Everyday Practice: Diabetes Mellitus

Approach to a patient with a diabetic foot

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ABSTRACT

Diabetic foot disease is an important cause of morbidity and mortality in persons with diabetes mellitus. The commonest presentation of diabetic foot is an ulcer. Neuropathy, ischaemia and infection are the main pathogenic factors involved. Clinical examination and investigations are focused on identifying the aetiology as well as the extent of foot disease. The monofilament test is a simple, bedside test that can predict the risk of neuropathic ulceration. Treatment of diabetic foot ulcer should focus on antibiotic therapy, dressings, debridement and timely surgery. Glycaemic control and management of systemic co-morbid conditions is important. Necrotizing fasciitis is a life-threatening situation where early diagnosis and therapy is important. In ulcers associated with peripheral vessel disease, revascularization, when feasible, can improve blood flow and hasten wound healing. Amputation is reserved for life-threatening situations as well as for severe, non-resolving cases. The majority of amputations are preventable by diabetes education, foot care and appropriate footwear.

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INTRODUCTION

Diabetic foot is a term that encompasses the abnormalities occurring in the feet of persons with diabetes mellitus. These range from acute problems such as cellulitis to chronic problems such as Charcot arthropathy as well as fulminant emergencies such as necrotizing fasciitis (*see* Box 1). Diabetic foot is arguably the commonest cause of non-traumatic amputations worldwide. In India, diabetic foot infections are an important cause of hospitalization. Diabetic foot infection and its treatment impose a heavy economic burden on patients in India. Foot ulcerations due to diabetes are generally preventable, and simple interventions can reduce amputation rates by about 80%.

Box 1: Spectrum of diabetes-related foot problems

Acute
- Cellulitis
- Thrombo-embolic phenomena
- Necrotizing fasciitis

Chronic
- Milder degrees of foot deformity
- Fungal infections
- Ulcer
- Osteomyelitis
- Gangrene
- Peripheral vascular disease
- Charcot foot

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PATHOGENESIS

The key manifestation of diabetic foot is a chronic ulcer. The most frequent underlying factors in the pathogenesis are trauma, neuropathy, deformity, high plantar pressures, infection and peripheral arterial disease. Certain risk factors place the patient at higher risk of foot ulcers (*see* Box 2). The most critical event triggering diabetic foot ulcer is the loss of protective foot sensation due to sensory neuropathy. This leads to a cascade of events culminating in an ulcerated foot (Fig. 1).

Box 2: Risk factors for foot ulceration in diabetes

- Poor glycaemic control
- Trauma
- Foot deformity
- Diabetic neuropathy
- Peripheral vessel disease
- Lack of foot care education
- Involvement of opposite foot
- Previous foot problems
- Smoking
- Barefoot walking

CLINICAL EVALUATION

The common presentation of diabetic foot is an ulcer and is the focus of this article. At presentation, a careful history of diabetes and its management must be elicited, focusing on the risk factors mentioned in Box 2. Also, symptoms of diabetic sensory neuropathy, including both positive symptoms (tingling, burning feet, paraesthesias) and negative symptoms (decreased or absent sensation, lack of awareness of pain/thermal injury) must be ascertained. Prior antibiotic use must be documented.

Foot examination should begin with inspection of the ulcer and surrounding skin. Redness or swelling of the skin indicates the extent of spread of infection. Dry, shiny skin, with lack of hair and brittle nails suggest poor nutrition, and this could be a consequence of either peripheral vessel disease (PVD) or diabetic autonomic neuropathy. Web space fungal infections are a common source of fulminant foot infections. The presence of a chronic foot deformity indicates motor neuropathy: a common example is the hammer toe—a deformity due to extension of the metatarsophalangeal joint and flexion at the interphalangeal joint. Plantar pressure is highest at the base of the big toe, which is the classical site for the occurrence of a neuropathic ulcer. In people with severe sensory neuropathy, complicated by motor/autonomic nerve involvement, a completely deformed foot can occur—this is called Charcot neuroarthropathy.

