Preventing Amputations in Patients with Diabetes and Chronic Kidney Disease

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Foot lesions are the single most frequently mismanaged problem of patients with diabetes mellitus and chronic kidney disease (CKD). Foot problems are often viewed as a minor problem, yet frequently impact patient survival (Schomig, Ritz, Standl, & Allenberg, 2000). Recommendations for improving the survival of patients with diabetes and CKD include improvement in the foot care and education of both patients and nephrology health care providers regarding diabetic foot complications (Ritz, Koeh, Fliesser, & Schwenger, 1999).

Over 40% of patients in United States starting chronic dialysis count diabetes mellitus as the primary cause of renal failure, making it the number one cause of CKD (Berman, 2001). Patients with diabetes and chronic renal disease frequently present with a combination of the devastations of diabetes including: nephropathy, retinopathy, and vasculopathy. Diabetic foot complications, including amputation, add significantly to the morbidity and mortality of the patient with diabetes and CKD. The main focus of the care of this patient has been the target organs of the heart and kidneys. Therefore, early risk factors for diabetic foot complications may be disregarded, and this may lead to amputation – a failure for both the patient and clinician. However, of all the long-term complications of diabetes, foot complications may be the most preventable.

In the United States, diabetes is the cause of 50% of nontraumatic lower extremity amputations and is increasing annually (Levin, 2002). The cost of treating patients with diabetes is astronomical both financially and in terms of quality of life. The loss of a lower extremity or even part of a lower extremity greatly impacts quality of life. Depression is common after amputation. Leisure activities as well as employment status are altered. The mortality rate after amputation in patients with diabetes is 11%-41% at 1 year, 20%-50% at 3 years, and 39%-68% at 5 years (Fritschi, 2001).

For 2 decades, the United States Department of Health and Human Services (USDHHS) has used health promotion and disease prevention objectives to improve the health of the American people. The overall goal for diabetes in the Healthy People 2010 objective is "Through prevention programs, reduce the disease and economic burden of diabetes and improve the quality of life for all persons who have or are at risk for diabetes" (USDHHS, 2000). A specific objective contained within this goal targets a 55% reduction in the rate of lower extremity amputations in persons with diabetes. This would amount to 1.8 lower extremity amputations per 1,000 patients with diabetes per year, down from 4.1 per 1,000 patients that occurred in 1997 (USDHHS, 2000).

The prevalence of lower extremity amputation for patients with diabetes...
and CKD is much greater than those without CKD. The rate of lower limb amputation for the population at large increased during a recent 4-year period from 4.8 to 6.2 /100 persons. During the same time frame, this rate of lower extremity amputation rose from 11.8 to 13.8/100 among persons with CKD attributed to diabetic nephropathy. The rate for patients with diabetes and CKD was 10 times greater than the diabetic population at large [Eggers, Gohdes, & Pugh, 1999]. These findings are consistent with other research that shows a greater prevalence of amputations among patients with diabetes on dialysis (McGarth & Curran, 2000; Rith-Najarian & Gohdes, 2000).

Multiple factors may be responsible for the immense increase in incidence of lower extremity amputation among patients with diabetes and CKD. Rith-Najarian and Gohdes (2000) postulated that dialysis patients often lose contact with primary care outside the dialysis setting. Typically, dialysis patients have multiple medical appointments, many specialists involved with their care, and little involvement from a primary care provider. Preventative foot care, early detection of foot problems, and follow-up care for foot ulcers after hospitalization are not always a part of the routine dialysis care.

Patients with diabetes and CKD have frequent contact with nephrology nurses, presenting numerous opportunities for assessment of risk, education, and early intervention of foot problems. Simple measures such as routine foot screening and education for those at high risk can prevent ulcer-initiating events and detect small ulcers when they may heal with proper intervention (Larsson, & Apelqvist, 1995).

Literature Review

A review of the literature was conducted surrounding the topics of assessing the feet of patients with diabetes and preventing lower limb amputations. The first part of the literature review evaluates evidence that assessment of the feet of these patients is successful in preventing amputations. Risk factors for foot ulcers and amputation are reviewed in the second part of the literature review. Assessment methods are reviewed in the third section. The final section describes a foot risk classification system that predicts the risk for amputation of the lower extremity.

Preventing amputations. Do diabetic foot examinations reduce the risk of amputation?

