# Vascular profile in Malaysian patients with diabetic foot complications

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**Abstract**

The early and perhaps ongoing misconception that the ischaemic component of diabetic foot complications is due to microvascular occlusive disease, only treatable by amputation has made foot complications one of the most feared complications of diabetes. Recent studies in Western populations have challenged the place of microvascular disease and favour macrovascular disease in the pathogenesis of the diabetic foot.

A study was performed to evaluate the place and extent of macrovascular arterial occlusive disease in Malaysian diabetic patients with foot complications utilizing non-invasive means of arterial pulse examination, arterial doppler ulrrasound examination and measurement of ankle brachial index.

Arterial pulse and doppler examination were abnormal in a higher proportion of the limbs with the foot lesion compared to that of the contralateral limb. There was however no difference in the mean ankle brachial index between the limbs with the foot lesion and the contralateral limbs.

These findings suggest that there is some degree of macrovascular arterial occlusive disease affecting Malaysian patients with diabetic foot complications and that ankle brachial indices may be spuriously elevated even in the presence of ischaemia.

Keywords: diabetic foot, diabetic complications, macrovascular disease

## Introduction

Diabetes is a common disease and its prevalence rate in Malaysia has increased from 6.3% in 1986 to 14.6% in 1996 (Khabier *et al.*, 1996). The prevalence of foot ulceration has been reported as 5% (Neil *et al.*, 1989) and 7.4% (Walters *et al.*, 1992) in community based studies in the United Kingdom. Foot complications were found to account for 12% of all diabetic hospital admissions which in turn made up 17% of all hospital admissions at Hospital Kuala Lumpur, Malaysia (Khalid, 1988).

The diabetic foot is one of the most feared of, diabetic complications because of the early and perhaps the misconception thar it is largely due to microvascular disease and treatable only by amputation. This was due to the identification of periodic acid schiff (PAS) positive material in the lumen of muscle capillaries on light microscopy (Goldenberg *et al.*, 1959). Predilection for macrovascular occlusive disease to affect the tibial and distal arteries in diabetics, which could not be visualized by early arteriographic techniques, portrayed no distal run off and thus the non-feasibility of peripheral arterial bypass.

The concept of occlusive arteriosclerotic microvascular disease, advocated initially by Goldenberg *et al.* (1959), has been challenged by histological studies (Strandness *et al.*, 1964), arterial casting studies (Conrad, 1967), and physiological studies of vasomotor response to vasodilator administration (Barner *et al.*, 1971) and reactive hyperaemia (Irwin *et al.*, 1988).

Sophisricated arteriographic and computer aided, digital subtraction techniques have now made visualization of macrovascular occlusive arterial disease in the distal tibial and pedal arteries possible (Gibbons *et al.*, 1995). The effect that macrovascular arterial occlusive disease can have in the pathogenesis of diabetic foot is now well recognized. Arterial revascularisation, even in the presence of foot sepsis have attained high limb salvage rates, and decreased amputation rates (Tanenbaum *et al.*, 1992; Chang *et al.*, 1996).

Two United Kingdom studies have reported that approximately 50% of diabetic foot patients had macrovascular arterial occlusive disease as a significant component in the pathogenesis (Edmonds *et al.*, 1986; Thomson *et al.*, 1991). However, a tecent study of diabetic foot patients in Thailand did not find that macrovascular disease was a significant risk factor (Sriussadaporn *et al.*, 1997). As there has not been any previously published study on the place and extent of macrovascular arterial occlusive disease on Malaysian diabetic foot patients, we sought to determine this through a prospective study using non-invasive methods of vascular assessment.

The objectives of this study were to determine the place and extent of macrovascular peripheral vascular occlusive disease in Malaysian patients with diabetic foot complications.

## Materials and Methods

Patients admitted to Hospital Kuala Lumpur, a metropolitan tertiary referral and teaching center, for treatment of diabetic foot lesions were included in the study. Their peripheral vascular system on the limbs affected by the foot lesion and the contralateral limbs were evaluated by clinical examination of the peripheral pulses, doppler signal examination with a portable hand-held doppler machine and an 8mHz probe, and determination of the Ankle Brachial Index (ABI). The peripheral pulses were graded as normal or abnormal (absent or faint), while the presence and character of audible doppler signals were graded as normal (triphasic signals) and abnormal (monophasic of absent). The ABI was calculated as the ratio of ankle to the brachial systolic blood pressure (taken as the average of brachial systolic blood pressures measured in the right and left arms).

