbs (Table 11 and 13).

CONCLUSION

On the basis of the clinical and investigative evaluation (including color doppler flowmetry) of 40 cases (20 diabetics without ischemic symptoms and 20 diabetics with ischemic symptoms) along with 10 controls, the following conclusions can be drawn: In both groups maximum patients (80-90%) are in age group of 40-60 years, in which males are predominantly affected as compared to females. Foot involvements among the symptomatic diabetics are maximum in 6th decade (60.3%). Duration of disease and treatment irregularity are important factors, as in symptomatic group average duration was 9.5 years with the patients taking irregular treatment, while in asymptomatic group it was 6.4 years and most of them were on regular treatment. The accuracy of doppler is more in comparison to clinical examination, as on clinical examination dorsalis pedis artery was not palpable in 6 patients while on doppler ultrasound flow was detected in 4 patients. In diabetics all the three parameters, the peak forward velocity, acceleration, deceleration is decreased, and these values are more marked in symptomatic diabetics. In diabetics without ischemic symptoms, most of the doppler wave patterns are triphasic and biphasic, while in diabetics with ischemic symptoms biphasic and monophasic waves are predominantly seen. But it was not applicable for the popliteal artery, where most of the waves were triphasic and biphasic. Here, author have concluded that dorsalis pedis and tibialis posterior are affected more than the popliteal artery. The limitation of the study was that this was a cross sectional study of those patients who already presented with risk factors and could be followed up for a period of many years. This work has more relevance as far as the developing countries are concerned where majority of the population do not have access of sophisticated investigations. This simple non-invasive

investigation might be of great help to patients with peripheral vascular disease.

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