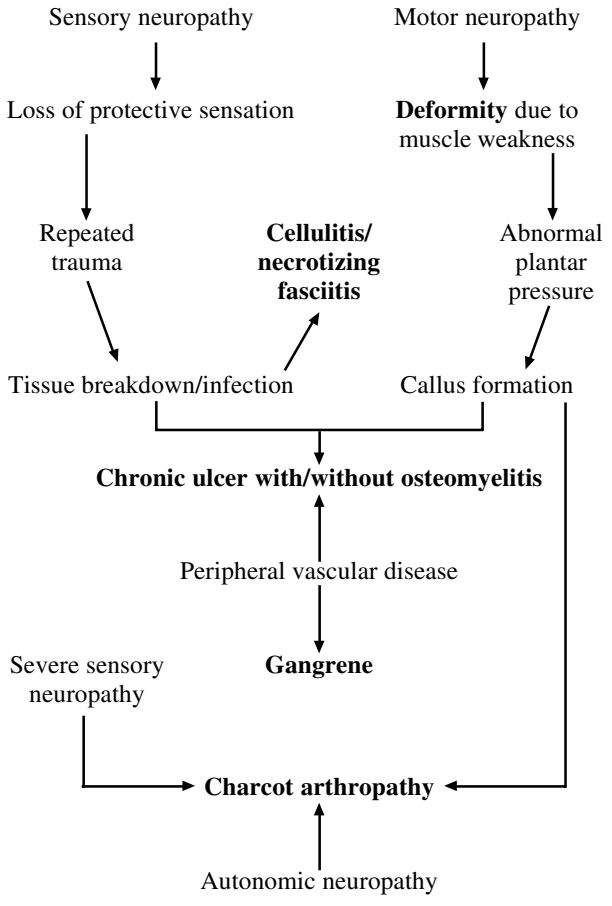

FIG 1. Pathogenesis of the diabetic foot; the important end-points are highlighted in bold

During palpation, all foot pulses must be felt, especially the dorsalis pedis and posterior tibial. A complete neurological examination must be done to rule out peripheral nerve disease. A complete physical examination is essential, as patients with diabetic foot usually have long-standing diabetes and other complications such as peripheral neuropathy, PVD, diabetic kidney disease, retinopathy, hypertension and coronary artery disease.

INVESTIGATIONS

Investigations include an assessment of glucose control and diabetes-related complications, e.g. assessment of nephropathy (blood urea and serum creatinine) as well as coronary artery disease (electrocardiogram). These will help guide management decisions such as the dose of antibiotics as well as safety of major surgical/vascular procedures. A complete blood count may reveal a high leukocyte count, which may be the only clue to underlying septicaemia. Foot-related investigations include:

1. *Assessment of infection*. In the case of superficial ulcers, a swab culture is sufficient, and a Gram stain can give an initial clue to the choice of therapy. Deeper ulcers may require a deep tissue culture. A probe may be passed into the base of the ulcer, and if this touches bone, it is assumed that osteomyelitis is present. In non-resolving cases of osteomyelitis a bone culture obtained at the time of bone curettage may be useful.
2. *Vascular evaluation*. Adequate vascularity is needed for ulcer healing. Clinical acumen usually plays a key role as expensive technologies such as transcutaneous oxygenation ($TcPO_2$) assessment ($TcPO_2$ <20 mmHg predicts a high risk for eventual amputation) are not commonly available. Ankle–brachial index (ABI) assessment is a simple test. The ABI is obtained by dividing the systolic blood pressure in the brachial artery (as detected by a sphygmomanometer) by the systolic blood pressure in the dorsalis pedis/posterior tibial artery. A value between 0.9 and 1.3 is normal. A low value suggests decreased vascularity. A high value suggests a false assessment due to atherosclerotic stiffening of the proximal arteries. A hand-held Doppler machine can also be used for the same purpose. Where facilities are available, a complete Doppler study of the lower limb vasculature may help to detect the extent and number of segments with arterial disease. Angiography may be reserved for more severe or non-resolving cases.
3. *Neuropathy evaluation*. A valuable test is the monofilament test. This uses a 10 g monofilament to assess light touch at pressure points on the sole, and to detect large-fibre neuropathy. The monofilament is placed vertically on selected pressure points on the sole and just enough pressure is exerted for approximately a second to buckle the filament. The most important site is the base of the great toe. If the patient cannot feel this light touch, then the risk of foot ulceration is very high. Testing 4 important sites (great toe and end of the first, third, and fifth metatarsals, Fig. 2) identifies 90% of subjects with an insensate site. Biothesiometry assesses the threshold for vibration perception using increasing electrical stimulation. The stimulators are kept on bony prominences such as the malleoli. The threshold at which vibration is perceived is important. If the patient can perceive vibration only above 15 V, then the patient has neuropathy. A simple alternative to assess neuropathy is to use a 128-Hz tuning fork to assess vibration.
4. *Imaging*. An X-ray of the foot is a useful investigation. It is important to look for bone abnormalities such as osteomyelitis, Charcot arthropathy, presence of gas (suggests clostridial infection) and vascular calcification (could be contributing to arterial stiffening and abnormal blood flow). Expensive imaging such as MRI seldom helps, except in the rare scenario where a pus collection is suspected despite a normal ultrasound assessment. A nuclear scan is usually not required, except in the very rare situation where it is important to distinguish between a Charcot foot and osteomyelitis.