The lesion affected limbs and contralateral limbs were compared to determine whether there was any difference in the evaluated parameters of vascular sufficiency. To determine whether there was a statistical significant difference in the proportion of abnormal pulses and doppler signals, between the lesion affected and the contralateral limbs, statistical analysis was performed only on patients with both limbs available for comparison. The patients who have had previous major amputation on their contralateral limbs were excluded.

The mean ankle systolic pressures and the mean ABI of the lesion affected limbs were compared for differences between those patients who underwent major amputation of the lesion affected limb and those patients who did not.

Statistical analysis was performed by personal computer with the SPSS (Statistical Package for the Social Sciences) programme utilizing the chi-squared test. A p value of less than or equal to 0.05 was considered as significant.

## Results

Thirty six consecutive patients admitted to Hospital Kuala Lumpur for the treatment of diabetic foot complications were included in the study. Their mean age was 56.4 years (range 31-73). There were 25 males (69.4%) and 11 females (30.6%). Foot complications for which the patients were admitted for, were, ulceration in 11 (30.6%), gangrene in 11 (30.6%), abscess in 9 (25%) and cellulitis in 5 (13.9%) patients.

Peripheral pulse examination and doppler signal assessment of the peripheral arteries were performed on 36 limbs that were affected by the diabetic foot lesion (lesion affected limbs) and 30 contralateral limbs. The remaining 6 contralateral limbs could not be assessed as they had been previously amputated. Of the 36 patients included, 7 required and eventually underwent major amputation of their lesion-affected limb. The remaining 29 patients needed either a local foot amputation or an incision and drainage procedure for the treatment of their diabetic foot lesion. Of the 7 patients who required and underwent major amputation, 3 had previously undergone major amputation of the contralateral limb. No patient was discharged without a surgical procedure being performed.

Of the 72 arteries (36 dorsalis pedis, 36 posterior tibial) examined for pulses on the 36 lesion affected limbs, 28 (38.9%) had abnormal pulses. Of the 60 arteries (30 dorsalis pedis, 30 posterior tibial) examined in the 30 contralateral limbs, 7(11.7%) had abnormal pulses (Table 1). The proportion of abnormal pulses found on the lesion affected limbs was higher than that of the contralateral limbs (38.9% vs. 11.7%) (Table 1).

Of the 108 arteries (36 dorsalis pedis, 36 posterior tibial, 36 peroneal) examined for doppler signals in the 36 lesion affected limbs, 63 (58.3%) had abnormal doppler signals (Table 2). Of the 90 arteries (30 dorsalis pedis, 30 posterior tibial, 30 peroneal) examined on the 30 contralateral limbs, 25 (27.8%) had abnormal doppler signals. The proportion of abnormal doppler signals found in the lesion affected limbs was higher than that of the contralateral limbs (58.3% vs. 27.8%) (Table 2).

Statistical analysis to determine whether there were significant differences in pulse and doppler abnormalities between the lesion affected limbs and contralateral limbs was performed in 30 patients who had undergone pulse and doppler signal examinations in both their lesion affected and contralateral limbs. Six patients who had previous major amputation in their contralateral limbs were excluded, as these were unavailable for comparison.

In these 30 patients where the lesion bearing and contralateral limbs were compared for the proportion of abnormal pulses, a higher proportion of abnormal pulses were found on the lesion affected limbs (dorsalis pedis, 60% vs. 16.7%; posterior tibial, 23.3% vs. 6.7%; total, 41% vs. 11.7%)(Table 3). The difference was statistically significant only for the dorsalis pedis pulse ($p = 0.007$), and for the total number of arteries examined for pulses ($p = 0.001$) (Table 3).

In these 30 patients where the lesion bearing and contralateral limbs were compared for the proportion of abnormal doppler signals, a higher proportion of abnormal doppler signals were found on the lesion affected limbs (dorsalis pedis, 76.7% vs. 16.7%; posterior tibial, 20% vs. 6.7%; peroneal 90% vs. 60%)(Table 4). This was statistically significant only for the dorsalis pedis doppler signal ($p = 0.001$) and for the total number of arteries examined for doppler signals ($p= 0.001$) (Table 4).

