

Study of Peripheral Vascular Disease in Patients with Diabetic Foot using Doppler Ultrasound

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Abstract

Objective: The objective of the study was to determine the extent of vasculopathy in patients with diabetic foot using Doppler ultrasound scanning.

Methodology: This descriptive study was carried out in surgical wards SS Medical College and SGMH Rewa from June 1, 2017, to May 31, 2018. All patients having diabetic foot complications including abscess formation, cellulitis, ulceration, and gangrene were included in the study after taking informed consent. Peripheral pulses such as posterior tibial, dorsalis pedis, and popliteal arteries were checked. The presence of vasculopathy was checked with Doppler scanning of dorsalis pedis artery, posterior tibial artery, and popliteal artery. The data were collected on a pro forma that was especially designed for this study.

Results: A total of 115 patients were included in this study. Out of total cases of the diabetic foot, 21% of cases peripheral pulses were not palpable, 30% of cases were weakly palpable, and in 50% of cases were palpable. In right affected limb out of 66 affected limb, peripheral pulses were palpable in 45% of cases, weakly palpable in 32% of cases, and absent in 23% of cases and left affected limb out of 49 affected limb peripheral pulses were palpable in 55% of cases, weakly palpable in 26% of cases, and absent in 19% of cases, with a male preponderance.

Conclusion: This study shows that vasculopathy is a strong independent risk factor in the development of diabetic foot lesions. The usual symptoms and signs of lower limb ischemia may not be present and indeed may be misleading in diabetic foot disease.

Key words: Diabetic foot, Color Doppler, Peripheral vascular disease

INTRODUCTION

Non-communicable diseases such as diabetes, hypertension, and cardiovascular diseases have been emerging as major causes of morbidity and mortality worldwide in the past few decades.

Infection, ulceration, and Gangreen in the foot are the complications among people with diabetes along with huge challenge in terms of physical as well as socioeconomic burden to both the patient and the health-care system.

The International Diabetes Federation atlas reported that the number of people with diabetes was approximately 366 million in 2011, and by the year 2030, this number would have risen to 552 million. It is also estimated that approximately 80% of people with diabetes live in low- and middle-income countries, which are designated as the developing economies in the world. These alarming numbers predict the future burden of associated complications arising due to diabetes worldwide, especially in the low- and middle-income countries.

Patients with diabetes mellitus are more likely to develop severe forms of angiopathies at an earlier age compared with their nondiabetic counterparts.

Diabetic foot is one of the major complications in diabetic patients. People with diabetes are 20 times more likely to undergo an amputation than the rest of the population.

At present, there is a clear need to diagnose peripheral vascular angiopathies in settings of primary health care.

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The unreliable nature of the symptoms and signs of the lower limb arterial insufficiency in diabetes means that non-invasive tests are essential to achieve effective screening.

The main risk factors for the development of diabetic foot disease are peripheral neuropathy and peripheral arterial occlusive disease. The detection of significant arterial disease is vital to the prevention and treatment of diabetic foot complications.

Doppler US is a non-invasive technique that does not require contrast, patient preparation before the study, or radiation exposure hazards. It is a good method for screening and follow-up, as well as for the definitive diagnosis.

Thus, the objective of this study was to discuss the characteristics of lower limb vascular angiopathy and plaque formation in diabetic patients and finding its relevance to, the clinical diagnosis and directing further management.

METHODOLOGY

All diabetic patients admitted in surgical wards of Shyam Shah Medical College and associated Sanjay Gandhi Memorial Hospital, Rewa for treatment of diabetic foot complications from June 1, 2017, to May 31, 2018, included in this study.

Informed consent was obtained in all cases. Detailed history was recorded such as family history of diabetes, history of smoking, symptoms of peripheral vascular disease, history of any foot trauma, and ill-fitting shoes.

Clinical examination included a complete inspection of the feet and legs noting the shape, any deformity, site, and extent of foot lesions and evidence of gangrene. Peripheral pulses such as posterior tibial and dorsalis pedis were palpated.

Diabetic foot grading was done on the basis of The Meggitt-Wagner classification (1981).

Table Meggitt-Wagner Classification

| Wagner's Presentation Grading | |
|-------------------------------|---|
| O | Pre-ulcerative lesions, healed ulcers, presence of bony deformity |
| I | Superficial ulcer without subcutaneous tissue involvement |
| II | Penetration through the subcutaneous tissue; may expose bone, tendon, ligament of joint capsule |
| III | Osteitis, abscess, or osteomyelitis |
| IV | Gangrene of digit |
| V | Gangrene of foot requiring disarticulation |

The presence of vasculopathy was checked with Doppler scanning of dorsalis pedis artery (DPA) and posterior tibial artery (PTA). The examination was usually performed with the patient placed in the supine position. The patient's hip was generally abducted and externally rotated, and the knee was flexed like frog legs to easily approach the PTA in the medial calf.

