Osteopathic Family Physician (2013) 5, 73–78

ELSEVIER

acofp Osteopathic Family Physician

The diabetic foot examination: A positive step in the prevention of diabetic foot ulcers and amputation

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KEYWORDS:
Diabetes;
Diabetic foot;
Foot ulcers;
Amputation

This paper proposes to introduce a method of performing the diabetic foot examination through introduction of a modified version of the cardinal techniques of examination (inspection, palpation, peripheral vascular or neurologic assessment, and auscultation), more consistent with the sequence taught in physical diagnosis classes in medical schools. The modified sequence should reduce physician time while improving efficiency and effectiveness, utilizing a physical examination sequence model with which the physicians are familiar and can easily adopt and apply in a consistent manner. Regardless of the technique employed, this paper hopes to remind primary care providers of the importance of incorporating a diabetic foot examination or screening tool as part of their practice.

Introduction

Diabetes affects 25.8 million people in the United States or roughly 8.3% of the population.[1] Unfortunately, up to 15% of all patients with diabetes are affected by lower-extremity amputation in their lifetime.[1] In the United States, diabetes is the leading cause of nontraumatic amputations (approximately 65,700 per year).[1] The Center for Disease Control and Prevention (CDC) estimates that comprehensive foot-care programs that include risk assessment, foot-care education and preventive therapy, treatment of foot problems, and referral to specialists can reduce amputation rates by 45%-85%.[1]

The primary goal in risk assessment of the diabetic foot is to prevent foot ulceration and amputation through identification, patient education, and prompt referral for appropriate specialty care when necessary. Though models presently exist, which outline the steps involved in the diabetic foot examination (some include checklists), they do not necessarily follow the cardinal sequence of physical examination (inspection, palpation, percussion, and auscultation) taught in physical diagnosis classes in medical schools.[2,3] The checklist models can not only be effective tools for prevention but can also be cumbersome for the busy practitioners because they require time to learn and implement.

Practitioners may be unfamiliar with the diabetic foot examination sequence utilized in the present models. It has been reported that only 23%-49% of people with diabetes have their feet evaluated yearly by their primary care physician.[4] It is important that primary care physicians develop a technique to efficiently and effectively evaluate the diabetic foot in a consistent manner.

This paper proposes to introduce a method of performing the diabetic foot examination through introduction of a modified version of the cardinal techniques of examination (inspection, palpation, peripheral vascular or neurologic assessment, and auscultation), more consistent with the sequence taught in physical diagnosis classes in medical

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1877-573X/$ - see front matter © 2013 Published by Elsevier Ltd.
doi:10.1016/j.osfp.2012.08.002

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Rationale

According to the data obtained from the CDC, diabetes mellitus affects 25.8 million people or 8.3% of the US population.[1] Complications involving the feet of people with diabetes are not only one of the most serious and but also costly to treat. These complications most commonly arise as a result of loss of peripheral sensation and peripheral vascular compromise, which can lead to ulceration. Current estimates predict that 25% of people with diabetes would develop a foot ulcer during their lifetime.[5] Ulcerations on the feet of people with diabetes may fail to heal and evolve to involve deeper tissues, causing tissue necrosis, local infection, osteomyelitis, gangrene, and sepsis and necessitating lower-extremity amputation. According to the CDC data, more than 60% of nontraumatic lower-limb amputations occur in people with diabetes. In 2006, the CDC estimated that more than 65,700 nontraumatic lower-limb amputations were performed in the United States on people with diabetes.[1] More recent estimates suggest that as high as 85% of all lower-extremity amputations are associated with diabetic complications, and almost all of these are preceded by a foot ulcer.[6]

Diabetic foot ulcers also create a significant economic burden on our financial resources. According to CDC estimates from 2007, the direct costs involving the treatment of diabetes and its complications in the United States were approximately $116 billion.[1] It is estimated that treatment of foot ulcers was responsible for approximately one-third of these costs.[7]

Recognizing that foot ulcers are a major cause of morbidity and disability, as well as emotional and physical costs for people with diabetes, the American Diabetes Association began to focus on risk assessment, foot-care education, and preventive treatment of foot problems.[8,9] A protocol was established for performing a comprehensive foot examination to identify risk factors for foot ulceration. In addition, practice guidelines and standards of care for the diabetic foot were established (Table 1).[10,11]