Of the 7 patients who underwent major amputation (3 having had previous major amputations in the contralateral limbs), a higher proportion of abnormal pulses were found on the lesion affected limb (dorsalis pedis, 71.4% vs. 50%; posterior tibial, 42.9% vs. 0%; total, 57.1% vs. 25%)(Table 5).

Of those 7 patients who underwent major amputation, a higher proportion of abnormal doppler signals were found on the lesion affected compared to the contralareral limb, (dorsalis pedis, 71.4% vs. 50%), (posterior tibial, 28.6% vs. 0%), (peroneal, 85.7% vs. 75%),

Table 1. Peripheral pulses in the lesion affected limb and contralateral limb

| Pulse | Lesion Affected Limb | | | Contralateral Limb | | |
|---|---|---|---|---|---|---|
| | Normal | Abnormal | Total | Normal | Abnormal | Total |
| Dorsalis Pedis | 16 (44.4%) | 20 (55.6%) | 36 (100%) | 25 (83.3%) | 5 (16.7%) | 30 (100%) |
| Posterior Tibial | 28 (77.8%) | 8 (22.2%) | 36 (100%) | 28 (93.3%) | 2 (6.7%) | 30 (100%) |
| Total (both arteries) | 44 (61.1%) | 28 (38.9%) | 72 (100%) | 53 (88.3%) | 7 (11.7%) | 60 (100%) |

Table 2. Doppler signals in the lesion affected limb and contralateral limb

| Pulse | Lesion Affected Limb | | | Contralateral Limb | | |
|---|---|---|---|---|---|---|
| | Normal | Abnormal | Total | Normal | Abnormal | Total |
| Dorsalis Pedis | 11 (30.6%) | 25 (69.4%) | 36 (100%) | 25 (83.3%) | 5 (16.7%) | 30 (100%) |
| Posterior Tibial | 29 (80.6%) | 7 (19.4%) | 36 (100%) | 28 (93.3%) | 2 (6.7%) | 30 (100%) |
| Peroneal | 5 (13.9%) | 31 (86.1%) | 36 (100%) | 12 (40%) | 18 (60%) | 30 (100%) |
| Total (three arteries) | 45 (41.67%) | 63 (58.33%) | 108 (100%) | 65 (72.2%) | 25 (27.8%) | 90 (100%) |

Table 3. Pulses in 30 patients in lesion affected and contralateral limbs showing p-values for differences in abnormal pulses between lesion affected and contralateral limbs

| Pulse | Lesion Affected Limb | | | Contralateral Limb | | | |
|---|---|---|---|---|---|---|---|
| | Normal | Abnormal | Total | Normal | Abnormal | Total | p value * |
| Dorsalis pedis | 12 (40%) | 18 (60%) | 30 (100%) | 25 (83.3%) | 5 (16.7%) | 30 (100%) | 0.007 |
| Posterior tibial | 23 (76.7%) | 7 (23.3%) | 30 (100%) | 28 (93.3%) | 2 (6.7%) | 30 (100%) | 0.96 |
| Total | 35 (58.3%) | 25 (41.7%) | 60 (100%) | 53 (88.3%) | 7 (11.7%) | 60 (100%) | 0.001 |

* Chi-square analysis, affected vs. contralateral limb

Table 4. Doppler signals in 30 patients in lesion affected and contralateral limbs showing p-values for differences in abnormal pulses between lesion affected limbs and contralateral limbs

| | Lesion Affected Limb | | | Contralateral Limb | | | |
|---|---|---|---|---|---|---|---|
| Pulse | Normal | Abnormal | Total | Normal | Abnormal | Total | p value* |
| Dorsalis pedis | 7 (23.3%) | 23 (76.7%) | 30 (100%) | 25 (83.3%) | 5 (16.7%) | 30 (100%) | 0.001 |
| Posterior tibial | 24 (80%) | 6 (20%) | 30 (100%) | 28 (93.3%) | 2 (6.7%) | 30 (100%) | 0.157 |
| Peroneal | 3 (10%) | 27 (90%) | 30 (100%) | 12 (40%) | 18 (60%) | 30 (100%) | 0.150 |
| Total | 34 (37.8%) | 56 (62.3%) | 90 (100%) | 65 (72.2%) | 25 (27.8%) | 90 (100%) | 0.001 |