The PTA is seen along the tibia at the medial side of the posterior calf and behind the medial malleolus of the ankle, and DPA distal to the ankle and metatarsal artery between the metatarsal bones transducer of ultrasound was placed over an artery for transverse scanning, and then is rotated 90° for longitudinal scanning. Pulsed-wave Doppler US is performed in the longitudinal plane.

Qualitative waveform analysis was performed by visual interpretation of continuously displayed waveforms.

If Doppler ultrasonography was triphasic, it was graded as normal biphasic as mild, monophasic as moderate and no sound was heard then the severe grade of vasculopathy.

Thus, we observe the presence of a degree of stenosis in the lower limb arteries with the help of pulse waveform ultrasonography and results were calculated and tabulated accordingly.

RESULTS

It is evident from Table 1 that the right lower limb is maximum affected by diabetes (51.30%). Out of 7 bilateral cases, the patient is having mainly symptom in right limbs.

It is evident from Table 2 that ulcer was the most common complication in diabetic foot patient (48.69%).

Table 1: Distribution of cases according to the affected lower limb by diabetes

| S. No. | Affected lower limb | No. of cases (%) |
|--------|---------------------|------------------|
| 1 | Right | 59 (51.30) |
| 2 | Left | 49 (42.60) |
| 3 | Bilateral | 7 (6.08) |
| Total | | 115 (100) |

Table 2: Distribution of cases according to the complication of diabetic foot

| S. No. | Complications | No. of cases (%) |
|--------|---------------|------------------|
| 1 | Abscess | 23 (20) |
| 2 | Cellulitis | 23 (20) |
| 3 | Ulcer | 56 (48.69) |
| 4 | Gangrene | 49 (42.60) |

It is evident from Table 3 that in right PTA 58% cases were of without any obstruction, 21% were with mild obstruction, 13% were with moderate, and 7% with severe obstruction were present.

Similarly in left PTA 52% cases were of without any obstruction, 31% were with mild obstruction, 14% were with moderate, and 3% with severe obstruction were present.

It is evident from Table 4 that in right DPA 30% cases were of without any obstruction, 26% were with mild obstruction, 20% were with moderate, and 24% with severe obstruction were present.

Similarly in left DPA 30% cases were of without any obstruction, 24% were with mild obstruction, 29% were with moderate, and 16% with severe obstruction were present.

It is evident from Table 5 that in case of the right affected limb 44% cases were of without any obstruction, 20% were with mild obstruction, 22% were with moderate, and 14% with severe obstruction were present.

Similarly in left affected limb 39% cases were of without any obstruction, 37% were with mild obstruction, 18% were with moderate, and 6% with severe obstruction were present.

It is evident from Table 6 that in case of the right affected limb 44% cases were of without any obstruction, 20% were

with mild obstruction, 22% were with moderate, and 14% with severe obstruction were present.

Similarly in left affected limb 39% cases were of without any obstruction, 37% were with mild obstruction, 18% were with moderate, and 6% with severe obstruction were present.

It is evident from Table 7 that in the right affected limb out of total cases 14 cases were present with Grade V diabetic foot, in which 1 case present with moderate obstruction, remaining 13 were present with severe obstruction. Maximum number of cases was presented with Grade II diabetic foot in which 14 cases were present without any obstruction, 7 cases were present with mild obstruction, 9 cases were present with moderate obstruction, and 6 cases were of severe obstruction.

It is evident from Table 7b that in the right affected limb out of total 8 cases were present with Grade V diabetic foot, in which 1 case was present with mild obstruction, 1 case was present moderate obstruction, and remaining 6 were present with severe obstruction. A maximum number of cases were presented with Grade II diabetic foot in which 15 cases were present without any obstruction, 13 cases were present with mild obstruction, 9 cases were present with moderate obstruction, and 5 cases were of severe obstruction.

It is evident that in right affected limb out of 66 affected limb peripheral pulses were palpable in 45% of cases,

Table 3: Distribution of cases according to Doppler ultrasound finding in posterior tibial artery

| S. No. | Flow | Obstruction | Right limb | Left limb |
|--------|------------|-------------|------------------|------------------|
| | | | No. of cases (%) | No. of cases (%) |
| 1 | Triphasic | No | 67 (58) | 60 (52.17) |
| 2 | Biphasic | Mild | 25 (21) | 36 (31.30) |
| 3 | Monophasic | Moderate | 15 (13.04) | 16 (13.91) |
| 4 | No | Severe | 8 (6.9) | 3 (2.60) |
| Total | | | 115 (100) | 115 (100) |