Subsequent studies proposed a range of tests that might help identify patients at risk of foot ulceration, which created confusion among practitioners as to which screening tests should be adopted in clinical practice.[12] A task force was assembled by the American Diabetes Association in 2008 to address, concisely summarize literature, and recommend what should be included in the comprehensive foot examination for adult patients with diabetes.[13] The risk factors for diabetic foot ulcers that the task force outlined include previous amputation, foot ulcer history, peripheral neuropathy, peripheral vascular disease, foot deformity, visual impairment, diabetic nephropathy (especially patients on dialysis), poor glycemic control, and cigarette smoking. In addition, the task force also outlined the key components for practitioners to evaluate when conducting the diabetic foot examination.

Table 1 Risk factors for developing foot ulcers

Previous amputation
Foot ulcer history
Peripheral neuropathy
Peripheral vascular disease
Foot deformity
Visual impairment
Diabetic nephropathy (especially patients on dialysis)
Poor glycemic control
Cigarette smoking

Considering that up to 50% of older patients with type 2 diabetes have one or more risk factors for foot ulceration, it becomes apparent that primary care physicians are in the best position to provide early recognition of risk factors and initiate interventions to prevent further complications.[14] Despite several initiatives to increase screening, only 23%-49% of people with diabetes have their feet evaluated yearly in primary care settings.[4]

Although physicians are taught in medical school that the key to a thorough and accurate history and physical examination is to develop a systematic sequence of examination, physical examination relies on 4 classic cardinal techniques: 1. inspection, 2. palpation, 3. percussion, and 4. auscultation (Table 2).[15]

To preserve consistency in this educational model, a modified version of these cardinal techniques is introduced for adaptation for the diabetic foot examination in the

Table 2 Key components of the diabetic foot examination

Foot inspection

Dermatologic
- Skin status: color, thickness, dryness, and cracking
- Sweating
- Infection: check between toes for fungal infection
- Ulceration
- Calluses/blistering: hemorrhage into callus

Musculoskeletal
- Deformity, for example, hammertoes, claw toes, prominent metatarsal heads, and Charcot joints
- Muscle wasting (atrophic gutters in the tissues between the metatarsals)

Vascular assessment
- Foot pulses
- ABI, if indicated

Neurologic assessment
- 10-g Monofilament and 1 of the following 4 tests
- Vibration using 128-Hz tuning fork
- Pinprick sensation
- Ankle reflexes
- VPT

following sequence: 1. inspection, 2. palpation, 3. peripheral vascular or neurologic assessment, and 4. auscultation.

History

It is important to take a focused history prior to beginning the comprehensive diabetic foot examination. It is best to start with open-ended questions inquiring whether the patient has experienced any problems with their feet. Practitioners should inquire about skin problems, such as dryness, corns, calluses, thick toenails, rashes, and areas of redness or open sores. History of foot ulceration or amputation, as well as symptoms of claudication, heart disease, vascular surgery, kidney disease (dialysis or transplant), or reduced vision, should be obtained. Questions regarding changes in the feet since their last examination, shoe problems, or any blood or discharge in their socks should be asked. Subjective neurologic changes should be ascertained from the history as well. Neurologic changes are typically reported as changes in sensation, such as burning or shooting pain, or numbness. A tobacco use history should be determined as its use is a risk factor for vascular disease and neuropathy.

Inspection

The examination should be conducted in a well-lit room. All patients should have his or her shoes removed prior to your arrival. Shoes should be examined for signs of breakdown or abnormal wear.[13] Ill-fitting shoes can be found by inspecting for signs of wear or areas of the shoe that appear distorted due to foot deformities or altered biomechanical influences. People with diabetes who have diminished or loss of protective sensation (LOPS) frequently wear shoes that are too small or too tight, because they frequently rely on the interpretation of stimuli from the remaining pressure receptors to determine a good fit. Pressure from tight-fitting shoes can promote friction, blistering, and callus formation, which may evolve to skin breakdown leading to infection, ulceration, and possible amputation.

