Diabetic-Foot Complications in African and Antarctica Continents

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2.1 Introduction

Continent of Africa is the second biggest on the earth, it is almost three times the size of Europe, 1000 ethnic groups live in 54 countries and speak more than 1000 dialects. As of now with 1.1 billion population, Africa is anticipated to increment and reach 2.4 billion in 2050. A great part of the expansion will occur in Sub-Saharan Africa (SSA), which incorporates 46 of African's 54 nations huge numbers of the world's least fortunate nations [1, 2]. Antarctica is the fifth-biggest mainland as far as absolute territory (it is bigger than both Oceania and Europe). Antarctica is an extraordinary mainland in that it does not have a local populace. There are no nations in Antarctica, albeit seven countries guarantee various pieces of it. Antarctica is the main landmass with no perpetual human home. There are, however, human settlements, where researchers and supporting staffs live piece of the year on turning premise [3]. The rate of diabetes mellitus is expanding in the populace over the world. Africa is encountering a quick increment in the commonness of diabetes. In December 2019, it was reported that people with diabetes in Africa are 19 million and if present patterns proceed with the general commonness is anticipated to be 29 million by 2030 and 47 million by 2045, which is increment of 143% [4]. There is currently considerable proof affirming that diabetes has arrived at pestilence extents in many creating or recently industrialised countries, and is relied upon to turn into the dominating medical issue in new developing countries [1]. Diabetes stays a main source of dismalness and mortality in both developed and developing world and force an overwhelming weight on their health services [5–21].

As the prevalence of diabetes is increasing along with it in parallel complications of diabetes will also increase. Among all the complications caused by diabetes, the

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M. Zubair et al. (eds.), *Diabetic Foot Ulcer*,
https://doi.org/10.1007/978-981-15-7639-3_2

most serious and dreadful complication will be diabetic foot, which will be associated with the highest morbidity and mortality [5–21]. Data across the world are reporting that 40–60% of all lower limb non-traumatic amputation are directly related to diabetes [21–25]. Up to 85% of amputation done in the people with diabetes are due to foot ulcer. There is a 50% risk of developing a serious lesion in the second limb in those people with diabetes who had a previous lower limb amputation within 2 years [21–25]. It has been shown in the literatures from Africa that patients with diabetic foot are associated with peripheral neuropathy compared to peripheral arterial disease (PAD) [5–20].

African continent is developing very fast and becoming more affluent due to urbanisation. At the same time, we report in the literatures increase rates of peripheral arterial diseases in people with diabetes in past two decades, which can be critical and costly [26]. Amputations are expensive, devastating on the people with diabetes and their families, leading to loss of independency and livelihood [26]. Complications of lower limb are associated with high rates of morbidity and mortality [5–21].

Time is tissue, which implies that therapeutic help for diabetic foot ulcers ought to be looked for as fast as could be allowed and intervention should be taken as a medical emergency [21–25]. Time is not tissue, which implies that a patient presenting with a diabetic foot ulcer, with a history of days, weeks or months, means it becomes difficult to save a toe, or a foot or a leg or even prevent death due to delay presentation [21–25]. Ideally these patients with diabetic foot ulcers should not delay to report at health centre.

In African setup reasons for late presentations have been reported by Abbas et al. and are mostly associated with cultural, traditional and customary behaviours [5–9, 13, 14, 19–21]. In the African continent, it is very common to go through many stages before patients actually lands in the health centre. First of all, patient will try to treat a foot lesion at home using a razor blade called bathroom surgery or herbal solution [5–8, 21]. Procedures are performed by relatives or patients themselves. If treatment at home fails then patients would be advised by relatives to see herbalist, faith healer or traditional healer. After going through herbalist, traditional or faith healer and if it fails then patients and relatives will decide to go to nearest primary health care centre or district or regional hospitals where unfortunately we cannot find a health care worker dealing with diabetic foot problems. All these journey delays treatment of diabetic foot ulcer and foot deteriorates. By the time patient is referred to a specialised centre or referred hospital it could be too late to salvage a foot and sometimes even to prevent death of the patient [6–9, 13, 14, 21]. In some community's delay in getting an expert opinion in the hospital is because of fear losing a limb, as according to culture losing a limb in African patients is considered a worse outcome than having a disease. Among health care workers at grass root level can lead to worse outcomes due to lack of knowledge. Awareness and education among health care workers are extremely important specially at the grass root level who are the first to see these patients [6–9, 13, 14, 21].

