Holistic management of diabetic foot

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Abstract. Diabetic foot ulcer (DFU) is the most costly and devastating complication of diabetes mellitus, which affect 15% of diabetic patients during their lifetime. DFUs are complex, chronic wounds, which have a major long-term impact on the morbidity, mortality and quality of patients’ lives. Individuals who develop a DFU are at greater risk of premature death, myocardial infarction and fatal stroke than those without a history of DFU. Unlike other chronic wounds, the development and progression of DFU is often complicated by wide-ranging diabetic changes, such as neuropathy and vascular disease. The management of DFU should be optimized by using a multidisciplinary team, due to a holistic approach to wound management is required. Based on studies, blood sugar control, wound debridement, advanced dressings and offloading modalities should always be a part of DFU management. Furthermore, surgery to heal chronic ulcer and prevent recurrence should be considered as an essential component of management in some cases.

1. Introduction
Individuals with diabetic foot ulcer (DFU) are demonstrating increased incidence of hospitalization due to infection, which has resulted in a rise in the number of amputations.[1] Of all amputations associated with a foot wound of any type, DFU precede up to 83% of major and 96% minor amputations.[2] Individuals with DFU are at greater risk of premature death, myocardial infarction and fatal stroke than those without a history of DFU.[3] Unlike other chronic wounds, the development and progression of a DFU is often complicated by wide-ranging diabetic changes, such as neuropathy and vascular disease. These, along with the altered neutrophil function, diminished tissue perfusion and defective protein synthesis that frequently accompany diabetes, present practitioners with specific and unique management challenges.

2. Definition
DFUs are complex, chronic wounds, which have a major long-term impact on the morbidity, mortality and quality of patients’ lives. Individuals who develop a DFU are at greater risk of premature death, myocardial infarction and fatal stroke than those without a history of DFU. Unlike other chronic wounds, the development and progression of a DFU is often complicated by wide-ranging diabetic changes, such as neuropathy and vascular disease.[3]

3. Epidemiology
Approximately 15 to 20 percent of the estimated 16 million persons in the United States with diabetes mellitus will be hospitalized with a foot complication at sometime during the course of their
disease.[4] Within the diabetic population, the incidence of DFU has been reported to be 4%—10%.[5] Furthermore it has been reported that 55% of individuals with diabetes and a lower extremity amputation will require further amputation in less than 3 years.[6] Furthermore, patients with peripheral neuropathy and PAD have higher reulceration and amputation rates than those with peripheral neuropathy alone.[7]

4. Natural History and Prognosis
To date, DFU is considered as a major source of morbidity and a leading cause of hospitalization in patients with diabetes.[8] It is estimated that approximately 20% of hospital admissions among patients with diabetes are the result of DFU. Indeed, DFU can lead to infection, gangrene, amputation, and even death if necessary care is not provided.[9]

5. Pathophysiology
Clinicians should be aware of three key aetiologies that will influence assessment, treatment of the underlying condition and management of the DFU: Neuropathy, Ischaemia, neuroischaemia. Neuropathy and peripheral artery disease (PAD), along with cardiovascular disease, renal dysfunction and others, are well known comorbidities of diabetes. Specialists involved in healing diabetic foot ulceration recognize the importance of perfusion, offloading and proper monitoring. However, when ulceration is present, appropriate classification and treatment strategies of each wound’s characteristic must be considered for adequate and timely treatment by appropriately trained physicians.[10] A clinically verified, holistic approach to DFU, such as wound, ischemia, and foot infection (WIfI) [11], outlines three areas that need to be addressed and helps to identify which, at any one time, is the most ‘dominant’ risk: 1. Tissue loss; 2. Ischaemia; 3. Infection.[12]

6. Diagnosis and Assessment
Documenting ulcer characteristics Recording the size, depth, appearance and location of the DFU will help to establish a baseline for treatment, develop a treatment plan and monitor any response to interventions. It is important also to assess the area around the wound: erythema and maceration indicate additional complications that may hinder wound healing. Digitally photographing DFUs at the first consultation and periodically thereafter to document progress is helpful.[13]

6.1. Testing For Loss Of Sensation
Two simple and effective tests for peripheral neuropathy are commonly used: 10g (Semmes–Weinstein) monofilament and Standard 128Hz tuning fork. The 10g monofilament is the most frequently used screening tool to determine the presence of neuropathy in patients with diabetes.[14] It should be applied at various sites along the plantar aspect of the foot. Guidelines vary in the number of sites advocated, but the international consensus is to test at three sites.[15]

6.2. Testing For Vascular Status
Palpation of peripheral pulses should be a routine component of the physical examination and include assessment of the femoral, popliteal and pedal (dorsalis pedis and posterior tibial) pulses. Assessment of pulses is a learned skill and has a high degree of inter-observer variability, with high false-positive and false-negative rates. The dorsalis pedis pulse is reported to be absent in 8.1% of healthy individuals, and the posterior tibial pulse is absent in 2.0%. Nevertheless, the absence of both pedal pulses, when assessed by an experienced clinician, strongly suggests the presence of pedal vascular disease.[16] If there is any doubt regarding diagnosis of PAD, it is important to refer to a specialist for a full vascular assessment. Where available, Doppler ultrasound, ankle brachial pressure index (ABPI) and Doppler waveform may be used as adjuncts to the clinical findings when carried out by a competent practitioner. Toe pressures, and in some instances, transcutaneous oxygen measurement, may be useful for measuring local tissue perfusion. An ischaemic foot may appear pink and relatively warm even with impaired perfusion due to arteriovenous shunting.[17]
6.3. Identifying Infection
Recognizing infection in patients with DFU can be challenging, but it is one of the most important steps in the assessment. It is at this crucial early stage that practitioners have the potential to curb what is often progression from simple (mild) infection to a more severe problem, with necrosis, gangrene and often amputation. Around 56% of DFU become infected and overall about 20% of patients with an infected foot wound will undergo a lower extremity amputation. The frequent occurrence of arterial insufficiency, an immunocompromised state and loss of pain sensation means that up to half of patients may not present with the classic signs of infection and inflammation, such as redness, heat and swelling.[17]

