MANAGEMENT OF DIABETIC FOOT

INTRODUCTION

The management of diabetic foot disease may seem poorly defined by comparison with complications such as nephropathy, hyperlipidaema and retinopathy, for which clear guidelines exist. A multidisciplinary team approach, particularly in specific diabetic foot clinics, is very successful in avoiding and treating foot complications. This strategy has been shown to reduce both the incidence of major leg amputation (by 40% or more), and the duration of in-patient admissions for the treatment of diabetic foot ulceration.1,2

The major challenges relating to diabetes foot are:-

1. Foot ulceration is common, affecting up to 25% of patients with diabetes during their lifetime.3
2. Over 85% of lower limb amputations are preceded by foot ulcers and Diabetes remains a major cause of non-traumatic amputation across the world with rates being as much as 15 times higher than in the non-diabetic population.
3. Prevention is the first step towards solving diabetic foot problems. Although it was estimated that an ankle is lost to diabetes somewhere in the world every 30 seconds, a more important fact is that up to 85% of all amputations in diabetes should be preventable.4
4. Strategies aimed at preventing foot ulcers are cost-effective and can even be cost-saving if increase education and effort are focused on those patients with recognized risk factors for the development of foot problem.5
5. Diabetes is now the most common cause of Charcot neuro-arthropathy in Western countries, another condition that should be generally preventable.6

EPIDEMIOLOGY OF DIABETIC FOOT DISEASE:

One-third of all diabetic patients have significant peripheral neuropathy and/or peripheral vascular disease (PVD). Diabetic foot problems are the commonest reason for hospitalization of diabetic patients (about 30% of admissions) and absorb some 20% of the total health-care costs of the disease—more than all other diabetic complication.2,7 In India prevalence of foot ulcers in diabetic patients in clinic population is 3%, which is much lower than reported in the western world. A possible reasoning for the low prevalence in Indians is younger age and shorter duration of diabetes.8,9 PVD has been reported to be low among Asians10-13 ranging between 3-6% as against 25-45% in Western patients.14-16 The prevalence of PVD increases with advancing age and is 3.2% below 50 years of age and rises to 55% in those above 80 years of age.17 Similarly it also increases with increased duration of diabetes, 15% at 10 years and 45% after 20 years.18

ETIOPATHOGENESIS OF DIABETIC FOOT LESIONS:

The breakdown of the diabetic foot does not occur spontaneously, and there are many warning signs that may be used to predict those at risk. Dr. Elliott Joslin recognised this more than 75 years ago, when he stated that “Diabetic gangrene is not heaven-sent but is earth-born”.19 Ulcers invariably occur as a consequence of an interaction between environmental hazards and specific pathologies in the lower limb.
Peripheral Vascular Disease in Diabetes

Peripheral arterial disease (PAD) is a contributing factor to the development of foot ulcers in up to 50% of cases. It commonly affects the tibial and peroneal arteries of the calf. Endothelial cell dysfunction and smooth cell abnormalities develop in peripheral arteries as a consequence of the persistent hyperglycaemic state. Moreover, smoking, hypertension, and hyperlipidemia are other factors that are common in diabetic patients and contribute to the development of PAD.

Plantar Callus:

Callus forms under weight-bearing areas as a consequence of dry skin (autonomic dysfunction), insensitivity and repetitive moderate stress from high foot pressure. It acts as a foreign body and cause ulceration. Callus should be removed by the podiatrist or other trained health care professional.

Foot Deformity

A combination of motor neuropathy, cheiroarthropathy and altered gait patterns are thought to result in the “high risk” neuropathic foot with clawing of the toes, prominent metatarsal heads, high arch and small muscle wasting.

Assessment of Diabetic Foot

A task force of the Foot Care Interest Group of the American Diabetes Association (ADA) released a 2008 report that specifies recommended components of foot examinations for patients with diabetes. Providers should take a history of all risk factors given in table 3. The foot should be examined for deformities. Hyperextension of the metatarsal-phalangeal joint with interphalangeal or distal interphalangeal joint flexion leads to hammer toes. In examining for PAD, the dorsalis pedis and posterior tibial pulses should be palpated and characterized as present or absent.