The skin should be inspected for excessive dryness or perspiration as well as any trophic changes, such as pallor, cyanosis, or rubor, especially over boney prominences.[16] The absence of digital hair, though not pathognomonic, may suggest arterial compromise given the nutritional requirement for hair growth. The nails are a frequent source of problems for people with diabetes, and the presence of ingrowing toenails, paronychia, hypertrophy, dystrophy, and onychomycosis must be assessed. The intertriginous spaces between the toes must be examined for the presence of calluses, infection, or ulceration.

Global inspection of the foot should be performed to determine any musculoskeletal abnormalities, which can serve as pressure areas on the foot when confined in a shoe. It is important to look for wasting of the intrinsic muscles of the feet (atrophic gutters in the tissues between the metatarsals), which creates altered biomechanics as opposing muscles gain mechanical advantage, culminating in digital abnormalities, such as claw toes, hammertoes, and bunions. The presence of digital abnormalities should be assessed to determine whether these areas receive increased pressure from shoes. In addition, it is important to determine whether the digital deformity is rigid or flexible, although both can lead to abnormal areas of pressure. Rigid deformities conduct retrograde pressure from shoes, leading to the development of a prominence of the metatarsal head on the plantar surface. The plantar surface of the foot should be inspected for the prominence of the metatarsal heads, which may create altered pressure distribution with weight bearing, resulting in callus formation and ulceration. The presence of callus (particularly with hemorrhage), nail dystrophy, or paronychia should prompt the patient to refer to a specialist or specialty clinic.

Palpation

The skin should be palpated to detect any significant temperature, texture, and turgor changes. The examiner can use the back of their hand to detect symmetry of temperature change from proximal to distal, as well as to note any temperature differences between either foot. Significant reduction in temperature (distal cooling) may be an indicative of peripheral arterial disease (PAD), and these patients should be promptly referred to a vascular surgeon for further evaluation.

Palpation of the musculoskeletal structures of the foot should be performed to assess joint range of motion. Restriction of motion in any musculoskeletal structure has been associated with abnormal pressure distribution, callus formation, and ulceration. Special attention should be paid to determine whether a digital deformity is rigid or flexible. Abnormal pressure over the digit or digital deformity causing increased plantar pressure should be additionally assessed. The presence of erythema from an increased pressure, callus formation, infection, or breakdown of the skin in any area overlying any musculoskeletal structure should be documented, and the patient referred to a podiatrist for further evaluation and treatment.

The abdominal aorta should be palpated to rule out the possibility of aneurysm formation. The femoral, popliteal, and pedal arteries can be palpated for patency.

Peripheral vascular assessment

Assessment for PAD is important in stratifying the overall risk status for ulceration of the lower extremity. PAD has been implicated as a cause of at least one-third of all ulcerations occurring in the feet of people with diabetes.[16] It is recommended that the peripheral vascular assessment includes palpation of both the dorsalis pedis and posterior tibial arteries, which are documented as either present or absent.[16] The examination is done with the barefooted patient sitting comfortably. The dorsalis pedis artery is palpated using 3 fingers across the dorsum of the foot 1 cm

proximal to the depression between the first and second metatarsals. The posterior tibial artery is palpated at the medial surface of the ankle in the space between the Achilles tendon and medial malleolus. If on palpation, either both vessels are nonpalpable or the patient is experiencing claudication, has rest pain, or has a nonhealing ulcer (all of which suggest PAD), it is recommended that an Ankle Brachial Index (ABI) should be performed or the patient be referred to a vascular surgeon for further evaluation or both. The ABI has 95% sensitivity and almost 100% specificity in identifying PAD, compared with angiography.[16] The ABI value $>$ 0.90 is considered normal. The ABI value of 0.71-0.90 indicates mild disease, 0.41-0.70 indicates moderate disease, and $\leq$ 0.40 indicates severe disease.

The ABI value can appear normal or may be falsely elevated (high ABI value) in patients whose arteries are heavily calcified and are noncompressible.[16] Noncompressibility of calcified arteries frequently results in ABI values well above normal ($>$1.3) and is seen to occur primarily in older individuals and in people with diabetes or end-stage renal disease.[16] ABI values above 1.3 are associated with increased mortality[16] and necessitate referral to a vascular surgeon for further evaluation.