* Chi-square analysis, affected vs. contralateral limb

Table 5. Pulses in lesion affected and contralateral limbs in 7 patients who had major amputation (3 patients had previous major amputation in contralateral limb)

| | Lesion Affected Limb | | | Contralateral Limb | | |
|---|---|---|---|---|---|---|
| Pulse | Normal | Abnormal | Total | Normal | Abnormal | Total |
| Dorsalis Pedis | 2 (28.6%) | 5 (71.4%) | 7 (100%) | 2 (50%) | 2 (50%) | 4 (100%) |
| Posterior Tibial | 4 (57.1%) | 3 (42.9%) | 7 (100%) | 4 (100%) | 0 (0%) | 4 (100%) |
| Total | 6 (42.9%) | 8 (57.1%) | 14 (100%) | 6 (75%) | 2 (25%) | 8 (100%) |

Table 6. Doppler signals in 7 patients who had major amputation (3 patients had previously undergone major amputation of the contralateral limb)

| | Lesion Affected Limb | | | Contralateral Limb | | |
|---|---|---|---|---|---|---|
| Pulse | Normal | Abnormal | Total | Normal | Abnormal | Total |
| Dorsalis Pedis | 2 (28.6%) | 5 (71.4%) | 7 (100%) | 2 (50%) | 2 (50%) | 4 (100%) |
| Posterior Tibial | 5 (71.4%) | 2 (28.6%) | 7 (100%) | 4 (100%) | 0 (0%) | 4 (100%) |
| Peroneal | 1 (14.3%) | 6 (85.7%) | 7 (100%) | 1 (25%) | 3 (75%) | 4 (100%) |
| Total | 8 (38.1%) | 13 (61.9%) | 21 (100%) | 7 (58.3%) | 5 (41.7%) | 12 (100%) |

(toral, 61.9% vs. 41.7%) (Table 6).

Peripheral pulse and doppler signal evaluation in this population of diabetic parienrs wirh foot complications showed a higher proportion of abnormal pulses and doppler signals in the lesion affected limb. In those 30 patients who had both lesion affected limbs and conrralateral limbs present for comparison, this was statistically significant (chi-squared test) for the dorsalis pedis pulse ($p = 0.007$), the dorsalis pedis doppler signal ($p = 0.001$), toral pulses examined ($p = 0.001$) and total doppler signals examined ($p = 0.001$).

On the 36 lesion affected limbs the mean ankle systolic blood pressure was 144.94 ± 19.2 mmHg (range 86-168 mmHg). The mean ABI on the lesion affected limbs was 1.15 ± 0.16 (range 0.66-1.56).

On the 30 contralateral limbs, the mean ankle systolic blood pressure was 142.93 ± 17.73 mmHg (range 90-164 mmHg). The mean ABI on the contralateral limbs was 1.15 ± 0.17 (range 0.69-1.63).

There was no statistically significant difference (chi square test, $p = 0.757$) in the mean ankle systolic pressure of the lesion affected limbs between the 7 patients who underwent major amputation (147.0 mmHg) and the 29 patients who did not do so (144.4mmHg).

There was also no statistical significance difference (chi square test, $p = 0.653$) in the mean ankle brachial index of the lesion affected limbs, between the 7 patients who underwent major amputation (ABI, 1.13) and the 29 patients who did not (ABI, 1.16).

## Discussion

The previous and perhaps, in some instances, ongoing misconception that diabetic foot complications were due to untreatable microvascular disease was previously responsible for therapeutic nihilism towards the entity. Recent srudies in Western populations have shown that macrovascular arterial occlusive disease has a significant role (approximately 50%) in the pathogenesis of the diabetic foot (Edmonds *et al.*, 1996; Thomson *et al.*, 1991). Arterial revascularisation procedures have been reported to attain good results in terms of limb salvage and decreased amputation rate (Tanenbaum *etal.*, 1992; Chang *et al.*, 1996).

Foot complications can be a substantial problem in the Malaysian diabetic population, being responsible for up to 12% of diabetic hospital admissions at Hospital Kuala Lumpur (Khalid, 1988). This study was therefore carried out to determine the presence and extent of macrovascular arterial occlusive disease in a population of Malaysian patients with diabetic foot complications.