Table 4: Distribution of cases according to Doppler ultrasound finding in dorsalis pedis artery

| S. No. | Flow | Obstruction | Right limb | Left limb |
|--------|------------|-------------|------------------|------------------|
| | | | No. of cases (%) | No. of cases (%) |
| 1 | Triphasic | No | 35 (30.43) | 34 (29.56) |
| 2 | Biphasic | Mild | 30 (26.08) | 28 (24.34) |
| 3 | Monophasic | Moderate | 23 (20) | 34 (29.56) |
| 4 | No | Severe | 27 (23.47) | 19 (16.52) |
| Total | | | 115 (100) | 115 (100) |

Table 5: Distribution of cases according to Doppler finding of a posterior tibial artery in the affected limb

| S. No. | Doppler findings (degree of stenosis) | Affected limb right n=59 | Affected limb left n=49 |
|--------|---------------------------------------|--------------------------|-------------------------|
| | | No. of cases (%) | No. of cases (%) |
| 1 | No | 26 (44.06) | 19 (38.77) |
| 2 | Mild | 12 (20.33) | 18 (36.73) |
| 3 | Moderate | 13 (22.03) | 9 (18.36) |
| 4 | Severe | 8 (13.55) | 3 (6.12) |
| Total | | 59 (100) | 49 (100) |

Table 6: Distribution of cases according to Doppler finding of dorsalis pedis artery in affected limb

| S. No. | Doppler findings (degree of stenosis) | Affected limb right n=59 | Affected limb left n=49 |
|--------|---------------------------------------|--------------------------|-------------------------|
| | | No. of cases (%) | No. of cases (%) |
| 1 | No | 06 (10.1) | 08 (16.3) |
| 2 | Mild | 14 (23.3) | 10 (20.4) |
| 3 | Moderate | 13 (22.03) | 16 (32.6) |
| 4 | Severe | 25 (42.3) | 15 (30.6) |
| Total | | 59 (100) | 49 (100) |

Table 7: Distribution of cases according to Doppler findings and diabetic foot grading

| Grading of diabetic foot | (a) Affected limb right side | | | | (b) Affected limb is left | | | |
|--------------------------|--------------------------------------|------|----------|--------|--------------------------------------|------|----------|--------|
| | Doppler finding (degree of stenosis) | | | | Doppler finding (degree of stenosis) | | | |
| | No | Mild | Moderate | Severe | No | Mild | Moderate | Severe |
| 0 | 2 | 2 | 3 | - | 1 | 5 | 2 | - |
| 1 | 7 | 8 | 6 | 2 | 6 | 3 | 5 | - |
| 2 | 14 | 7 | 9 | 6 | 15 | 13 | 9 | 5 |
| 3 | 4 | 2 | 1 | 1 | 1 | 1 | - | - |
| 4 | 5 | 7 | 6 | 10 | 4 | 5 | 8 | 7 |
| 5 | - | - | 1 | 13 | - | 1 | 1 | 6 |

weakly palpable in 32% of cases and absent in 23% of cases.

It is evident that in left affected limb out of 49 affected limb peripheral pulses were palpable in 55% of cases, weakly palpable in 26% of cases. and absent in 19% of cases.

It is evident from Table 9 that conservative management was done in 15 patients (13.04%), debridement done in 35 (30.43%) cases, incision and drainage 8 (6.9%) cases, relaxing incision in 13 (11.30%) cases, disarticulation was done in 32 (27.82%) cases, and amputation was done in 12 (7.7%) cases [Table 8].

DISCUSSION

The subjective study of arterial assessment, i.e., feeling the pulses is not reliable. In our study, Doppler ultrasound finding showing 58% of cases of rt PTA found triphasic flow with no obstruction, 21% of cases of rt PTA found biphasic flow with mild obstruction, and 13.04% and 6.9% of cases of rt PTA found with monophasic and without any flow, respectively. In left PTA, we found that 52.17% cases were with the triphasic flow, 31.30% with biphasic flow, 13.91% with monophasic flow, and 2.60% without any flow in Lt PTA.

In respect to DPA in rt, DPA 30.43% of cases found triphasic flow. 26.08% case found biphasic flow, 20% found monophasic flow, and 23.47% cases were found without any flow. In left DPA we found that 29.56% cases were with the triphasic flow, 24.34 cases with biphasic flow, 29.56% with monophasic flow, and 16.52% were present without any flow in Lt DPA.

These findings were asymmetrical and they were mostly found in the affected limbs with male preponderance.

Richards-George^[1] in his paper about vasculopathy on Jamaican diabetic clinic attendees showed that Doppler measurement of ankle-brachial pressure index revealed that 23% of diabetics had a peripheral occlusive arterial disease which was mostly asymptomatic.