MANAGEMENT: GENERAL PRINCIPLES

A team approach is essential because patients with diabetic foot disease often have poor glycaemic control as well as complications

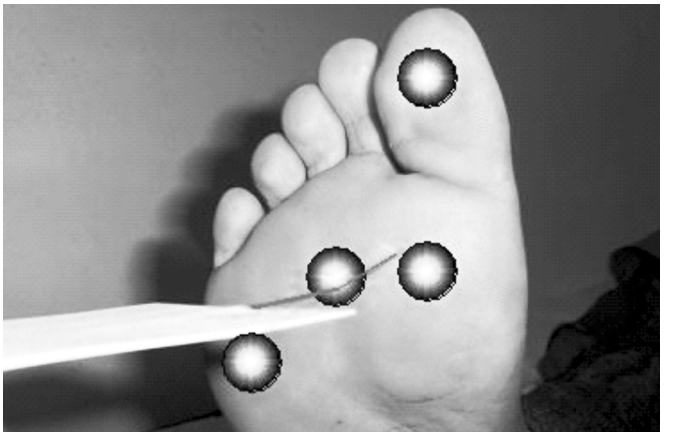

FIG 2. The monofilament test. Testing these 4 sites together is fairly sensitive in detecting high risk feet.

such as nephropathy and heart disease. All patients with limb or life-threatening infections must be hospitalized and given systemic antibiotic cover (*see* Box 3). Patients with a superficial skin infection or ulcer without osteomyelitis, pus discharge or systemic signs may be safely treated with oral antibiotics (e.g. an amoxicillin–clavulinic acid combination) on an outpatient basis.

Sophisticated measures such as vacuum-assisted healing and hyperbaric oxygen are not commonly available and are not discussed here. A management plan based on the Meggitt–Wagner grading is given in Table I. The important aspects of management are:

1. *Antibiotics*. Appropriate antibiotic cover is essential for treating diabetic foot infections. While wound culture reports are awaited, a presumptive antibiotic regimen is usually started. Tertiary care hospitals have institutional antibiotic protocols depending on their microbial profile as well as culture/susceptibility patterns. Though ideal, this may not be practical in a peripheral setting—an empirical antibiotic regimen that covers Gram-negative pathogens, Gram-positive pathogens as well as anaerobes is the best strategy. A simple example would be a combination of cefoperazone and sulbactam given intravenously to combat Gram-positive and Gram-negative organisms with metronidazole added to cover anaerobes. Changes in antibiotic therapy may be based on the clinical response as well as culture reports. Osteomyelitis requires 1–2 months of culture-specific antibiotics. After an initial 7–14 days of intravenous antibiotics, depending on the response, a shift to oral antibiotic therapy may be considered.
2. *Dressing*. Water and saline are good enough for cleaning the ulcer. The use of costly dressing materials, topical antibiotics and wound irrigants is neither necessary nor of proven benefit. Commonly used materials such as povidone, hydrogen peroxide and acetic acid must be avoided. These have been shown to be cytotoxic to fibroblasts and granulation tissue, and may impair wound healing. Saline gauze, water-based gels, paraffin gauze and metronidazole gel for topical use can be used. Topical antibiotics must not be used for >2 weeks, as this may induce bacterial resistance and select out more virulent pathogens. Expensive growth factors such as platelet-derived growth factor (PDGF) and epidermal growth factor (EGF) are newer modalities. These are useful in a limited subset of patients with pure neuropathic ulcers who do not respond to routine treatment for >1 month. Growth factors are effective only when the necrotic debris has been removed, the blood supply is adequate and adequate antibiotic penetration has been achieved.
3. *Control of systemic illness*. Many patients with diabetic foot infections have poorly controlled blood glucose levels, and may also suffer from poor nutrition, coronary disease and renal insufficiency. Adequate medical therapy for these problems is very important.
4. *Debridement*. Removal of all dead tissue (slough) as well as callus and collections of pus is essential to limit the progression of the infection as well as to promote healing. This may be done at the bedside by a podiatrist, but more extensive infection/necrosis may need surgical debridement.
5. *Offloading*. Complete relief of pressure from the area of the wound is referred to as offloading. Common examples of excess pressure interfering with wound healing are repetitive trauma from ill-fitting footwear and abnormal foot structure leading to high pressure on selected areas. (Dressings alone may not heal ulcers unless pressure is also relieved.) Continuing to walk with a foot ulcer will result in ongoing trauma, eventually preventing wound healing. It is important that the patient realizes how important 'offloading' or giving rest to the foot is. A simple method is to use a wheel chair or crutches so that pressure is 'offloaded' completely, but this is inconvenient. An alternative approach is to help the patient walk on the other leg using a walker. Probably the best way to offload is to use a total contact cast (TCC). This uses a well-moulded and minimally padded cast to maintain contact with the sole and the lower leg. TCC should be used only in clean ulcers that are free from infection.
6. *Skin grafting*. Once ulcer debridement has been done and the underlying bed looks red and granulating and is micro-biologically sterile, it is expected that the ulcer will heal. If the surface area of the ulcer is large, then skin grafting may be done.
7. *Limb salvage by vascular procedures*. Once necrotic tissue around an ulcer has been debrided, if the base of the ulcer still looks dry, pale and necrotic, this means that the vascularity is suboptimal. In such patients, a lower limb angiogram/Doppler may be considered. In case a focal tight stenosis in the blood vessels to the peripheral limbs is detected on angiogram, an angioplasty would be useful. In case a surgically correctable problem exists, vascular bypass is an important step. However,