"All individuals with diabetes should receive a thorough foot examination at least once yearly to identify high-risk foot conditions" (American Diabetes Association [ADA], 2000). The ADA goes on to recommend more frequent evaluation for people with one or more risk factors and a visual foot inspection at every visit with a health care professional for diabetic patients with neuropathy. "Examination of the foot is an obvious, fundamental step to identifying certain foot risk factors that can be modified, thus reducing the risk of ulceration and amputation" (Mayfield, Reiber, Sanders, Janisse, & Pogach, 1998).

Although foot exams are widely recommended throughout the literature, there are only a few investigations regarding their independent effect on the reduction of lower extremity amputations in patients with diabetes. Mayfield, Reiber, Nelson, & Greene (2000) failed to demonstrate that foot examinations decrease the risk of amputation in Pima Indians with type 2 diabetes. The research was conducted as a population-based, case-controlled study of primary care provided to Pima Indians from the Gila River Indian Community. Sixty-one Pima Indians with type 2 diabetes and a first amputation were compared to 183 diabetic patients without amputation over the same 36-month period. Foot examinations, co-morbid conditions, and foot risk factors present in the 36 months before amputation were extracted from medical records. The independent effect of foot examinations on the risk of amputation was assessed by logistic regression. The median number of preventive foot examinations was seven for study patients and three for control patients. After controlling for differences in comorbid conditions and foot risk conditions, the risk of amputation for persons with one or more foot examinations found an odds ratio of 0.55 (95% confidence interval, 0.2-1.7; p = .31). The results were not statistically significant. However, it is important to note that foot examinations have been shown to detect high-risk conditions for which specific interventions are effective in reducing amputation risk.

Several limitations of this study should be noted. The population studied had more foot risk conditions, foot ulcers, diabetic complications, and longer duration of diabetes than the control patients. All of these conditions may have increased the opportunity for foot examinations (Mayfield et al., 2000). The researchers attribute the lack of statistical significance to the limited power of the study due to small sample size and the high examination rate in both case and control patients. In commenting on the limitations of the study, Dr. Ganiats (2000) notes that the study used a highly selective group of subjects. The Gila River Indian community has one of the highest reported rates of diabetes and amputations. It may be that diabetes in this population is a fundamentally different disease, and the effect of foot examinations may be under or over estimated when applied to the general population.

Diabetic foot assessment should consist of more than a visual inspection of the foot. It should be a means to identify risk factors and stimulate efforts toward prevention of further problems. A study conducted at the Seattle Veterans Affairs Medical Center (Del Aguila, Reiber, & Koepsell, 1994) revealed that primary care providers recognize the prognostic significance of foot ulcers and are twice as likely to refer patients with foot ulcers for podiatric foot care and education as compared to patients with other high risk conditions such as patients with bone deformities and neuropathy.
A randomized controlled trial by Litzelman et al. (1993) revealed that when health care providers were given practice guidelines and information on foot-related risk factors, the foot examination tended to be more complete and podiatric referral more likely. Unfortunately, the sample size and length of follow-up were inadequate to show whether these interventions could reduce the incidence of lower extremity amputation.

Additional research has demonstrated that the implementation of practice guidelines by primary care providers is associated with improved diabetic foot outcomes (Rith-Najarian et al., 1998). A prospective study of American Indians with diabetes was completed in an Indian Health Service facility serving approximately 5,000 Chippewa Indians in northern Minnesota. The study covered an 11-year period and was divided into three periods of observation. The first period was considered the standard care period during which patients were screened for foot problems and received care at the discretion of the primary care provider. The second period was labeled the public health period during which simple preventive services were organized and targeted for those individuals with high-risk findings on examination. A process called Staged Diabetes Management was implemented in the third period of the study (Mazure et al., 1994). Staged Diabetes Management included screening, diagnostic, and treatment guidelines in many aspects of diabetic care, including foot care. Practice guidelines were developed to address the specific criteria for diagnosis, risk factor assessment, treatment options, therapeutic targets, monitoring, and follow-up. Flow sheets based on Staged Diabetes Management were produced and copies placed in each of the patients' charts.

