Diabetic Foot Ulcer

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INTRODUCTION

Diabetic foot ulceration is one of the most common complications of diabetes. Diabetic foot ulceration (DFU) affects 15-25% of diabetic patients in their lifetime[1] and is responsible for up to 50% of hospital admissions in persons with diabetes[2]. It is estimated that up to 25% of patients with diabetes will develop a foot ulcer during their lifetime[1]. 85% of lower limb amputations in people with diabetes are reportedly preceded by a foot ulcer[3]. 40% of diabetic foot ulcers have been shown to be preventable through a conscientious team approach by medical personnel[4]. One in six patients with an infected diabetic foot ulcer will die within one year[5]. In the USA there is an annual incidence of 200,000 foot ulcers and 56,000 major amputations while incidences of coronary heart disease, stroke, blindness and kidney failure are 101,000, 27,000, 6,900 and 5,900 respectively[6]. In Nigeria there is an incidence rate of 17.9% to 19.1% of admitted DFU patients[7]. In Nigeria the mean cost of treating a patient with Diabetic foot ulceration in the year 2011 is 181,581.00 Nigerian Naira (NGN), which is approximately equivalent to 1200 US dollars.,this amount is unaffordable for most hospitalized patients with DFU in Nigeria, as about 60% of the Nigerian populace live below the poverty line[8]. The aim of this article is to give an overview of DFU and highlight modalities for the management and prevention of DFU and consequently prevention of lower limb amputation in persons with diabetes.

Risk factors for Diabetic Foot Ulceration are as outlined below:

- Peripheral neuropathy (loss of protective sensation)
- Peripheral vascular disease
- Foot deformity
- Inappropriate/poorly fitting foot wear
- History of previous foot ulcer/amputation
- Presence of callus
- Poor glycaemic control
- Long Diabetes duration
- Chronic kidney disease
- Visual impairment
- Social deprivation
- Cigarette smoking

PATHOPHYSIOLOGY

DFU occurs as a result of the simultaneous action of multiple causes[9,10], the main risk factors being peripheral neuropathy and ischaemia resulting from peripheral vascular disease[11]. Peripheral neuropathy is the leading risk factor of DFU accounting for more than 60% of patients admitted with DFU[12, 13]. Underlying neuropathy has been shown to result from hyperglycaemia induced metabolic abnormalities. One of the patho-physiologic mechanisms in the development of diabetic neuropathy is via the polyol pathway[14]. Hyperglycaemia leads to an increased action of the enzymes sorbitol dehydrogenase and aldose reductase, which consequently results in the conversion of intracellular glucose to fructose and sorbitol. Increased amount of these sugars cause a reduced synthesis of nerve cell myoinostol which is essential for neuron conduction. This leads to the depletion of nicotinamide adenine dinucleotide phosphate (NADP) stores which are necessary for oxidative detoxification. NADP also prevents the synthesis of nitric oxide a local vasodilator . These changes lead to an increased oxidative stress on the nerve cell and vasoconstriction thereby causing ischaemia[15].

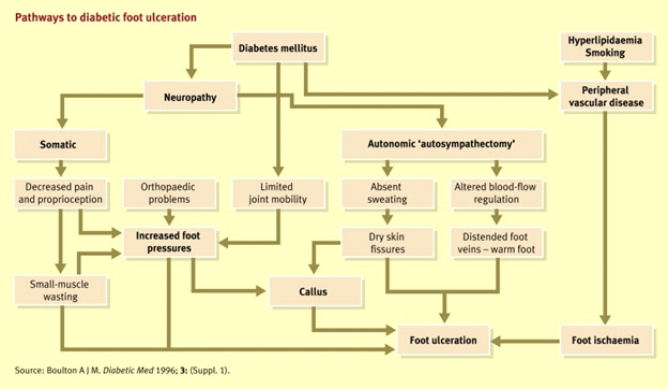
Neuropathy affects the motor, sensory and autonomic components of the nervous system. When the motor component of the nervous system is affected the intrinsic foot muscles are damaged thereby causing an inbalance in flexion and extension, this invariably leads to abnormal bony prominence and pressure points causing ulceration. A diminution in the functions of the sweat and oil glands of the skin makes it susceptible to tears increasing the risk of an infected ulceration[15].