7. Management of DFU
7.1. Multidisciplinary Approach To Care
A multidisciplinary team (MDT) approach to DFU is key to understanding the linear relationship between uncontrolled diabetes, vascular compromise, foot deformity, diabetic foot infection and other comorbidities. The burden of care and spectrum of services required for sustainable success in diabetic foot care requires a team of organized and unified specialists. A team effort, along with a systemic approach towards controlling ischaemia, wound severity, and foot infection will help reduce the risk of amputation and identify the ever-changing dominant risk factors during the lifetime of the patient’s care.[18] In many countries there is a shortage of specialist practitioners, which makes establishing an MDT extremely difficult. However, non-specialist practitioners can play a key role in the early detection of problems and prompt referrals.[19]

7.2. Debridement
Debridement is the removal of necrotic and senescent tissues as well as foreign and infected materials from a wound, which is considered as the first and the most important therapeutic step leading to wound closure and a decrease in the possibility of limb amputation in patients with DFU.[20] Debridement seems to decrease bacterial counts and stimulates production of local growth factors. This method also reduces pressure, evaluates the wound bed, and facilitates wound drainage.[21]

7.3. Offloading
The use of offloading techniques, commonly known as pressure modulation, is considered the most important component for the management of neuropathic ulcers in patients with diabetes.[22] The most effective offloading technique for the treatment of neuropathic DFU is total contact casts (TCC).[23]

7.4. Advanced dressing
Passive dressings are used as protective functions and for acute wounds because they absorb reasonable amounts of exudates and ensure good protection. Active and interactive dressings are capable of modifying the physiology of a wound by stimulating cellular activity and growth factors release. In addition, they are normally used for chronic wounds because they adapt to wounds easily and maintain a moist environment that can stimulate the healing process.[24]

7.5. Revascularization
Appropriate vascular evaluation and strategy formulation to ameliorate or monitor the effects of ischaemia must be used to aid wound healing in all patients presenting with a diabetic foot ulceration.[18] The first step in wound treatment is thorough, routine cleansing, this includes removing all surface debris, slough and infected tissue; areas of necrosis should be debrided to the point of clean and healthy tissue.[25]
7.6. Surgery
Diabetic foot surgery plays an essential role in the prevention and management of DFU [26], and has been on the increase over the past 2 decades.[27] In general, surgery for DFU healing includes nonvascular foot surgery, vascular foot surgery, and in some cases amputation. Nonvascular foot surgery is divided into elective, prophylactic, curative, and emergent surgeries that aim to correct deformities that increase plantar pressure.[28]

7.7. Advanced Therapies
Hyperbaric oxygen therapy (HBOT) has shown promise in the treatment of serious cases of non-healing DFU, which are resistant to other therapeutic methods.[29] Electrical stimulation (ES) has been reported as a perfect adjunctive therapy for DFU healing in recent literature. Based on the literature review, it is suggested that ES could improve common deficiencies that have been associated with faulty wound healing in DFU, such as poor blood flow, infection, and deficient cellular responses.[30] Bio-engineered skin (BES) has been used during the last decades as a new therapeutic method to treat DFU.[31] This method replaces the degraded and destructive milieu of extra cellular matrix (ECM) with the introduction of a new ground substance matrix with cellular components to start a new healing trajectory.[32] DFU has demonstrated the benefits from growth factors (GFs) such as platelet derived growth factor (PDGF), fibroblast growth factor, vascular endothelial growth factor, insulin-like growth factors (IGF1, IGF2), epidermal growth factor, and transforming growth factor.[33]

8. Prevention Strategies
Increasing the level of GP involvement in diabetic foot care can help to reduce the number of times patients present to emergency departments. As the risk of complications from diabetes heightens, the role of the GP is paramount in providing early referrals to specialist care, as well as initiating the direction intervention should take. Research reveals that GP often have insufficient instruction in diabetic foot care, and that regular comprehensive foot exams on patients with diabetes are infrequent. Wound healing specialists are at the forefront of providing vital information concerning the diabetic foot among peer physicians. Critical points of discussion include: reviewing the 3-minute foot exam, while promoting its utility in every patient with diabetes. Summarizing the American Diabetes Association (ADA) guidelines for primary care physicians, the ADA Comprehensive Foot Examination and risk Assessment guidelines. Promoting an approach to the care of DFU when discussing appropriate referrals for specialist care.[5]

9. Conclusion
DFU are complex and costly to patients and health systems alike. As diabetic foot syndrome incorporates endocrine, histologic, neurologic, ischaemic and orthopaedic factors, it is important that DFU assessment is holistic and multidisciplinary, with a focus not only on evaluating and managing the wound, but diagnosing and treating underlying disease. However, by adopting a holistic approach to wound healing, with appropriate referrals and multidisciplinary involvement, DFU can be healed and limbs saved.

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