2.2 Pathophysiology of Foot Ulcers

The pathophysiology of diabetic foot lesions is complex and multifactorial. Contributory factors include peripheral neuropathy (sensory, motor, autonomic) peripheral arterial disease, neuro-ischemia, infection, biomechanics, social-economic factors, non-ulcerative lesions of ulcers and local trauma. The pattern of foot ulcer occurrence depends on the varying degree of contribution of each of these factors. For example, an ulcer may be secondary to both ischemia and neuropathy so-called neuro-ischaemic ulcer.

2.3 Diabetic Foot Complications

Diabetic foot ulcer is a major public health problem in many African countries [1, 2, 5–22]. It is the main cause of prolonged hospital admission due to late presentation and can lead to high morbidity and mortality [1, 2, 5–22].

2.3.1 Peripheral Neuropathy (PN)

Published literature from the Western world reports that PN is the foremost common complication of diabetes, happening in 5–80% of patients with diabetes [27, 28]. Peripheral neuropathy is one of the most common diabetic foot complications affecting patients with diabetes in both developed and less developed world [8, 9, 16–21, 29–48] (Table 2.1).

Diabetic peripheral neuropathy commonly presents as bilateral symmetrical glove and stocking distribution predominately sensory neuropathy. Foot with peripheral neuropathy is classical numb, warm, dry and painless, but pulses are palpable. Typical patient will present with numbness of feet, pins and needles sensation, burning feet, feeling like walking in the sand, stabbing pain, fatigue or weakness of feet. Due to the loss of protective sensation in the feet patient can easily sustain injury.

The resulting loss of sensation in the feet invariably leads to sequelae that include callosities, cracked soles, breakdown of skin or non-discernible injuries, such as burn or rat bite. These complications can result in foot ulcers, which in our set leads to infection, gangrene, amputation or even death [8, 9, 16–21, 29–48]. This is the main reason that peripheral neuropathy with foot ulcers are admitted in the hospital, leads to prolonging stay in and are associated with amputation [8, 9, 16–21, 29–48]. Peripheral neuropathy also remains the most common initiating factor for diabetic foot ulcer (DFU). The prevalence of PN rates across Africa in last two decades has been documented [8, 9, 16–21, 29–48] (Table 2.1).

In a major study performed in Tanzania, Abbas et al. found no differences in the rates of PN among African and Asians diabetic patients with ulcers [17, 18]. In another comparative study, Abbas and colleagues found no significant differences in

Table 2.1 Prevalence of diabetic peripheral neuropathy (PN) across the African continent in last two decades

Publication year	Author	Ref. No.	Country	Prevalence of PN (%)
2020	Abbas	[19]	Tanzania	84.7
2019	Garoushi	[29]	Libiya	42.2
2019	Khalil	[30]	Egypt	20
2018	Chahbi	[31]	Morroco	15
2018	Khalifa	[32]	Egypt	69
2017	Kisozi	[33]	Uganda	24.9
2017	Awadalla	[34]	Sudan	68.2
2015	Assaad-Khalil	[35]	Egypt	29.3
2015	Olamoyegun	[36]	Nigeria	69.6
2015	Ogbera	[37]	Nigeria	37
2015	Kuate-Tegueu	[38]	Cameroon	77.4
2012	Owolabi	[39]	Nigeria	71
2011	Jarso	[40]	Ethiopia	48.2
2009	Abbas	[17]	Tanzania	81
2009	Oguejiofor	[41]	Nigeria	69.2
2009	Mugambi-Nturibi	[42]	Kenya	42
2008	Gill	[43]	Ethiopia	41
2006	Ndip	[44]	Cameroon	27.3
2006	Ugoya	[45]	Nigeria	75
2005	Abbas	[20]	Tanzania	100
2004	Morbach	[18]	Tanzania	82
2003	Moulik	[46]	Zambia	61
2000	Abbas	[16]	Tanzania	25.5
2000	Benotmane et al.	[47]	Algeria	84.4
1999	Kadiki et al.	[48]	Libiya	45.7