Sensory nerves are involved in perception of pain, pressure, proprioception and temperature. Sensory neuropathy may result in a loss of pain, pressure awareness, temperature and proprioception.

Loss of sensation, foot deformities, and limited joint mobility can result in increased biomechanical stress on the foot. Due to the loss of protective sensation, damaging stimuli or trauma is less well perceived or not at all, which may result in foot ulceration. In people with neuropathy, trauma - caused for example by ill- fitting shoes, walking barefoot, burns from hot objects and foreign bodies in the shoes (e.g. stones or pins) can precipitate a foot ulcer. While trauma may include puncture wounds and blunt injury, a common injury leading to ulceration in persons with peripheral neuropathy is moderate repetitive stress associated with walking or day-to-day activity.

Peripheral vascular disease (PVD) affects major arteries in the lower extremities causing atherosclerosis, arteriolar hyalinosis, capillary basements membrane and endothelial proliferation in tibial and

peroneal arteries of the calf[16]. The risk of PVD is markedly increased among individuals with diabetes mellitus. Other well-known risk factors for PVD are cigarette smoking, advanced age, hypertension, and hyperlipidemia. Hyperglycaemia is also associated with an increase in Thromboxane A2 which is a vasoconstrictor and plasma coagulation agonist[17]. Persons with diabetic foot ulcers and PVD are more likely to have non healing ulcers, gangrene and require major amputations.



Socio-cultural Risk factors

Certain socio-cultural practices have shown to increase the risk of DFU. These include practices such as barefoot walking[1]. Cigarette smoking increases the risk factor for peripheral vascular disease and neuropathy. Lack of appropriate education in foot care and foot wear and poor self-foot care increases the risk for DFU

PRESENTATION

When a diabetic foot ulcer has purulent discharge and /or two or more signs of inflammation such as erythema, pain, tenderness, induration or a foul smell, it indicates a that the DFU is infected. Symptoms and signs of localized infection include pain, tenderness and erythema, while the presence of anorexia, nausea, vomiting, fever, chills, change in mental status and a recent worsening of glycaemic control are signs of systemic infection[18].

CLASSIFICATION

There are several classification systems for DFU. The systems are based on different criteria's such as the wound depth and the wound size[18]. Only a few classification systems use important parameters such as neuropathy, ischaemia and severity of ulcer infection[18]. The two most used classification systems are the (A) Wagner classification system and (B) The University of Texas Health Science Center San Antonio (UT) classification system.

(a) The Wagner Classification System

The Wagner classification system is a universally accepted classification system based on ulcer depth. The major drawback of the Wagner classification system is its inability to recognize neuropathy and ischaemia as independent risk factors of DFS in all its six grades of classification[18].

Grade	Description
0	Skin intact
1	Superficial ulcer
2	Deeper, full-thickness extension of ulcer
3	Deep abscess or osteomyelitis associated with ulcer
4	Partial forefoot gangrene with ulcer
5	Extensive foot gangrene with ulcer

Wagner Ulcer Classification System[19]

(b)The University Of Texas Health Science Center San Antonio (UT) Classification System

The system is a more recent method of classification and has received a large acceptance and popularity among physicians. This system addresses ulcer depth, but unlike the Wagner Ulcer classification system it includes infection and ischaemia as important factors in its grading and classification. This system uses a matrix structure of four grades of wound depths and subgroups denoting infection or ischaemia or both[18]. Wounds of increasing grade and stage are less likely to heal without a timely vascular repair or an Amputation.

