The diabetic foot in sub-Saharan Africa: A new management paradigm

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Article points

1. In Tanzania, the overall mortality rate among people with diabetic foot ulcers is 27%.
2. Lack of trained personnel and formal podiatry services, and limited financial resources all have a negative impact on the management of the condition.
3. The Step by Step Foot Project was created to reduce rates of lower limb complications in people with diabetes through improvements in educational skills and the management of diabetic foot problems

Key words

- Africa
- Peripheral neuropathy
- Peripheral vascular disease
- Diabetic ulcers and infection

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The incidence of diabetes mellitus is increasing in populations across Africa. A parallel increase in the incidence of foot complications in these populations has been documented (Abbas and Archibald, 2005). Factors associated with poor outcomes include delays in seeking medical attention and ulcers that have progressed to gangrene at the time of presentation.

Data from a recently published study (Step by Step Project) have demonstrated a marked improvement in diabetic foot care in less-developed countries through a formal program of education for healthcare professionals and people with diabetes in the management of diabetic foot problems. It is anticipated that interventions like the Step by Step Project that focus on the dissemination of education and learned skills among healthcare personnel (training the trainers) and patients alike will ultimately reduce the number of lower extremity amputations among people with diabetes and provide an innovative, sustainable paradigm for the prevention of diabetic foot complications in less-developed countries.

Diabetes mellitus reached epidemic proportions in much of the less-developed world over a decade ago and the number of people afflicted with the condition in these regions is projected to increase from 84 million in 2000 to 228 million by 2030 (Amos et al, 1997; Wild et al, 2004). As expected, incidence and prevalence rates have been increasing in many African countries and have largely been attributed to the increasing sedentary lifestyle and diet associated with urbanisation (Amos et al, 1997; McLarty et al, 1990).

Currently, there are 7–8 million individuals with diabetes resident on the African continent (McLarty et al 1990; Amos et al, 1997; Abbas et al 2002; Gulam-Abbas et al 2002; Wild et al, 2004; Abbas and Archibald, 2005). In the poorer African nations, high costs and a lack of trained medical personnel and facilities often preclude the institution of the diabetic foot management paradigm that is standard in Europe and North America. These limitations are compounded by the reality that diabetes already imposes a heavy burden on the health services in some African countries, where resources are already scarce or cut back. For example, nearly 4% of the annual healthcare budget in the Gambia is spent exclusively on the treatment of diabetes and in Tanzania, the total government expenditure on health as a percentage of total expenditure declined from 5% in 1988/89 to 2.8% in 1992/93; per capita health expenditure declined in Tanzania from about US$7 in 1980 to US$2 in 1992/93 (Rolfe et al, 1992; Msambichaka,

1997). The seriousness of the crisis is underscored by current estimates that sub-Saharan Africa is part of the world that will experience the greatest rise in diabetes prevalence over the next 20 years (Wild et al, 2004).

Foot complications in Africans with diabetes

In Africa, foot complications are the main cause of prolonged hospital stays for people with diabetes and are associated with substantial mortality, constituting a major public health problem (McLarty et al, 1990; Abbas et al, 2002; Gulam-Abbas et al, 2002; Abbas and Archibald, 2005). In Tanzania, the highest mortality rates are observed in people with severe gangrenous ulcers not treated with aggressive surgery (Gulam-Abbas et al, 2002).

The diabetic foot (defined as one or more of infection, ulceration or destruction of deep tissue in the lower limbs) is invariably associated with peripheral neuropathy and varying degrees of peripheral vascular disease, especially affecting the lower limb (International Working Group on the Diabetic Foot, 2007). Data from Tanzania show that 25% of people with diabetes attending a large diabetes clinic in Dar es Salaam had varying degrees of symptoms and signs of peripheral neuropathy and that the severity of symptoms was not associated with type or duration of diabetes, gender, age, peripheral vascular disease, alcohol consumption, literacy, or educational status (Abbas and Archibald, 2000). Data from other countries in sub-Saharan Africa have documented wide ranges in the occurrence of peripheral neuropathy, ranging from 4% in Zimbabwe to 69% in Nigeria (*Table 1*).

Table 1. Documented prevalence of peripheral neuropathy in sub-Saharan Africa. Adapted from Abbas and Archibald (2005) with permission.