the prevalence of neuropathy in patients with foot ulcers from Tanzania, Germany and India [18]. There is no difference across the world in the rates of PN [18]. Published data from the last two decades across Africa have shown wide difference in the occurrence of PN [8, 9, 16–21, 29–48] (Table 2.1).

2.3.2 Peripheral Arterial Diseases (PAD)

Peripheral arterial disease is defined clinically in patients with a history of intermittent claudication, rest pain, absence of pedal pulses abnormalities on non-invasive arterial assessment indicates disturb or impaired lower limb circulation [21, 22]. There are no specific diabetes-related peripheral arterial lesions, but the distribution of arteriosclerosis in patients with diabetes is different compare to what is seen in non-diabetes patients. In patients with diabetes, it is more frequently, younger age groups are affected more, no differences in gender, progression rate is faster, it is

multisegmented and more distally [21–22]. It is general to see that ischemic foot is associated with pain at rest, increase risk of foot ulcers, digital necrosis or gangrene and absent pulses. This in turn increases the risk of localised or widespread infection of the lower limbs.

PAD is very common in the industrialised world, but was not that common in Africa and Asia [8, 10, 14, 16–19, 30, 32, 35, 37, 44, 46, 49–56]. Now across Africa and Asia rates of PAD are increasing [8, 10, 14, 16–19, 30, 32, 35, 37, 44, 46, 49–56] (Table 2.2). More people in Africa are adopting the Western style of life as are becoming more urbanised, sedentary lifestyle, lack of exercise, changing diet, etc. Abbas et al. established that rates of PAD in Tanzania are not different by ethnicity as it was in the past [18]. PAD is now playing a more substantial role in the causation of foot ulcer in Africa than was previously thought. Likely, reasons for this include increased urbanisation and adoption of behaviours and diet from the west. Prevalence rates of PAD are increasing across Africa seen in last two decades [8, 10, 14, 16–19, 30, 32, 35, 37, 44, 46, 49–56] (Table 2.2).

Peripheral arterial diseases are underdiagnosed and treated in Africa and we need to conduct more measurements of Ankle Brachial Index [17, 21, 22]. Computer tomography scan angiography of lower limbs are quite comparable in visualising vessels. It is done to evaluate the extent of arterial block and help in the feasibility of revascularization [22].

Table 2.2 Prevalence of peripheral arterial disease (PAD) across the African continent in last two decades

Publication year	Author	Ref. No.	Country	Prevalence of PAD (%)
2020	Abbas	[19]	Tanzania	27.2
2019	Khalil	[30]	Egypt	20
2018	Khalifa	[32]	Egypt	12
2016	Codjo	[49]	Benin	42
2015	Ogbera	[37]	Nigeria	40
2015	Assaad-Khalil	[35]	Egypt	11
2014	Konin	[50]	Ivory Coast	22
2014	Mwebaze	[51]	Uganda	39
2014	Okello	[52]	Uganda	24
2014	Oyelade	[53]	Nigeria	52
2013	Umuerri	[54]	Nigeria	35.6
2009	Abbas	[17]	Tanzania	26
2007	Kumar	[55]	South Africa	29
2006	Ndip	[44]	Cameroon	21.3
2004	Morbach	[18]	Tanzania	12
2003	Moulik	[46]	Zambia	41
2002	Abbas	[14]	Tanzania	21
2000	Abbas	[16]	Tanzania	12.5
1997	Levitt	[56]	South Africa	8.2