Table 8: Distribution of cases according to peripheral pulses

| S. No. | (a) In the right affected limb | | (b) In the left affected limb | |
|--------|--------------------------------|------------------|-------------------------------|------------------|
| | Peripheral pulses | No. of cases (%) | Peripheral pulses | No. of cases (%) |
| 1 | Palpable | 30 (45.45) | Palpable | 27 (55.1) |
| 2 | Weakly palpable | 21 (31.8) | Weakly palpable | 13 (26.5) |
| 3 | Absent | 15 (22.7) | Absent | 9 (18.3) |
| Total | | 66 (100) | | 49 (100) |

Table 9: Distribution of cases according to modes of treatment

| S. No. | Mode of treatment | No. of cases (%) |
|--------|-----------------------|------------------|
| 1 | Conservative | 15 (13.04) |
| 2 | Surgical | 100 (86.95) |
| 3 | Debridment | 35 (30.43) |
| 4 | Incision and drainage | 8 (6.9) |
| 5 | Ralxing incision | 13 (11.30) |
| 6 | Disarticulation | 32 (27.82) |
| 7 | Amputation | 12 (7.7) |

Berry *et al.*^[2] used Doppler flow volume to show a 29% reduction in systemic arterial compliance.

Rydén Ahlgren *et al.*^[3] also showed increased arterial stiffness among women with Type-I diabetes.

In our study in the right affected limb, PTA 44% of cases were present without obstruction, and 12% of cases were present with severe obstruction, whereas in left affected PTA artery 38% cases were present without any obstruction, and 6% cases were present with severe obstruction, showing that right-sided PTA is more severely obstructed than left PTA.

Similarly, in the right affected limb, DPA 10% of cases were present without obstruction and 40% of cases were present with severe obstruction, whereas in left affected DPA artery 16% cases were present without any obstruction, and 30% cases were present with severe obstruction, showing that right-sided DPA is more severely obstructed than left DPA.

In our study, maximum number of cases was belong to Grade II diabetic foot 35.65%. In the right affected limb, maximum numbers of cases were presented with Grade II diabetic foot in which 14 cases were present without any obstruction, 7 cases were present with mild obstruction, 9 cases were present with moderate obstruction, and 6 cases were of severe obstruction.

Similarly in left affected limb, maximum numbers of cases were presented with Grade II diabetic foot in which 15 cases were present without any obstruction, 13 cases were present with mild obstruction, 9 cases were present with moderate obstruction, and 5 cases were of severe obstruction.^[4]

Narsirhan *et al.* (2000) in their found that majority of the patients had Grade II and Grade III of diabetic foot.

Van Acker *et al.*^[5] found in their study of 253 patients of the diabetic foot that 57.3% of cases were of Grade I and 15.8% of Grade II, 17% of Grade III, and 9.9% of Grade IV.

In our study, out of total cases of diabetic foot 21% of cases, peripheral pulses were not palpable, 30% of cases were weakly palpable and in 50% of cases were palpable.

It is also found that in the right affected limb, out of 66 affected limb peripheral pulses were palpable in 45% of cases, weakly palpable in 32% of cases, and absent in 23% of cases and in left affected limb out of 49 affected limb peripheral pulses were palpable in 55% of cases, weakly palpable in 26% of cases, and absent in 19% of cases.

In comparison with Doppler finding which shows in affected rt PTA, 55% of cases were found with stenotic changes in vessels and 60% of cases of affected left PTA were found with stenotic changes. Similar finding was present with DPA.

It shows that Doppler ultrasonography helps in early diagnosis and early treatment of diabetes foot as a screening tool in the health-care system.

In a study done by Rahman *et al.*^[6] found results that clinically the pulses were weakly palpable 33.33% and absent in 23.33% patients. However, Doppler ultrasonography, which assesses the blood flow revealed that in 56.67% cases the DPA and in 63.33% the PTA were involved.

In the study, at last, treatment was planned according to the mode of presentation of diabetic foot and severity of stenosis of peripheral arteries. In study conservative management was done in 13% cases, debridement was done in 30.43% cases, incision was done in drainage 6.9% cases, relaxing incision was done in 11.30% cases, disarticulation was done in 27.82% cases, and amputation was done in 7.7% cases.

Manes *et al.*^[7] found results in their study of 58 cases of diabetes foot with osteomyelitis three patients required major amputation, 13 cases had disarticulation. Majority of patients underwent simple surgical debridement of soft tissue and bones.

CONCLUSION

Vasculopathy is a strong risk factor in the development of diabetic foot lesions. The usual symptoms and signs of lower limb ischemia may not be present and indeed may be misleading in diabetic foot disease.

The presence of diabetic microvascular disease imparts even greater importance on the early detection and treatment of significant macrovascular disease. Laboratory vascular assessments are an important aid in detecting lower limb vascular disease. It is important to identify and quantify the role of vasculopathy, to plan effective strategies for preventing or delaying foot complications, especially its fatal outcome, i.e., amputation.

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