Box 3: Indications for hospitalization in diabetic foot infections

Limb-threatening
- Deep ulceration
- Purulent discharge
- Tissue necrosis
- Osteomyelitis

Life-threatening
- Bacteraemia
- Marked tissue necrosis
- Gangrene
- Systemic toxicity
- Leukocytosis
- Deranged renal function
- Disseminated intravascular coagulation
- Shock

TABLE I. Ulcer management plan based on the Meggitt–Wagner classification*

Grade	Condition	Treatment
0	High risk foot, no ulcer	Follow up, footwear, diabetes education
1	Superficial ulcer that is not clinically infected	Pressure offloading with a cast (*see* text), walking brace or special footwear
2	Deeper ulcer, often with cellulitis, no abscess or bone infection, often exposing joints and tendons	Debridement, dressing, culture-specific antibiotics and offloading after vascular assessment
3	Deep ulcer with bone involvement or abscess formation	Debridement with or without amputation, vascular assessment and therapy, dressing, culture-specific antibiotics and offloading
4	Localized gangrene (forefoot or heel)	Vascular assessment and amputation
5	Whole foot gangrene	Vascular assessment and whole extremity amputation

* Note that at any stage (1–4) if infection is spreading in a septicaemic and toxic patient with multiorgan dysfunction, amputation may be considered for saving life.

these procedures carry a high risk in people with diabetes, especially those with heart/kidney disease. In addition, these procedures by themselves do not heal ulcers, but only help improve vascularity and increase the rate of ulcer healing, and prevent or limit the extent of amputation.

8. *Vascular medication*. Antiplatelet therapy should be offered to all persons with type 2 diabetes >40 years of age, particularly those with diabetic foot and impaired peripheral vascularity. The most useful is aspirin (75–150 mg/day). Clopidogrel (75 mg/day) is an acceptable alternative. Low dose aspirin (75 mg/day) may be continued for patients undergoing minor procedures such as debridement, as there is no evidence for an increase in risk of major bleeding. Stopping aspirin in patients with coronary disease can be very risky. In this situation it is probably better to continue aspirin during minor procedures. Cilostazole (100 mg twice a day), which is a vasodilator and also inhibits platelet aggregation, is useful for symptom relief in those with intermittent claudication. Low molecular weight heparin (enoxaparin 20 mg s.c. daily for 7–10 days) will prevent deep vein thrombosis and improve microcirculation in immobilized and hospitalized patients.
9. *Amputation*. If limb salvage and systemic measures fail to heal the ulcer and sepsis supervenes, then amputation becomes necessary. There are several indications for amputation. These include extensive gangrene, spreading necrosis in a toxic patient, extensive necrosis with irreversible arteriopathy and severely disrupted ankle due to Charcot foot. A timely amputation may halt the progression of the systemic inflammatory response associated with a foot infection and may be life-saving. The decision of the 'level' of amputation is critical as adequate vascularity is essential for healing of the stump. The amputation level must be based on (i) the extent of infection, (ii) the level of vascular occlusion, (iii) the predicted 'walkability' of the remaining stump, and (iv) the degree of systemic sepsis. An inadequate amputation, which can result in persistent sepsis/vascular insufficiency, is as dangerous as an overzealous amputation, which may result in an inadequate and 'unwalkable' stump. Above-knee, below-knee, toe and forefoot amputations are the commonest forms of amputations. It is important to consider that over 50% of patients with diabetes who survive a major amputation would succumb in the next one year to cardiovascular disease. The preventive management of co-morbid conditions in this setting cannot be overemphasized.