Amputation rates were reduced 28% in the public health period associated with screening individuals for high-risk foot problems and targeting them with simple interventions including patient education and provision of protective footwear. Substantial reductions in amputation rates (48%) were achieved when the Staged Diabetes Management was implemented. As the researchers note, it is not possible to determine whether a specific element of Staged Diabetes Management was responsible for the observed outcome or whether there were several reasons (Rith-Najarian et al., 1998). The foot screening process may have increased both the patient and provider awareness of the individual's high-risk foot status. Such awareness may be associated with increased provider prescription of preventive foot care services among patients with diabetes. The authors assert that the foot screening and risk stratification are simple and low-cost, and the system changes to incorporate them into clinical practice are practical for any primary care setting.

**Risk factors for lower extremity amputation in persons with diabetes.** An understanding of the pathophysiology and risk factors for amputations in patients with diabetes is essential for determining foot-screening criteria. The literature describes numerous risk factors in the development of foot ulcers and amputations. Events leading to amputation can result from a single factor or a combination of factors.

Fritschi (2001) noted that it is important to evaluate the risk profile in terms of the individual patient rather than weighing the risks separately. A cumulative risk for ulceration associated with the addition of each risk factor was found by Lavery, Armstrong, Vela, Quebedeaux, and Fleischli (1998). Patients with only peripheral neuropathy and no other risk factors were at 1.7 times greater risk for ulceration. Patients with both neuropathy and foot deformity were 12.1 times more likely to have an ulcer, and patients with neuropathy, deformity, and a history of amputation were 36.4 times more likely to have a wound develop. Analytical studies (Frykberg, 1999; Mayfield et al., 1998) have shown risk factors for lower extremity amputation related to diabetes to be similar to those for ulceration. Therefore, they are considered together in this paper.

**Diabetic neuropathy.** There is little debate in the literature that diabetic neuropathy is one of the most important risk factors in the etiology of diabetic lower extremity ulceration and amputation (Levin, 1995; Lavender et al., 1998). Rith-Najarian et al. (1992) conducted a prospective study in a primary care clinic for an American Indian population involving 358 patients with diabetes over a 32-month period. Insensitivity occurred in 19% of the patients screened. Among this group, the odds ratio of subsequent ulceration was 9.5 (95% CI 4.5-95), and amputation was 17 (95% CI 4.5-95.0) compared with those who maintained sensation.

Peripheral neuropathy of diabetes has three major effects on the lower extremity: sensory, motor, and autonomic (Habershaw, 2000). Distal symmetric sensorimotor polyneuropathy is the most common form of diabetic neuropathy. It usually appears first in the distal portions of the extremities, moving proximally in a "stocking glove distribution." This type of neuropathy encompasses sensory and motor nerve damage and affects both limbs.

The major function of the sensory nerves on the lower extremity is to act as an alarm system for perception of injury. Immediate perception of injury is vital to healing. Injury caused by disruption of the skin is made worse with each successive step when pain perception is absent. Pain or hyperesthesia may be the first symptom of peripheral neuropathy and may persist for years. Ulcers do not develop during this time due to restricted activity and the development of habits by the patient that make the feet and legs more comfortable such as rotating shoes and socks frequently. When the painful neuropathy subsides, hypoesthesia or lessened sensation may begin. At this point injury may occur without pain (Habershaw, 2000). The implications of the loss of protective sensation cannot be over emphasized. It is the major stumbling
block to early problem recognition (Deery & Sangeorzan, 2001).

The motor component of polyneuropathy results in foot deformity and weakness. The small intrinsic muscles of the foot help hold the toes on the ground during the powerful contraction of the muscles in the legs. When the strong proximal muscles are left unopposed, confrontational changes in the feet occur. Hammertoes or claw toes will typically be the result. Pressure points will develop on the tips and tops of the toes. The second important result is the loss of the protective fat pad from beneath the metatarsal heads. The overall effect is pressure on the parts of the foot that are not designed to withstand it. This puts the foot at risk for ulceration and should be identified early and protected by appropriate footwear (Deery & Sangeorzan, 2001; Habershaw, 2000).

