# Understanding diabetic foot

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DIABETES IS A CHRONIC condition that's become an epidemic worldwide. Two to three percent of people with diabetes will develop a foot ulcer each year, and their lifetime risk of developing a foot ulcer is as high as 25% due to neuropathy and potential coexisting vascular disease.[1] When following people with diabetes and neuropathy for 1 year, researchers estimated that 7.2% would develop their first foot ulcer.[2,3] Over 80% of all nontraumatic amputations in patients with diabetes are preceded by foot ulcers, which are one of the prognostic indicators for advanced diabetes.[2,3]

This article will review proper assessment techniques and treatment options for patients with diabetic foot ulcers to help minimize complications.

## Assessing for foot ulcers

Inadequate management of diabetes can put patients at risk for many serious complications, including foot ulceration. Hyperglycemia triggers metabolic and cellular abnormalities that lead to excessive production of advanced glycation end-products, impaired leukocyte function, and generation of oxygen-free radicals that can delay healing of foot ulcers.[1] Assessing risk factors for diabetic foot ulcers should always be part of a comprehensive patient history.[3,4] (See *Recognizing risk factors for diabetic foot ulcers*.)

Conduct a thorough foot assessment with each patient visit to individualize the plan of care.[5] A comprehensive foot assessment is recommended at diagnosis of diabetes and annually or more frequently, depending on the presenting risk factors.[6] (See *Keeping an eye on the foot* for a list of recommendations.)

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# ulcers

## Types of neuropathy

Diabetic neuropathy is present in almost 60% of patients with diabetes who have foot ulcers. Nerve dysfunction associated with diabetes may be described as sensory, motor, or autonomic.[3,4]

***Sensory neuropathy*** makes a patient less aware of trauma to the skin. Blisters, erythema, or subcutaneous hemorrhage indicates local damage from friction or shear caused by excessive movement or poorly fitting footwear. Callus formation is a reaction to increased local pressure and leads to skin breakdown and ulceration. By recognizing early signs of injury related to pressure and friction, nurses can initiate prompt interventions to prevent ulceration.

To screen patients for sensory neuropathy, the 5.07/10 g Semmes-Weinstein monofilament test is recommended. Patients with significant sensory impairment (4 or more out of the 10 points) are five times more likely to develop foot ulcers.[3,4,6]

***Motor neuropathy*** interferes with the normal signaling to the lumbrical and interosseus muscle, leading to atrophy and wasting of muscles, foot deformity, upper displacement of fat pads, and altered foot biomechanics.[7] Common foot deformities, including foot drop, equinus deformity, hammertoes, and prominent plantar metatarsal heads, create areas that sustain high impact and pressure, which are prone to ulcer formation.[8,9]

Charcot foot, often characterized by an outward bowing of the arch that gives it a rocker-bottom appearance, is a serious complication of neuropathy that leads to fractures and marked deformity. Signs of acute Charcot foot may include joint displacement and/or dislocation, and increased warmth, erythema, and edema of the foot. Charcot foot is likely precipitated by repetitive trauma that triggers the release of proinflammatory cytokines and increased bone perfusion, leading to bone resorption and demineralization.[10]

***Autonomic neuropathy*** is associated with decreased production of sweat and components of the natural moisturizing factor, leading to disruption of the epidermal barrier.[7] Inspect the skin for dryness, especially the presence of fissures or cracks that may become a portal of entry for bacteria. Fungal infection is common in people with diabetes, so check between the toes for maceration. This warning sign of fungal infection usually starts at the fourth and fifth toe space, where the greatest occlusion occurs. Many antifungal agents such as imidazole, allylamines, and thiazoles are available for local or systemic management of a fungal infection.