Diabetic Neuropathy: More than 60% of diabetic foot ulcers are the result of underlying neuropathy. The more commonly described mechanisms of action is the polyol pathway. The hyperglycaemic state leads to an increase in action of the enzymes aldose reductase and sorbitol dehydrogenase. This results in the conversion of intracellular glucose to sorbitol and fructose. The accumulation of these sugar products results in a decrease in the synthesis of nerve cell myoinositol, required for normal neuron conduction. Additionally, the chemical conversion of glucose results in a depletion of nicotinamide adenine dinucleotide phosphate (NADP) stores, which are necessary for the detoxification of reactive oxygen species (ROS) and for the synthesis of the vasodilator nitric oxide (NO). There is a resultant increase in oxidative stress on the nerve cell and an increase in reactive oxygen species (ROS) and for the synthesis of the

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findings suggestive of potential ischemia. Measuring the Ankle Brachial Index (ABI) can be used for determining the extent of vascular disease. The ABI is obtained by measuring the systolic blood pressures in the ankles (dorsalis pedis and posterior tibial arteries) and arms (brachial artery) using a handheld Doppler and then calculating a ratio. Ratios below 0.91 are suggestive of obstruction. However, in patients with calcified, poorly compressible vessels or aorto-iliac stenosis, the results of the ABI can be complicated.\(^6\) If there is a strong suspicion of PAD, the patient should undergo vascular imaging / peripheral arterial angiogram.

The loss of pressure sensation in the foot has been identified as a significant predictive factor for the likelihood of ulceration. A screening can be done by the diabetic foot is the 10-gauge monofilament. The monofilament is tested on various sites along the plantar aspect of the toes, the ball of the foot, and between the great and second toe. The test is considered reflective of an ulcer risk if the patient is unable to sense the monofilament when it is pressed against the foot with enough pressure to bend it.\(^24\) Areas of callus should not be tested.\(^24\)

**WOUND HEALING IN DIABETIC FOOT:**

Diabetes may influence foot wound healing by an impairment of the peripheral circulation, altered leukocyte function, disturbed balance of cytokines and proteases and even chronic hyperglycemia itself.\(^6,33\) Recently, it has been suggested that levels of matrix metalloproteinases (MMP) are important in predicting the likelihood of wound healing and a high level of MMP-1 seems essential to wound healing.\(^34\)

**OFFLOADING**

The neuropathic plantar foot wounds will heal satisfactorily when offloaded in a Total Contact Cast (TCC).\(^4\) The Principle of TCC management is that pressure is mitigated but, in addition, the device is irremovable thus enforcing compliance with therapy. The Removable Cast Walkers (RCW) redistribute pressure in a similar manner to the TCC, but it’s results are inferior to TCC due to patient’s non-compliance. Appropriate offloading result in angiogenesis, fibroblast proliferation and presence of granulation tissue. Offloading is an essential component to the management of predominantly neuropathic plantar foot ulcers (UT 1A and 2A) ulcers. For those patients treated with irremovable cast walkers, it is recommended that the cast be removed initially on a weekly basis for wound assessment, debridement and cleansing. Healing can generally be achieved in a period of 6-12 weeks in a cast. It is strongly recommended that after the plantar wound has healed, that the cast be worn for a further 4 weeks to permit the scar tissue to firm up. Thereafter, the patient may be gradually transferred to appropriate footwear which may need extra depth or in the case of severe deformity, custom moulded.

**MANAGEMENT OF INFECTION:**

Clinically non-infected ulcers:

Where ulcers are not infected and predominantly neuropathic (UT grade 1A, 2A), the use of antibiotics may be withheld as Chantelau et al\(^35\) have shown that with appropriate wound management, patients do equally well with or without systemic antibiotics in a randomized controlled trial. Nevertheless, frequent review, debridement and callus removal together with offloading are essential parts of management of neuropathic foot ulcers and if signs of infection develop, antibiotics may be needed. For those ulcers with an ischemic component which do not have gross signs of infection (UT 1C, 2C) antibiotics should probably be given in most cases as the combination of infection and ischemia in the diabetic foot are a common cause of ultimate lower extremity amputation.