Grade /Stage	0	1	2	3
A	No open lesion	Superficial wound	Tendon / Capsule	Bone / Joint
B	With infection	With infection	With infection	With iInfection
C	Ischemic	Ischaemic	Ischaemic	Ischaemic
D	Infection / Ischaemic	Infection / Ischaemic	Infection / Ischaemic	Infection / Ischaemic

The University Of Texas Health Science Center San Antonio (UT) Classification System[20]

There are other classifications that are less known such as the Brodsky depth/ischaemia classification.

Grade	Definition
0	At-risk foot with previous ulcer that may cause new ulcer
1	Superficial non-infected ulcer
2	Deep ulcer with tendon or joint exposed (+/- infection)
3	Extensive ulcer with bone exposed or deep abscess

ISCHEMIA

Grades	Definition
A	No Ischaemia
B	Ischaemia , No Gangrene
C	Partial Foot Gangrene
D	Total Foot Gangrene

The Brodsky depth/ischemia classification

MANAGEMENT

Management of DFU requires a holistic approach which includes the proper education of the patient and the best results are obtained with multi-disciplinary care. The methods of management depend on the stage of ulceration, the presence or absence of ischaemia and the attendant co-morbidities, if any.

Wound care, debridement, offloading, foot care education and an intensive glycaemic control can reduce the progression of the ulcer by as much as 50-60 %[22]. The aim of offloading is to redistribute force away from ulcer centers and pressure points at risk to a wider area .This can be achieved by the use of crutches, half shoes, wheel chairs, removable cast walkers[23] and Total contact casting (TCC). TCC is regarded as the best method of off-loading pressure at ulcer points especially when other method proves inadequate. Offloading significantly increases the healing rate of neuropathic plantar ulcer[24]. Debridement includes the removal of callus around the wound thereby reducing the pressure around callused part of the foot and, the removal of necrotic tissue which can also help in the removal of

colonizing bacteria in the wound preventing secondary bacterial infection[18]. In wound care, the wound dressing is an important component, and should be able to provide a moist environment for the wound, absorb excess exudate, provide a protective barrier and not increase the risk of infection[26].

Persons with diabetic foot ulcers and peripheral arterial disease are more likely to have non healing ulcers, develop gangrene or require a major amputation. Because adequate arterial supply is crucial for wound healing, a patient presenting with clinical features suggestive of decreased blood flow (peripheral arterial disease) in the lower extremities would undergo vascular studies, which can be done using the measurement of ankle-brachial pressure index (ABPI) and digital arterial pressures, Doppler ultrasonography with , transcutaneous toe oxygen measurement and angiography, with revascularisation surgery performed where indicated Surgical bypass is a favorable treatment for feet with underlying ischemia[27]; it has recorded a limb salvage rate of 10%-90%[28]. In patients with several points of occlusion, revascularization at each point is required to restore arterial blood flow and increase the chances of limb salvage[29].

In Nigeria, the majority of patients with DFU present with infected ulcers . Treatment depends on the severity of the Diabetic Foot infection and whether or not ischaemia is present. Superficial ulcers without ischaemia can be treated on an outpatient basis with repeated debridement, meticulous wound care, offloading and oral antibiotics[30]. Cases of deep foot infections with systemic toxicity should be admitted. When there is a combination of ischaemia and neuropathy, DFU should be treated as a medical emergency[13]. Surgery should be considered in all patients ranging from minor debridement to major extensive resections [32]. The choice of the initial antimicrobial therapy is usually empiric and based on the severity of the infection, prior antibiotic use and local resistance to most common pathogens[32].

Other adjunctive treatments for DFU in practice are:

- Bioengineered human skin substitutes (Dermagraft, Apligraf) may hasten healing of chronic non-healing, uninfected neuropathic foot ulcers via the action of cytokines and dermal matrix components that stimulate tissue growth and wound closure.
- Negative pressure wound therapy (NPWT), using vacuum devices generating negative pressure for complex DFU's
- Hyperbaric Oxygen: For patients with foot ulcers and severe ischemia in whom revascularization is not possible hyperbaric oxygen is an useful additional therapy. Hyperbaric oxygen is associated with a reduction with major amputations but not in minor amputations. It may be seen as a promising treatment option when other strategies have failed[32].