Peripheral neurologic assessment

The goal of performing the lower-extremity peripheral neurologic assessment is to identify patients at risk for ulceration due to LOPS. There are at least 5 clinical tests, which can be performed to identify LOPS: 1. 10-g monofilament, 2. vibration using 128-Hz tuning fork, 3. pinprick sensation, 4. ankle reflexes, and 5. vibration perception threshold (VPT). The Task Force of the Foot Care Interest Group of the American Diabetes Association agrees that any of these 5 tests can be used clinically to identify LOPS, although only 2 of these should be performed regularly as part of the diabetic foot screening examination.[13] The task force recommends that the 10-g monofilament test and any one of the other 4 tests be conducted to assess LOPS.[13] If one or more of these clinical tests results are positive (abnormal), it would confirm LOPS, whereas 2 normal tests would rule out LOPS.

10-g Monofilament test or the Semmes-Weinstein 10-g monofilament test

The 10-g monofilament test or the Semmes-Weinstein 10-g monofilament test is used to assess the ability of a patient to sense pressure when a 10-g load has been applied to the skin. There is a strong evidence that confirms the loss of pressure sensation detected by 10-g monofilament test as an extremely effective tool to predict ulceration of the foot.[5,17] The 10-g monofilament test involves having the patients close their eyes while the examiner places the monofilament perpendicular to predefined sites on the plantar surface of the foot. It is recommended that 5 sites on each foot be tested, which include the plantar surface of the great toe (hallux), fourth toe, first, third, and fifth metatarsal heads (Figure 1). After placing the monofilament, the examiner applies sufficient pressure until the filament bends (buckles), which should be the equivalent of a 10-g load (Figure 2). After applying the filament to a specific site, the patient should respond with either "yes" or "no" when asked whether they perceive the pressure of the monofilament that is being applied. In addition, the patient must correctly identify the site where the filament has been placed. Findings are documented as either normal or abnormal. Before starting the examination, the examiner should first demonstrate this technique on the patients' hand or arm as a control. The examiner should avoid applying the filament on callused areas as pressure perception is reduced in these areas.

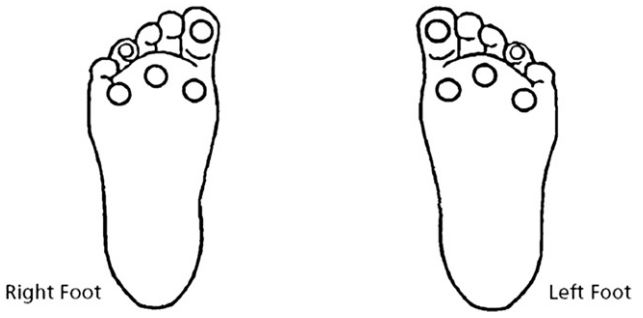

Figure 1 Reproduced courtesy of the National Diabetes Education Program.[2]

128-Hz tuning fork test

The 128-Hz tuning fork is commonly available in most primary care offices and represents an easy and inexpensive means to assess loss of vibratory sensation. The128-Hz tuning fork test involves having the patients close their eyes followed by the examiner striking the tuning fork and applying it on the plantar hallux.[18] An abnormal finding is suggested if the subject reports no vibration though the examiner could still perceive vibration while holding the tuning fork on the toe.

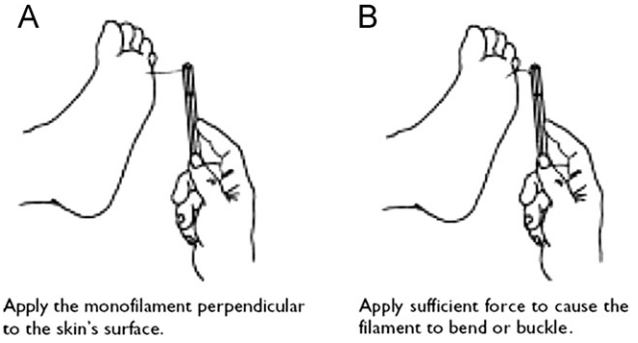

Figure 2 Reproduced courtesy of the National Diabetes Education Program.[2]

Pinprick sensation test

The inability of a person with diabetes to perceive pain via pinprick sensation testing has been found to place them at an increased risk of ulceration.[19] The examiner applies a disposable pin to the skin on the dorsal surface of the hallux just proximal to the toenail. The examiner should apply sufficient pressure to deform the skin. An abnormal finding would be the inability to perceive pain with a pinprick over either hallux.