## Vascular changes

Diabetes is associated with a two- to threefold increased risk of accelerated atherosclerosis.[11] The severity may depend on the duration and severity of diabetes, severity of dyslipidemia, obesity, hypertension, smoking, a family history of

### Recognizing risk factors for diabetic foot ulcers[26]

| Risk factors | Recommendations |
|---|---|
| Hyperglycemia | • A1C should be <7.0% for most nonpregnant adults. Check A1C at least two times a year in patients who have stable glycemic control and every 3 months (quarterly) in patients whose therapy has changed or who aren't meeting glycemic goals.<br>• Patients should exercise regularly (aerobic, resistance, or both) for at least 150 minutes per week to improve glycemic control. |
| Hypertension | • Patents should aim for a systolic BP under 140 mm Hg. Lower targets (<130 mm Hg) may be appropriate for younger patients.<br>• Patients with diabetes should keep a diastolic BP under 80 mm Hg. |
| Dyslipidemia | • Most adult patients with diabetes should have a fasting lipid profile measured at least once a year.<br>• Adults with low-risk lipid values (LDL cholesterol <100 mg/dL, HDL cholesterol >50 mg/dL, triglycerides <150 mg/dL) should have lipid assessments repeated every 2 years. |
| Nephropathy | • Patients with type 1 diabetes who've been diagnosed for 5 or more years and all patients with type 2 diabetes beginning at diagnosis should have an annual test to assess urine albumin excretion.<br>• All adults with diabetes should have serum creatinine measured at least annually regardless of the degree of urine albumin excretion. Serum creatinine should be used to estimate glomerular filtration rate and stage the level of chronic kidney disease, if present. |
| Obesity | • Weight loss is recommended for all overweight or obese individuals who have or are at risk for diabetes.<br>• Low-carbohydrate, low-fat calorie-restricted, or Mediterranean diets may be effective. |

atherosclerosis, and anatomical location of vascular damage (proximal versus distal). Over time, chronic hemodynamic and metabolic alterations damage the endothelium, resulting in functional and structural changes that may involve thickening of the basement membrane and sclerosis of capillary walls.

Peformed with a handheld Doppler, the ankle-brachial index (ABI) is a noninvasive vascular screening test used to identify peripheral arterial disease (PAD) by comparing systolic blood pressures in the ankle to brachial systolic blood pressures. Measuring ABI and assessing the pedal pulses is considered the most convenient noninvasive diagnostic method for detecting PAD. However, false elevation of the ABI is common in people with diabetes due to noncompressible arteries associated with advanced atherosclerosis and vascular calcification.[11] (See *Common noninvasive studies for PAD*.)

The loss of triphasic waveform, as indicated by pulsed-wave Doppler, indicates stiff atherosclerotic vessels and further validates the presence of PAD. Alternatively, the toe-brachial index (TBI) may be superior to ABI because it assesses digital arteries that are less likely to be affected by calcification. A full segmental arterial Doppler exam provides an accurate assessment of lower extremity arterial disease.[12]

Vascular study results should be considered in conjunction with clinical signs and symptoms of PAD. Physical findings valuable for identifying advanced PAD include absence of pedal pulses, atrophic (thin) skin, decreased skin temperature, blue/purple skin color, absence of lower limb hair, and prolonged capillary refill time.[12,13]

## Keeping an eye on the foot[6]

| Assessment area | Recommendations |
|---|---|
| Skin | Inspect feet for dry skin, cracks, fissures (scaling or changes that may indicate tinea). Check for hyperkeratotic areas such as calluses, which indicate high pressure or friction areas. |
| Nails | Identify nail problems (ingrown, onychomycosis). |
| Deformity | Assess for foot deformity and areas prone to trauma. |
| Pulses | Palpate pedal pulses, both dorsalis pedis and posterior tibial. Vascular studies may be required in patients with diabetes due to calcification of vessels. |
| Temperature | Evaluate skin temperature differences: increased warmth may indicate infection or fractures; decreased temperature may indicate poor perfusion. |
| Sensation | Conduct monofilament testing. |
| Range of motion | Assess for hallux rigidus, or stiff big toe. |

## Treating diabetic foot ulcers

*Plantar pressure redistribution* should be considered for all patients with diabetic foot ulcers. Most experts advocate walking casts (often made nonremovable with a flexible cohesive bandage or casting material to increase adherence to therapy) or the total contact cast for forefoot ulcers.[8,9] The contact cast effectively redistributes pressure, but it's contraindicated in the presence of ischemia or deep infection. Deep-toed shoes and orthotics are more appropriate for maintenance after healing to prevent recurrence. Patients with ulcers in the heel area could benefit from modified shoes rather than pneumatic walkers and contact casts, which actually increase pressure.[8,9] Patients should see a foot specialist with appropriate training and be reevaluated at regular intervals (2 to 6 weeks with an active ulcer, 6 to 12 weeks with a deformity or previous ulcer, or 6 to 12 months with neuropathy alone).[14] For patients with severe foot deformity and high-risk patients, surgical interventions should be considered to prevent further deterioration and recurrence of foot ulcers.