**CLINICALLY INFECTED ULCERS**

Non- limb- threatening infected ulcers (UT 1B, 1D, 2B, 2D) can generally be treated on an outpatient basis, and oral broad- spectrum antibiotics should be used initially until results of sensitivities are obtained. Generally, mild infections are relatively superficial and limited, moderate infections involve deeper tissues.\(^36\) Any ulcer with clinical evidence of infection should have tissue taken and sent for culture and sensitivity. Although superficial swabs are commonly taken, deep (preferably tissue) specimens are preferable in terms of accuracy of diagnosis.\(^36\) Most infective ulcers are polymicrobial, often with a mixture of anaerobes and aerobes. If there is any suspicion of osteomyelitis, further investigations

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<th>University of Texas wound classification system</th>
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<td><strong>Stage C:</strong> with ischemia</td>
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<td><strong>Stage D:</strong> with infection and ischemia</td>
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**Table 4**

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Limb-threatening infection

Patients with limb-threatening infection usually have systemic symptoms and signs and require hospitalization with parental antibiotics. Deep wound and blood cultures should be taken, the circulation assessed with non-invasive studies initially, and metabolic control is usually achieved by intravenous insulin infusion. Early surgical debridement is often indicated in such cases, and initial antibiotic regimens should be broad-spectrum until sensitivities are determined from cultures. Examples of initial antibiotic regimens include: clindamycin and ciprofloxacin, or fluoroxyacin, ampicillin and metronidazole. The Polymerase chain reaction (PCR) assay has been shown to be effective at identifying many virulent organisms. A recent study from France showed the potential advantages of using this new technique in the rapid distinction between colonizing and virulent infecting organisms.

An increasing problem in diabetic foot clinics is the antibiotic-resistant pathogens such as methicillin-resistant staphylococcus aureus (MRSA). If MRSA is felt to be an infecting organism, there are useful new agents such as linezolid, which can be given parentally or orally.

Osteomyelitis:

Contrary to traditional teaching, it is increasingly recognized that some cases of localized osteomyelitis can be managed by long-term (10-12weeks) antibiotic therapy; however, localized bony resection after appropriate antibiotic therapy remains a common approach. Those cases with osteomyelitis confined to one bone without involvement of a joint are most likely to respond to antibiotic therapy particularly in the absence of PVD.

Adjunctive therapy

Growth factors

The recombinant platelet derived growth factor (PDGF) Becaplermin was the first growth factor, approved for treating diabetic neuropathic foot ulcer. There is some support for their use from randomized clinical studies, their expense together with the fact that most neuropathic ulcers can be healed with appropriate offloading, have limited their use and there is still no consensus as to their place in day – to – day clinical practice.

Hyperbaric oxygen

Hyperbaric oxygen (HBO) has been promoted for the management of non-healing diabetic foot ulcers in ischemic diabetic foot wounds. Though the systematic review of the International working group considered HBO accepted, that there was some evidence to support its use, it is clear that more data are required from larger controlled trials not only to confirm efficacy but also to clarify which wounds might best benefit from this expensive treatment.

Negative pressure wound therapy

Over the past several years negative pressure wound therapy (NPWT) using vacuum-assisted closure has emerged as the treatment of complex wounds of the diabetic foot. It decreases local tissue edema and removes excessive fluid and pro-inflammatory exudates from the wound bed. There is now controlled trial evidence for the use of NPWT in both local postoperative wounds in the diabetic foot and, more recently, in the management of complex but non-surgical diabetic foot ulcers. It is clear that this treatment helps promote the formation of granulation tissue, but its cost will limit its use.

Biologically engineered skin substitutes

Tissue engineered skin, Apligraf comprises of cultured living dermis and sequentially cultured epidermis. Dermagraft is dermis derived from human fibroblasts used for treatment of non-infected neuropathic ulcers. A systematic review on this topic concluded that the trials assessed were of questionable quality and until high quality studies were performed, recommendations for the use of these skin substitutes could not be made.