2.3.3 Diabetic Foot Ulceration (DFU)

Diabetic peripheral neuropathy in Africa is still the main underlying risk factor in the causation of diabetic foot ulcers [8, 10, 12, 13]. In one of the studies conducted in Tanzania it showed that 15% of admitted cases were of diabetic foot ulcer and out of this 80% were first-time ulcer [14]. Across African continent prevalence of DFU ranges from 12% to 24% [34, 44, 57–61]. It further showed in the study that the amputation rate was found 33% as a frequent outcome in people with DFU and associated with neuro-ischemic lesions and/or progressive infection [14]. Mortality rate was as high as 54% who presented late with severe foot ulcers Wagner score ≥4 [14]. It has been reported the same with high rates of morbidity and mortality from other parts of Africa [10, 14, 62–67]. It is difficult to obtain consent from patients for surgery due to severe DFU, which can reflect low amputation rates than what is actually expected [14]. Some patients discharge themselves against medical advice with severe DFU and thus risk severe sepsis and may be death [14].

Major factors contributing to development of the DFU in rural Africa are walking bare foot. In particular, farmers walking barefoot, or due to religious obligations people have to walk barefoot and, in some cultures, entering the house we need to take out of footwear. This could be due to culture or may be low income [8, 10, 11, 21]. People with diabetes living below poverty line could be difficult for them to buy appropriate footwear. Flip flop slippers are very cheap and rubber made commonly used in the developing world and rural Africa it is common to produce footwear from worn out motor car tyres [8, 10, 21]. Poverty can lead to unhygienic condition, which is in turn prone to DFU [11–15, 21]. Patients with peripheral neuropathy sustain injuries but presents with DFU when they become symptomatic and by that time foot ulcer has already progressed to fulminating foot sepsis. Most of the time it has been noticed and reported that these patients do not have access to basic education on foot care at primary, district or regional health centre are most at risk developing infected ulcers [12, 13].

2.3.4 Diabetic Foot Infection

In Africa first presentation to health centre is usually too late when patient has already developed localised gangrene or full foot gangrenous with severe sepsis. This may not respond to supportive treatment with intravenous antibiotics, intravenous fluids and insulin, this progress to serious systemic infection and high risk of mortality [1, 5–21]. First presentation at health centre is late with severe infected DFU and already has acute limb-threatening conditions leading to foot or leg amputation in 25–50% for patients with diabetes [22–25]. Fungal infection in between the toes is also common and dryness of the feet seen in patients with diabetes develops cracks and fissures on the sole of the feet [16–21]. All these open lesions in the skin lead to secondary bacterial infection [16–21]. We can start with antibiotics initial empirically and then can be changed after the results of culture and sensitivity [68]. According to the International Working Group of Diabetic Foot superficial

swabs are not recommended for culture [22–25]. Obtain specimens of superficial swabs are not useful due to give polymicrobial growth. Deep tissue biopsy is recommended by IWGDF to give proper and useful data [22–25]. Unfortunately, in Africa majority of laboratory services do not have resources to provide or maintain microbiology routine services. Microbiology services are only available in the university tertiary level of the hospitals [68]. Reports of the utility of Gram staining has been published is equally sensitive compare to cultures in the management of diabetic foot ulcer [68].

Infection is the immediate cause of amputation and this varies widely by geographic regions. True rates of amputation following foot infection in Africa remain underestimated [1, 6–21]. There are many cited reasons for amputation in patients with diabetes, but gangrene and infection are common and occur simultaneously [16–21]. Medical health care workers always think (Incorrectly) that a degree of self-neglected among the patients with DFU. This happens because foot with infected ulcers frequently feel no pain due to peripheral neuropath. Developing countries need treatment planning for the prevention and management of diabetic foot infections.

Diabetic foot ulceration, infection and amputation are preventable through organised foot care programmes. Education is the only tool in the developing world that can prevent diabetic foot complications. Education should be targeted to health care workers, patients and relatives and it has shown to reduce complications by 85%.