Nonviable tissue, including eschar or soft slough, promotes bacterial growth and inhibits healing. For wounds with the ability to heal, *surgical debridement* of calluses and abnormal surface granulation with

## Common noninvasive studies for PAD[26]

| Test (normal values) | Comments |
|---|---|
| ABI (0.9 to 1.3) | An index <0.9 has 95% sensitivity for detecting angiogram-positive PAD. Can cause false elevation in patients with calcified vessels; the accuracy is poor if ABI is >1.3. |
| Transcutaneous oxygen tension (60 mm Hg) | Local edema, skin temperature, emotional state (sympathetic vasoconstriction), inflammation, and pharmacologic agents limit the accuracy of the test. Patients with a reading of <20 mm Hg are severely ischemic and likely to need revascularization for wound healing. |
| TBI (0.7 to 0.8) | TBI is a more reliable indicator of limb perfusion in patients with diabetes because the small vessels of the toes are often spared from medial arterial calcification. |

a curette, scissors, or scalpel blade is the most effective way to destroy the biofilm structure and reduce the number of cells that delay healing.[15] Debridement of hyperkeratotic lesions such as calluses can reduce overall peak plantar pressure by as much as 29%.[14]

## Dealing with infection

Patients with diabetes are susceptible to infection related to immunodeficiency, neuropathy, and arteriopathy.[16] Phagocytosis and bactericidal capacity is significantly reduced in these patients. Early assessment and prompt treatment may help prevent complications. (For a helpful mnemonic, see *Spelling out wound infection*). Increased surface bacterial burden may be treated with topical antimicrobials, such as silver, honey, and polyhexamethylene biguinide, while systemic treatment is required for deep tissue involvement.

Diagnosis of wound infection is determined by clinical assessment, not by wound swabs. No one sign or symptom accurately confirms a wound infection diagnosis; clinicians must assess for a combination of two or more indicators.[17] Wounds that probe to bone, exist for more than 30 days, recur, and relate to trauma and PAD are independent risk factors for foot infection.[18]

**When patients exhibit signs and symptoms associated with deep and surrounding wound infection, systemic antimicrobial therapies should be considered.**

Osteomyelitis should be suspected if ulcers probe to bone. Although magnetic resonance imaging is more sensitive and specific for the diagnosis of osteomyelitis, changes in radiographic appearance over a 2-week interval are also a reliable indicator of infection.[18] Elevation in erythrocyte sedimentation rate and C-reactive protein in the absence of other inflammatory conditions help validate the diagnosis of osteomyelitis.[18]

Increased bacterial burden on the wound surface results in tissue damage, which is referred to as critical colonization. Recognizing the signs and symptoms of critical colonization and initiating prompt treatment can potentially improve healing and prevent the spread of bacterial invasion into deep tissue. Management of increased bacterial burden in the superficial wound surface may involve an array of antibacterial dressings (such as cadexomer iodine or silver dressings) or topical antimicrobial agents (such as silver sulfadiazine, mupirocin, fusidic acid, or polymyxin B-gramicidin cream).[19] When patients exhibit signs and symptoms associated with deep and surrounding wound infection, systemic antimicrobial therapies should be considered.

While most infections are caused by Gram-positive cocci, patients with longstanding and refractory ulcers may need broad-spectrum antibiotic therapy. Systematic reviews of trials to evaluate the effectiveness of antimicrobial treatment for diabetic foot ulcers fail to support the superiority of any I.V. or oral antibiotic regimen over any other.[20] When wound healing isn't a realistic goal, use of topical antiseptic agents that are often considered to be cytotoxic such as povidone-iodine may be appropriate because reducing bacteria is more important than the toxic effects on healthy tissues.