Publication year	Author	Country	N	Prevalence of peripheral neuropathy (%)
2003	Moulik et al	Zambia	185	61
2000	Abbas et al	Tanzania	200	25.5
1997	Levitt et al	South Africa	300	27.6
1996	Nambuya et al	Uganda	252	46.4
1995	Lester	Ethiopia	43	50
1995	Gill et al	South Africa	64	42
1995	Elbagir et al	Sudan	128	37.5
1993	Lester	Ethiopia	1386	10.5
1992	Lester	Ethiopia	431	8
1991	Lester	Ethiopia	121	36.4
1991	Friend et al	Malawi	100	59
1991	El Mahdi et al	Sudan	413	31.5
1990	Akanji et al	Nigeria	50	68
1989	El Mahdi et al	Sudan	448	28.1
1988	Rolfe	Zambia	600	31.2
1987	McCance et al	South Africa	118	11.9
1984	Omar et al	South Africa	133	21.7
1984	Lester	Ethiopia	847	9.4
1984	Gill et al	South Africa	475	5.9
1983	Lester	Ethiopia	105	46.7
1980	Mhando et al	Tanzania	139	32.4
1977	Morley et al	South Africa	170	50
1976	Adetuyibi	Nigeria	52	69.6
1971	Osuntokum et al	Nigeria	832	49.2
1970	Belcher	Ethiopia	94	47
1968	Greenwood et al	Nigeria	240	58.3
1964	Haddock et al	Tanzania	116	31
1964	Goodall et al	Malawi	90	6
1963	Kinnear et al	Nigeria	309	33.3
1963	Gelfand et al	Zimbabwe	99	4
1961	Gelfand et al	Zimbabwe	150	6

More recent data suggest that peripheral vascular disease is an increasing problem among diabetes populations in various African countries (Abbas and Archibald, 2005): for example, rates of peripheral vascular disease in Tanzania have increased from 2.9% in 1980 to 12.5% in 1997 and reached 21% in 2002. Similarly, rates in Nigeria have increased from 1.7% in 1968 to 4.4% in 1971 and 54% in 1990 (Abbas and Archibald, 2005). Other published data on the occurrence of peripheral vascular disease in sub-Saharan Africa also show overall increasing trends (*Table 2*).

Although it is reasonable to conclude that the increasing occurrence of peripheral vascular disease in African individuals with diabetes is the natural progression of the condition and a manifestation of the increasing incidence of diabetes in the general population, changes in diet trends, increasing tobacco usage and atherosclerotic vascular disease are almost certainly important contributory risk factors, though the relative contribution of each of these risk factors remains uncharacterised.

While most reports from Africa suggest that diabetic foot lesions are more likely to be associated with neuropathy rather than vasculopathy, concomitant infections in the foot seem to play a critical role in the pathogenesis of foot ulcer disease, which can progress to systemic infection, necrosis, gangrene, loss of the limb or

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1. In sub-Saharan Africa, peripheral neuropathy is the principal underlying risk factor in the pathogenesis of foot ulcers in people with diabetes.
2. Unhygienic conditions and poverty are largely associated with foot ulceration.
3. In Tanzania, the overall mortality rate among people with foot ulcers is 27%.

death (Abbas and Archibald, 2005; Abbas et al, 2002; Gulam-Abbas et al, 2002). Diabetic foot infection is a limb-threatening complication and several studies have shown it to be the immediate cause of amputation in 25–50% of people with diabetes (Deerochanawong et al, 1992; Larsson and Apelqvist, 1995; Larsson et al, 1995; Abbas and Archibald, 2000; International Working Group on the Diabetic Foot, 2007).

Morbidity and mortality associated with foot ulceration in sub-Saharan Africa

In sub-Saharan Africa, peripheral neuropathy is the principal underlying risk factor in the pathogenesis of foot ulcers in people with diabetes (McLarty et al, 1990). In Tanzania, 100% of individuals who present with foot ulcers to the diabetes outpatient clinic had varying degrees of severity of peripheral neuropathy (Gulam-Abbas et al, 2002; Abbas and Archibald, 2000). Data from Gulam-Abbas' study shows that amputation is a frequent outcome (reported as 33%), is invariably associated with neuro-ischaemic lesions and progressive infection, and that the highest in-hospital mortality rate of 50% is observed in individuals with severe foot ulcers (Wagner grade >4) whose inpatient management did not include surgery with amputation (Gulam-Abbas et al, 2002).