Minor or Major amputation may be required when there is a severe progression of the ulcer into the soft tissue and bone and/or gangrene. When it becomes apparent that amputation becomes the required option, the vascular state of the major arteries of the lower extremities become important in deciding the level of amputation[29]. For example, a below the knee amputation may be necessary in a patient, when there is absence of the dorsalis pedis or posterior tibial artery pulse, but an intact popliteal pulse. This might be necessary, if a surgical bypass is not feasible, as the healing potential of any distal amputation becomes greatly compromised.

The different types of amputation are listed below:

1. Hallux amputation
2. Ray amputation
3. Lateral foot amputation
4. First ray amputation
5. TMT amputation
6. Chopart amputation
7. Syme amputations
8. Below the knee amputation
9. Above the knee amputation

Despite advances in medical and surgical management of DFU, the 5 year mortality of 66% after amputation of a leg remains poor. Patients with DFU frequently have numerous medical co-morbidities such as heart failure, other cardiovascular diseases and renal disease[31].These fact points to the debilitating and morbid nature of the disease, as well as the requirement for multi-disciplinary care.

Patient Education

One of the reasons for the poor outcome of DFU in developing countries like Nigeria is poor patient awareness as regards proper foot care. In Nigeria, DFU is associated with high morbidity and mortality partly due to late presentation with severely infected and advanced foot ulcers, on the background of unsatisfactory metabolic control.

Persons with diabetes need structured foot care education to enable proper foot care. It is recommended that the foot care education should ideally be individualized according to the patients level of risk. It promotes self-care and addresses common misconceptions. Patient education is needed to effectively contain the multi-factorial pathology of diabetic foot ulcerations[33]. Therefore medical education suitable for the individual's risk status is essential

PREVENTION OF DIABETIC FOOT ULCERATION/REULCERATION

To prevent DFU, It is recommended that all patients with diabetes undergo foot examination by a healthcare provider at least annually to determine predisposing conditions to ulceration[34]. Patients with demonstrated risk factor(s) should be examined more often every 1–6months[35]. Identifying and categorizing feet at risk by appropriately trained healthcare providers, followed by the institution of adequate preventive measures, and if necessary appropriate treatment strategies will help reduce ulceration, reulceration and amputation rates.

Patients should be educated about the basic diabetic foot care principles which include[35]:

- Daily foot inspection, including areas between the doors
- Regular washing of feet, with careful drying
- Keeping feet away from sources of heat
- Checking shoes inside and outside for sharp bodies/areas before wearing
- Avoidance of barefoot walking both indoors and outdoors
- Chemical agents for removal of corns and calluses, corn plasters or strong antiseptic solutions should not be used
- Cigarette smoking cessation
- Maintaining good glycemic control
- Checking water temperature before stepping in
- Avoid standing for long hours

CONCLUSION

Diabetic foot syndrome is a major medical complication of diabetes which affects 15% of diabetics. Poorly controlled diabetes is a risk factor for peripheral neuropathy and ischaemia. Treatment and management depends on the level of progression of ulceration. Conservative treatment options include offloading, good wound care, debridement and intensive glycaemic control/restoration of euglycaemia. Revascularization and surgical bypass becomes necessary once the distal arterial blood supply has become compromised. Many times, amputation is the last option in the presence of gangrene, and may be indicated in the presence of extensive necrotic soft tissue or bony involvement. A synergy between physicians, surgeons, chiropodists, nurses and physiotherapists is necessary for the proper care of patients with DFUS. The prevention and management of diabetic foot ulcers and subsequent major amputation can be achieved by a consistent preventive foot care programme. This is best accomplished through a multidisciplinary approach involving a team which provides a coordinated process of care.

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