DFU and infections are very common where services are scarce especially as in Africa, for example, Chiropody services are almost non-existing in Africa. Foot lesions once sustained by the patient are either ignored or detected relatively late. During this process, the patient starts treatment himself at home by home therapy such as socking in herbal medications, applying the herbal medication, etc. This leads to further deterioration of the foot with high risk of morbidity and even mortality due to sepsis [9–16, 21].

2.3.5 Amputation

Gangrene and infection appear to be most common cited indications for foot amputation in patients with diabetes [8, 10]. High rates of amputation are seen across Africa from 16% to 55% [8, 10, 61–63, 65–67]. However the true lower limb amputation rate resulting from foot infections in Africa remains underestimated. About 10% of patients who needed and agreed to undergo surgery died due to severe sepsis in Africa before the surgical procedure [8].

2.3.6 Mortality

Mortality rates are high in African patients with diabetic foot ulcers [8, 10, 61–63, 65–67]. Abbas and colleagues ascertained clinical correlates for mortality of patients with diabetic foot ulcers in Tanzania. They found that the overall mortality rate was

high in the patients with foot ulcer was 29% and was significantly higher among patients with PAD, neuro-ischaemic, late presentation, or non-healing ulcers [8, 10, 14]. The mortality rate was 54% who presented when gangrene has set [8, 10, 14]. The highest mortality rate has been documented in those patients who did not undergo amputation of the affected limb [8, 10, 14].

2.4 Prevention

It is important that it should be directed to people with diabetes and health care workers.

Education is the only tool we have in Africa, which is free of charge for the patients and effective if implemented. Several educations have been conducted and were successful in both the developing and developed world [5, 6, 69–74].

2.4.1 Step by Step (*SbS*) Foot Project

Step by step foot project was first and the unique project started from the developing world. It was piloted and conducted in Tanzania and India. This project was launched in 2003 and the curriculum was developed initially focusing developing world. The main aim of this project was to create awareness on diabetic foot, to provide sustainable training on diabetic foot, to transfer knowledge to other colleagues and export ideas to other developing countries, to reduce the risk of lower limb complications and to empower people with diabetes regarding diabetic foot. Several successful projects were done in Tanzania targeting physicians and nurses [69–74]. It was always aimed to train a team from each centre. It all started in Tanzania, developing world exported to other developing countries, later to the second world and finally the first world in Europe [69–74]. Step by step has already touched about 110 countries in the world. In 2009 it was decided to bring surgeons on board. It felt that surgeons should be trained for salvaging diabetic foot. So those centres where physician and nurses were already trained surgeon were asked to join to complete the team. First course of its kind for surgeons was held in Tanzania [69–74]. Several other groups of surgeons were later formed in Europe and Asia. Step by step foot project showed us that ulceration, infection and amputation all are prevented through organised diabetic foot care programmes. Regular education of the staffs and patients, regular follow of the patients and multidiscipline approach to manage diabetic foot ulcers. Step by step reported that above strategic plan there was greater than 50% reduction rates in amputation rate [5, 6, 69–74].

2.4.2 Train the Foot Trainer (*TtFT*) Project

In December 2012, a decision was made to introduce Train the foot Trainer project (*TtFT)*. It is almost similar to the original step by step foot project, but here health care workers from different countries in that region are asked to come under one

roof. Once health care workers go back to their own countries, they need to disseminate the knowledges by conducting step by step foot projects. The first successful *TtFT* course was conducted in Brazil in 2012 [75].

2.5 Conclusion

Africa is in epidemiological transition with a massive projected increase in diabetes and diabetes-related lower limb complications including peripheral neuropathy, peripheral arterial disease, DFUs and amputations. Unless urgent action is taken to tackle these by developing cost-effective and evidence-based strategies, a situation that is already challenging will become substantially worse. DFUs and amputations rates in patients with diabetes can be reduced by >50% by better education of patients. Education on diabetic foot is the only tool we have in Africa that should be part of the curriculum. It should be targeted at both health care workers and patients.

Acknowledgments I would like to acknowledge all our colleagues for their constructive discussion during the genesis of this manuscript. We usually highly appreciate Shabneez Gangji and other staff in diabetes centre's in Dar es Salaam for their assistance.

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