Although relatively basic and non-invasive means were used to evaluate the lower limb arterial circulation these have been reported as being reliable. Stoflers *et al.* (1997) found clinical examination of the peripheral pulses reliable for rhe diagnosis of peripheral vascular disease. Bronzi *et al.* (1991) reported that evaluation of arterial doppler signal quality and character was of high sensitivity and specificity in the detection and localization of macrovascular occlusive arterial disease.

Ankle systolic blood pressures and ABIs are widely used as screening tests for disease of the peripheral arterial circulation (Gibbons *et al.*, 1995). However, between 5% and 10% of the total diabetic population have non-compressible peripheral vessels due to cystic medial calcification, resulting in spuriously, elevated ankle sysrolic pressures (Edmonds & Foster, 1996).

In the present study, macrovascular occlusive disease was found to affect both the lesion affected, and the contralateral limbs, registering abnormalities in 38.9% and 11.7%, of the toral pulses examined respectively, and abnormalities in 58.3% and 27.8% of the toral doppler signals examined respectively. The lesion affected limb was found to have a higher proportion of abnormal pulses and doppler signals compared to the contralateral limb. This was statistically significant for the total number of pulses examined, the total number of doppler signals examined, the dorsalis pedis pulse and dorsalis pedis doppler signal.

The posterior tibial artery was found to have a relatively higher proportion of normal pulses in the lesion affected limbs (80.6%) and contralateral limbs (93.3%), (Table 2); and also a relatively higher proportion of normal doppler signals in the lesion affected limbs (77.8%) and contralateral limbs (93.3%), (Table 2). The reason for this is not entirely clear but could possibly be the predilection for sparing of the posterior tibial artery by occlusive vascular disease in this diabetic population.

The mean ankle systolic pressures and ABIs did not significantly diffier between the lesion-affected limb and the contralateral limb. Neither was there a statistically significant difference in the ankle systolic pressure and ABI between those 7 patients who required and underwent a major amputation and those 29 patients who did not. This perhaps could be due to a substantial proportion of patients in the study population having cystic medial calcification, resulting in spuriously elevated ankle systolic pressures and thence ankle brachial indices.

The mean ABIs in the lesion affected limbs (1.15), the contralateral limbs (1.15), the lesion affected limbs of those requiring major amputation (1.13), and the lesion affected limbs of those not requiring major amputation (1.16), were greater rhan the 1.10 ascribed by Emmanuele *et al* (1981). These were closer to the 1.20 ascribed by Chantelau *et al.* (1990) to be associated with cysric medial calcification.

The lack of difference in ABIs between rhe lesion affected and contralateral limbs found in rhis study population, is similar to thar of a Thai diabetic foot study (Sriussadaporn *et al.*, 1997). Although somewhat speculative, perhaps a higher proportion of Asian diabetic patients are affected by cystic medial calcification than the 5-10% incidence quoted by Edmonds & Foster (1996). This could cause spurious elevations of ankle systolic pressures, resulting in no detectable differences in ABIs between the lesion affected and contralateral limbs in this study, as well as that of the Thai study of Sriussadaporn *et al.* (1997).

Based on a 50% prevalence of an ischaemic macrovascular component being present in diabetic foot complications (Edmonds *et al.*, 1986; Thomson *et al.*, 1991), and 5-10% prevalence of concomitant atherosclerosis in diabetic patients (Shigematsu, 1998), a sample size of 30 was statistically adequate for hypothesis tests for two population proportions (the two populations in this study being the lesion affected limb and the contralateral limb). With a 50% prevalence of an ischaemic macrovascular component in diabetic foot complications, a 5% and 10% prevalence of concomitant atherosclerosis in diabetics, a sample size of 21 and 15 respectively, is needed for testing at a significance level of 5% and test power of 90%. Limitations of the study were possible selection bias, the subjective nature of pulse and doppler signal evaluation, and ankle systolic pressure measurement.

Based upon pulse and doppler signal examination, the population studied was found to have a compromised macrovascular circulation in both the lesions affected limb and contralateral limb. This was worse in the lesion affected limb. Although the pathogenesis of diabetic foot complications is not entirely due to ischaemia, but to a complex interplay of neuropathy, ischaemia and infection, healing requires a pulsatile blood flow (Gibbons *et al.*, 1995). Perhaps the state of the arterial circulation in Malaysian patients with diabetic foot complications should be assessed with view, to the need for, and the feasibility of peripheral vascular reconstruction.

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