Ankle reflexes

The absence of ankle reflexes has also been reported to place patients with diabetes at an increased risk of ulceration.[19] Ankle reflexes can be tested with the patient seated, kneeling, or lying prone. With the patient seated or lying prone, the ankle is slightly dorsiflexed to 90° and the examiner taps the Achilles tendon just above the heel. An alternative method is to ask the patients to kneel on a chair facing the back of the chair so that their feet are dangling off the seat of the chair. The examiner taps over the same area in this position. If a reflex is absent or difficult to elicit, try 'reinforcement'.[15] The patients are asked to flex their fingers and interlock them with one palm facing upward and the other facing downwards. They are then asked to try and pull their fingers apart just before being struck on the tendon. An abnormal response is total absence of the ankle reflex at rest or with reinforcement.

VPT testing

The VPT test employs the use of a handheld biothesiometer (or neurothesiometer) to quantify the VPT. The patients are placed in the supine position and asked to close their eyes as the examiner applies a stylus to the plantar surface of the great toe (hallux). The amplitude is gradually increased until the patients report that they can detect the vibration. The voltage measured is recorded as the VPT. Before starting the examination, the examiner should first demonstrate this technique on the patients' hand or wrist as a control. The examiner should document a mean of 3 readings taken from each hallux. A measurement of 25 V or greater is abnormal and has been shown to be strongly predictive of subsequent foot ulceration.[20]

Auscultation

In the presence of type 2 diabetes, the prevalence of all cardiovascular diseases, including carotid stenosis, abdominal aortic aneurysm, and PAD, is doubled.[21] Adults with diabetes have both a 2-4 times higher risk for stroke and a 2-4 times higher heart disease death rate than adults without diabetes.[1] Auscultation should be performed not only to aid in the assessment of the diabetic foot but also to assist in the early identification of the macrovascular complications of diabetes mellitus. The presence of a carotid bruit is associated with a 6-fold increased risk of stroke.[22] The presence of at least 1 bruit at rest (iliac, femoral, or popliteal) increases the likelihood of PAD. When considering PAD in patients who are symptomatic with leg complaints, the most useful individual clinical findings are the presence of cool skin, at least 1 bruit, and any palpable pulse abnormality. The absence of any bruit (iliac, femoral, and popliteal) and the presence of normal peripheral pulses reduce the likelihood of PAD.[16]

Auscultation should be performed over both carotid arteries, as carotid bruits are associated with carotid stenosis, which is not only a risk factor for stroke, but also correlates with the presence of PAD in other vascular beds.[23] In addition, the abdominal aorta, renal, iliac, femoral, and popliteal arteries should be auscultated for bruits, the presence of which should increase the suspicion of PAD. Any positive findings would necessitate referral to a vascular surgeon for further evaluation and testing.

Recommended screening guidelines

In its position statement on Standards of Medical Care in Diabetes 2011, the American Diabetes Association recommends that a comprehensive foot examination be conducted at least annually on all people with diabetes.[24] A comprehensive foot examination should include inspection, palpation of pedal pulses, and testing to detect LOPS, which includes standard monofilament testing combined with an additional test, such as vibration, pinprick sensation, or ankle reflexes.[24] People with one or more high-risk foot conditions should have a visual inspection of their feet at every clinic visit.

Conclusion

To aid primary care physicians in the preventative treatment of their patients with diabetes, an additional method of performing the diabetic foot examination has been introduced, utilizing a modified version of the cardinal techniques of examination (inspection, palpation, peripheral vascular or neurologic assessment, and auscultation). This model is more consistent with the sequence of physical examination taught in physical diagnosis classes in medical schools. It is believed that with practice the modified sequence should reduce physician time while improving efficiency and effectiveness, utilizing a physical examination sequence model with which they are familiar and can easily adopt and apply in a consistent manner. It is important that primary care providers recognize the importance of incorporating a diabetic foot examination or screening tool as part of their practice in the prevention of diabetes complications.

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Further reading

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