## Keeping it moist

Moisture balance is critical to the healing process. Although a

### Spelling out wound infection[17]

| | |
|---|---|
| **UPPER: Signs and symptoms of wound infection in the upper wound compartment** | |
| **U**—unhealthy tissue | Presence of >50% of debris, red friable tissue, or abnormal discoloration of granulation tissue |
| **P**—pain | Sudden increase in pain |
| **P**—poor healing | Changes in wound size of <10% in the last 7 days |
| **E**—exudate | Moderate to heavy amount of exudate |
| **R**—reek | Foul odor |
| **LOWER: Signs and symptoms of wound infection in the lower or deeper wound compartment** | |
| **L**—larger in size | Increase in wound size or new areas of satellite breakdown |
| **O**—osseous tissue | Wound that probes to bone |
| **W**—warmth | Increased periwound temperature of >2° F compared with temperature in proximal area |
| **E**—edema | Mild-to-moderate edema |
| **R**—redness | Erythema of >2 cm beyond wound margin |

## The 12 S's of foot care[1,3]

Use this summary of risk factors to educate patients about self-care.

| Things to consider | Take action! |
|---|---|
| **S**ugar | Check your blood sugar regularly and have your healthcare provider check your long-term sugar control every 3 months. |
| **S**moking | Stop smoking. Every cigarette will decrease the circulation in your legs by 30% for an hour. |
| **S**ores (blisters, cuts, open skin) | Check for sores on your feet every day. The skin breaks down because of a loss of protective sensation, and you may not feel cuts or blisters on your feet. |
| **S**cale or callus | Check for scale (caused by dry skin or a fungal infection) and callus (caused by too much pressure) on your feet every day. |
| **S**ee the bottom of your feet daily | Make sure you can see and check the bottom of your feet. You may want to ask someone else to help check your feet if your vision is poor. Remind your healthcare professional to check your feet at every visit. |
| **S**ocks | Wear socks with no seams that don't bunch up in your shoes. Wear socks at night if your feet are cold. Wear light-colored socks so you can see any drainage from cracks or sores. |
| **S**hoes | Wear properly fitting shoes that have plenty of room for your toes with orthotics. Avoid shoes with pointed toes and sandals. Have your shoes fitted at the end of the day by a professional shoe fitter. |
| **S**teps | Wear your shoes at all times. Wear them inside and outside of your home and when going to the bathroom at night. Don't walk barefoot or in socks only, and don't wear slippers that have no support. |
| **S**hower and wash | Shower and wash your feet every day. Dry them carefully, especially between toes. |
| **S**oaks | Never soak your feet. |
| **S**afe nail care | Cut nails straight across, or have your foot care specialist trim your nails. |
| **S**kin care | Avoid adhesive tape and chemical treatments such as wart removers. Use moisturizers to keep your skin soft. Don't put oil or moisturizers between your toes. |

desiccated wound environment can slow keratinocyte migration, too much moisture can damage the surrounding skin and promote bacterial growth.[21]

Many dressings have been developed to maintain moisture balance.[21,22] Foam dressings wick up and lock in large volumes of exudate. Alginate and hydrofibers can absorb copious amounts of exudate; their gelling effect keeps the wound base moist without maceration.[23] Hydrogels and occlusive dressings are usually indicated for dry wounds. Careful monitoring of the wound is required with any dressing regimen.

The optimal care of patients with chronic foot ulcers is complex and time-consuming. Management of these ulcers involves a detailed assessment and discussion with patients to address their concerns and encourage adherence to treatment and lifestyle changes (see *The 12 S's of foot care*). Patients who adhere to routine foot care, including daily self-exam of the feet and podiatry care, are less likely to develop ulcers than those who don't follow foot care recommendations.[19,24] However, many patients fail to maintain self-care measures over time. Studies have documented that less than one-third of patients with diabetes and active foot ulcers regularly wear recommended offloading devices during activities.[24]

## An important step

Patients living with foot ulcers experience poor quality of life due to limited mobility, social isolation, disruption of work and leisure activities, sleep disturbance, depression, and pain.[25] Nurses who routinely assess patients with diabetes for foot ulcers can ensure that ulcers are found early and treated properly to minimize complications and improve patients' quality of life. ■


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