Larval therapy

The use of sterile maggots, the larvae of the common green bottle fly, is not new. Sterile maggots are useful in desloughing wounds that are resistant to surgical debridement. It is believed that they secrete a broad spectrum of powerful enzymes that break down dead tissue. Limited evidence also suggests that they do not harm healthy tissue because the enzymes are inactivated by inhibitors present in normal skin.

Charcot neuroarthropathy

Charcot neuroarthropathy (CN) is a non-infective arthropathy which occurs due to a combination of motor, autonomic, and sensory neuropathies in which there is muscle and joint laxity that lead to changes in the arches of the foot. Further, the autonomic denervation leads to bone demineralization via the impairment of vascular smooth muscle, which leads to an increase in blood flow to the bone with a consequential osteolysis. The exact mechanism underlying the development of CN remains unclear. Patient may have history of trauma and may present with a warm, swollen foot and may be accompanied by pain or at least discomfort. The treatment of CN in acute phase is offloading of the affected foot by use of a plaster cast. The cast should continue until the swelling and hyperemia have resolved and then custom moulded shoes with appropriate insoles are indicated. Bisphophonates are potent inhibitors of osteoclast activation and intravenous Pamidronate has been shown to be useful in reducing disease activity in acute CN. Larger randomized controlled trials.
Charcot’s Arthropathy

Gangrene

Bunion with Nail Changes

Planter Infected Ulcer

Hammer Toes

Tinea Interdigitalis

Foot Care

Self Inspection

Take care of Dry skin
to see feet in mirror for redness, Swelling, ulcer or crack foot

Cut the nails straight
are required to confirm these preliminary observations. The management of advanced CN with bone deformity requires reconstructive surgery.

FOOTWEAR, ORTHOSES, AND HOISIERY
Inappropriate (Often tight) footwear is a major cause of ulceration. Studies have suggested that specialized foot wear with padded hosiery reduces high foot pressures and gives all- around protection to the high-risk diabetic foot provided that the shoes are fitted to accommodate the padded socks.28

INJECTED LIQUID SILICONE
A randomized, double-blind trial of injected liquid silicone in the diabetic foot has confirmed that silicone injections were associated with increased soft-tissue thickness under the metatarsal head, decreases foot pressure, and reduced callus formation. Such an “injectable orthosis” might well be beneficial in high-risk patients. Subsequent follow-up studies confirmed that patients at greatest risk of ulceration were most likely to benefit from silicone injections but that after two years of follow-up, the benefits of injections, though still demonstrable, were reduced compared to baseline, suggesting that booster injections may periodically be needed. This is an area of ongoing research29,30

PATIENT EDUCATION
Patients need to be informed of the risk of having sensory loss and the need for regular self-inspection, foot hygiene, and podiatry treatment as required. They must also be told what action to take in the event of injury or the discovery of a foot ulcer.51

THE DIABETIC FOOT: NEED FOR A TEAM APPROACH
A number of reports have shown the benefits of the multidisciplinary approach to diabetic foot care. The team might include diabetologists, surgeons (both orthopaedic and vascular), specialist nurses, diabetes educators, podiatrists, orthotists, pedorthists and patient or a care taker of patient.27

CONCLUSION
Patients with diabetes are at an increased risk for developing foot ulcerations. The consequences of persistent and poorly controlled hyperglycemia lead to neuropathic and vascular abnormalities that cause foot deformities and ulceration. The feet of diabetic patients should be examined at least annually to determine predisposing conditions to ulceration. Treatment plans should be based on examination findings and the individual risk for ulceration. If ulcers are present, the treatment strategy should include offloading, debridement, and appropriate dressings. Further, the presence of infections should be determined by clinical findings and appropriate wound cultures and treated based on the culture results. If evidence for ischemia is present, revascularization may be indicated to restore arterial blood flow and increase the chance for limb salvage. There are adjunctive therapies available that can also contribute to the overall healing process of the wounds in affected patients. Patient education and team approach towards management plays the key role to words the success.

REFERENCES


23. Huijberts MS et al.: Advanced glycation end products and diabetic foot disease. Diabetes