Unhygienic conditions and poverty are largely associated with foot ulceration (Abbas and Archibald, 2000). For people with diabetes living at or below the poverty level, the purchase of appropriate footwear may not be feasible or of high priority (barefoot walking, a common practice in rural communities in Africa, is commonly associated with low income, but may be culturally influenced as well). In a report from the Gambia, Rolfe documented that wearing slippers or rubber 'flip-flops' instead of proper shoes led to increased risk of foot trauma – a primary antecedent for foot infections and foot ulcers (Rolfe et al, 1992).

Abbas and colleagues have further recorded some unusual examples of foot ulcerations among attendees at their outpatient clinic in Dar es Salaam, Tanzania. In particular, individuals with peripheral neuropathy were found to be at increased risk of acquiring rodent bites on their feet (see *Figure 1*). People with diabetes appear to be at greater risk from rodents than people without the condition (Abbas et al, 2005).

In Tanzania, the overall mortality rate among people with diabetic foot ulcers is 27% and is significantly higher among individuals with peripheral vascular disease, neuro-ischaemia or non-healing ulcers (Gulam-Abbas et al, 2002). In addition, those with foot ulcers that had progressed to gangrene (Wagner grade ≥4) were significantly more likely to have delayed presentation and to die compared with people with ulcers of a lesser severity (Gulam-Abbas et al, 2002).

Foot infection

Foot infections usually begin in foot ulcers that are sequelae of existing neuropathy, macro-vascular diseases or certain metabolic disturbances (Lipsky, 1999). Risk of infection is exacerbated by the decrease in cellular immunity caused by acute hyperglycaemia and circulatory deficits caused by chronic hyperglycaemia (Lipsky, 1999). Diabetic foot infection is a limb-threatening complication and several studies have shown it to be the immediate cause of amputation in 25–50% of

Table 2. Documented prevalence of peripheral vascular disease in sub-Saharan Africa. Adapted from Abbas and Archibald (2005) with permission.

Publication year	Author	Country	N	Prevalence of peripheral vascular disease (%)
2003	Moulik et al	Zambia	185	41
2002	Abbas et al	Tanzania	92	21
2000	Abbas et al	Tanzania	200	12.5
1997	Wikbald et al	Tanzania	153	12.5
1997	Levitt et al	South Africa	300	8.2
1995	Lester	Ethiopia	43	11.6
1995	Elbagir et al	Sudan	128	10
1991	Friend et al	Malawi	100	15
1991	El Mahdi et al	Sudan	413	3.4
1990	Akanji et al	Nigeria	50	54
1989	El Mahdi et al	Sudan	448	6.2
1988	Rolfe	Zambia	600	1.7
1987	McCance et al	South Africa	118	10.2
1984	Lester	Ethiopia	847	0.9
1984	Gill et al	South Africa	475	2.1
1980	Mhando et al	Tanzania	139	2.9
1971	Osuntokun et al	Nigeria	832	4.4
1970	Belcher	Ethiopia	94	1.1
1968	Greenwood et al	Nigeria	240	1.7
1963	Gelfand et al	Zimbabwe	99	0

Figure 1. Rat bites on the feet of an individual with peripheral diabetic neuropathy.

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1. People with diabetic foot complications in African communities often present to hospital only after the onset of gangrene or during a stage of sepsis that might be intractable to conventional supportive treatment.
2. Foot infections are especially common where there are no available services for follow-up of the diabetic foot or when lesions are ignored or detected relatively late in the course of the infection after unsuccessful home therapy.

people with diabetes (Larsson and Apelqvist, 1995; Larsson et al, 1995; International Working Group on the Diabetic Foot, 2007).

In Tanzania, Abbas and colleagues have described a population of people with diabetes with infected ulcers who have neither neuropathy nor vascular disease (Abbas et al, 2002; Gulam-Abbas et al, 2002). Typically, these individuals are young adults with type 1 diabetes who were diagnosed during their initial presentation to the outpatient clinic with infected feet. The pathogenesis of these infections usually starts with a non-specific injury followed by breakdown of skin and spread of infection to deeper tissue layers (Gulam-Abbas et al, 2002). In fact, one-third of individuals with infected feet who attend the diabetes clinic in Dar es Salaam have this pattern of acute foot ulcers (personal communication: Dr ZG Abbas). However, the complete epidemiology and microbiology of foot infections in this population needs to be better defined and characterised.