MANAGEMENT: SPECIAL SITUATIONS

Charcot foot

Charcot neuroarthropathy is characterized by severe foot deformity and destruction of the bones and joints. It occurs due to a combination of severe sensorimotor and autonomic neuropathy. The latter causes arteriovenous shunting leading to vascular imbalance and worsening bone density (resulting in osteopenia) of the foot. The early stages (called an acute Charcot foot) are characterized by a hot, swollen foot often mimicking cellulitis. At this stage, bisphosphonates such as alendronate may occasionally help. The chronic Charcot foot is an insensitive, deformed foot, which if left untreated rapidly results in an ulcer. In later stages, the X-ray shows a 'bag of bones' appearance. Treatment involves 3 steps: (i) TCC to avoid mobilization and weight bearing, (ii) customized orthotic shoes, and (iii) surgery to re-fashion the deformity. Treatment should be done at specialized centres.

Necrotizing fasciitis

This is a rapidly spreading, inflammatory infection in the deep fascia, with secondary necrosis of the subcutaneous tissues. Necrotizing fasciitis may be difficult to recognize initially, but early therapy is life-saving. Typically, the infection begins with erythema, and the redness spreads rapidly, leaving a dusky red colour at the initial site of insult. The skin and subcutaneous tissue are loosened by the underlying necrotic fascia and this occurs at some site from the initial insult. The most important signs are necrotic tissue, putrid discharge, bullae, pain, gas production, rapid burrowing through the fascial planes and absence of the classical signs of inflammation. Aggressive surgical debridement of all necrotic tissue is important and may need to be repeated several times. Antibiotic coverage should be instituted early, with an empirical regimen that covers aerobic as well as anerobic organisms till culture reports are available.

PREVENTION

The majority of amputations are preventable. Preventive podiatric care must be given to all feet at risk (*see* Box 4). Both the healthcare professional and patient can play an active role in prevention. The physician must ensure that a foot examination is conducted at least annually. Imparting foot care education is important and a checklist is useful (*see* Box 4). Prescribing appropriate footwear is essential. It is preferable to use footwear that is made of natural material such as leather/canvas, because synthetic materials such as plastic make the feet sweaty as they do not stretch or allow air circulation. High heels and pointed toe slippers are best avoided as they increase plantar pressure and predispose to bone/joint deformity. Sandal-like footwear is appropriate. Footwear with open toes, which often have a strap between the first two toes, can predispose to injury. To prevent shoebite injury, instruct the patient to break in the new shoes gradually, by wearing them for a few hours every day before assigning them to routine use. Using a pedopodogram (a footprint anaylsis which gives the 'geography' of plantar pressure) to assess pressures and prescribe shoes with customized molded insoles is appropriate for high risk/deformed feet. A recent innovation is the use of corrective foot surgery to prevent ulcers and correct deformity in severely deformed feet. Finally, it is important to maintain good metabolic control and overall health in these patients.

Box 4: Foot care information checklist for patient education

1. Inspect your feet daily. Use a mirror if needed.
2. Keep feet dry and clean especially between the toes.
3. Use footwear that is well fitting and comfortable.
4. Low heel and flat footwear is ideal.
5. If a shoe bite injury occurs, stop wearing that shoe.
6. Avoid 'home surgeries' on the feet.
7. Maintain good glucose control.
8. Avoid walking barefoot.
9. Consult a doctor for the slightest foot injury.
10. 'Shake out' shoes before use. Even a small pebble can lead to injury/infection.

SELECTED READING

1 Prompers L, Huijberts M, Apelqvist J, Jude E, Piaggesi A, Bakker K, *et al*. Optimal organization of health care in diabetic foot disease: Introduction to the Eurodiale study. *Int J Low Extrem Wounds* 2007;**6:**11–17.
2 Edmonds ME, Foster AVM. Diabetic foot ulcers. *BMJ* 2006;**332:**407–10.