People with diabetic foot complications in African communities often present to hospital only after the onset of gangrene or during a stage of sepsis that might be intractable to conventional supportive treatment (McLarty et al, 1990; Gulam-Abbas et al, 2002; Rolfe et al, 1992). Owing to the fact that people with infected ulcers often feel no pain because of neuropathy, or may have no systemic symptoms until late in the course of the condition, medical providers often presume (incorrectly) a degree of self-neglect among affected individuals. Fungal infection of toenails or in the intertriginous areas may lead to cracked skin or fissures on the sole of the feet. This type of infection produces relatively slight discomfort, but its real importance lies in the fact that these lesions pave the way for the entry of microorganisms into the foot leading to secondary bacterial infection.

It is not surprising, therefore, that foot infections are especially common where there are no available services for follow-up of the diabetic foot or when lesions are ignored or detected relatively late in the course of the infection after unsuccessful home therapy – such as soaking in hot water and application of herbal remedies prescribed by traditional healers. Foot infections of this nature culminate in the onset of gangrene or disseminated infection with ensuing amputation of the foot or entire limb, or death from overwhelming sepsis.

Step by Step: Improving diabetic foot care in the developing world

Until recently, there had been no sustainable infrastructure for diabetic foot management in Tanzania and other sub-Saharan countries. Compounding the problem is the lack of trained personnel and formal podiatry services in the country, plus limited financial resources to underwrite comprehensive preventive programmes. For these reasons, the Step by Step Foot Project was initiated as an applied approach to improve educational skills and the management of diabetic foot problems (Bakker et al, 2006).

The main objectives of the Step by Step Project were as follows:

- Implement sustainable training programmes for healthcare professionals in the management of the diabetic foot.
- Initiate educational programs focused upon the transfer information and expertise from healthcare professionals who have undergone training to other healthcare professionals with little or no training in foot care ('training the trainers').
- Reduce rates of lower limb complications in persons with diabetes through identification of attributable risk factors that are potentially modifiable.
- Utilise education as a means of engendering

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1. Institution of the Step by Step Foot Project in Tanzania resulted in improved foot ulcer management for people with diabetes in 14 regions in Tanzania and a reduction in the number of documented lower limb amputations.
2. In the long term, motivation and action by people with diabetes themselves will be the essential element for protecting the feet from complications. Such action, however, depends on education, which remains the most important preventive tool in Africa and other less-developed countries.
3. success will depend on the ability of healthcare providers to nurture the motivation and self-help that is essential for the well-being of people with diabetes.

greater motivation among people with diabetes to take greater responsibility for the care of their feet, to detect problems earlier on (and act upon them) and to appreciate the importance of seeking help in a timely manner when problems do arise.

Institution of the Step by Step Foot Project in Tanzania resulted in improved foot ulcer management for people with diabetes in 14 regions in Tanzania and a reduction in the number of documented lower limb amputations (Bakker et al, 2006). The project also demonstrated that for people with diabetes who have or are at high risk of foot complications, it is feasible to circumvent amputation or death through a programme of education involving both healthcare providers and patients allied with dissemination of information to other healthcare professionals involved in patient care.

It is expected that the acquired knowledge and skills gained through the Step by Step Project will ultimately help reduce the number of lower extremity amputations. The authors believe that in order to address the increasing rates of diabetic foot complications in less-developed countries, Ministries of Health in these countries may need to consider implementing educational interventions at a national level similar to the Step by Step model.

Prevention

While it may be impossible to totally prevent foot ulceration, it is certainly feasible to prevent the progression of small ulcers to infection, sepsis, osteomyelitis or gangrene through the golden rules of prevention:

- Maintaining glycaemic control to prevent or delay the onset of peripheral neuropathy.
- Utilising podiatric care that includes regular foot inspection.
- Discouraging barefoot walking and cutting foot calluses with razors or knives at home.
- Avoiding delays in presenting to hospital when a foot lesion, however minor, develops.

In truth, experience in the diabetes clinic in Dar es Salaam suggests that the implementation of these golden rules of prevention does not require exorbitant amounts of finances or high technology and, if followed, should go a long way in reducing adverse events associated with the diabetic foot in Africa.

In the long term, motivation and action by people with diabetes themselves will be the essential element for protecting the feet from complications. Such action, however, depends on education, which remains the most important preventive tool in Africa and other less-developed countries. Education should be an integral part of all preventive programmes. It should be simple, repetitive and targeted at both healthcare workers and patients alike. People with diabetes must be educated on the importance of foot care, use of appropriate, affordable footwear and of consulting a doctor during the early stages of foot-related symptoms. Ultimately, success will depend on the ability of healthcare providers to nurture the motivation and self-help that is essential for the well-being of people with diabetes. ■

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