Autonomic neuropathy also plays a role in the pathology of the diabetic foot. Autonomic neuropathy may lead to atrophy of the sebaceous and sweat glands causing skin drying and cracking. The skin becomes more prone to damage from minor trauma. A diminished "flare reaction" to trauma reduces the body's ability to heal small areas of damage before skin integrity is destroyed. Flawed temperature regulation and edema of the extremities may occur due to arteriovenous shunting and peripheral vasodilatation. The nails may thicken making the nails and toes difficult to care for without professional help (Habershaw, 2000).


calssified as aseasclerosis that occurs in patients with diabetes as compared to patients who do not have diabetes. Atherosclerosis occurs at a younger age and progresses more rapidly in patients with diabetes. Men and women are equally affected. The vessels affected are also different. The vessels involved in the patient with diabetes are usually those below the trifurcation, the tibialis and the peroneals, while the patient without diabetes is likely to have more proximal vessels involved including the femorals, iliacs, and aorta (Levin, 1995).

Peripheral vascular disease rarely leads to ulceration by itself. However, once an ulcer develops, pre-existing arterial insufficiency will result in poor wound healing and an increased risk of amputation (Frykberg et al., 2000). Attempts to resolve any infection will be impaired due to lack of oxygenation and difficulty delivering antibiotics to the site of infection. Early recognition and treatment of lower limb ischemia is, therefore, essential in preventing amputations (Caputo, Cavanagh, Ulbrecht, Gibbons, & Karchner, 1994; Levin, 1995).

According to Levin (1995) the most important risk factors for peripheral arterial disease in the patient with diabetes are genetic predisposition and duration of diabetes. Other macrovascular risk factors are smoking, dyslipidemia, hypertension, obesity, and hyperglycemia. Dr. Levin (1995) notes many of these risk factors are modifiable and should be addressed aggressively by all physicians.

**Altered biomechanics.** Alterations in the normal biomechanics of the foot have been associated with an increased risk of ulceration and amputation. Increased plantar pressure, bony abnormalities, and limited joint mobility are among changes in biomechanics that may lead to an increased risk of ulceration (Mayfield et al., 1998).

**Increased plantar pressure.** Static plantar pressures can be measured using a Harris mat or polytechnic modified force plate; dynamic pressures can be measured with a pedobarograph, instrumented shoes, and in-shoe or insole pressure transducers. Normal ranges and risk cutoffs have not been standardized because of differences in methodologies of measurement (Mayfield et al., 1998). Dynamic foot pressures are elevated in diabetic neuropathy and especially in patients with a history of plantar ulceration (Boulton et al., 1983). In addition, elevated plantar pressures were found to be predictive of ulceration (Vees, Murray, Young, & Boulton, 1992). Plantar ulcer development was found in 35% of the people with static pressures greater than 12.3 kg/cm² measured on an optical pedobarograph, while no ulcers developed on people with pressures less than 12.3 kg/cm².

**Bony abnormalities.** The major origin of increased pressure is believed to be a change in the shape of the foot that results in prominent metatarsal heads (Shaw & Boulton, 1997). As discussed earlier, the changes of motor neuropathy lead to hammer toes, claw toes, and a loss of the protective fat pad from beneath the metatarsal heads. When these vulnerable areas become ulcerated, they heal with scar tissue that is less vascular and less elastic than the original tissue. Thus, these areas are prone to repeated ulceration (Deery & Sangeorzan, 2001). Common foot deformities such as bunions and hallux rigidus can also be a cause of increased pressure (Mayfield et al., 1998).

**Limited joint mobility.** Limited joint mobility is linked with elevated plantar pressure and risk of ulceration (Fernando, Masson, Veves, & Boulton, 1991; Mayfield et al., 1998; Shaw & Boulton, 1997). Limited joint mobility develops gradually in patients with diabetes due to the glycosylation of the skin, soft tissue, and joints. These patients are noted to have thick, tight, waxy skin. A study conducted by Fernando and associates (1991) demonstrated that limited joint mobility can be a major factor in causing high plantar pressure. However, limited joint mobility alone does not cause foot ulceration, but rather contributes to the risk in a susceptible neuropathic foot.

**Charcot deformity.** Charcot deformity has been a cause for altered biomechanics, increased plantar pressures, and increased risk of ulceration (Levin, 1995). Diabetes is the most common case of Charcot foot deformity or neuropathic osteoarthropathy (Shaw & Boulton, 1997). Fritschi (2001) describes two potential theories for the etiology of the bone and joint lesion. The first theory suggests that decreased sensation to trauma due to neuropathic sensory loss leads
to repeated microscopic fractures and intensified osseous response to healing. This theory is titled "neurotraumatic theory" since the loss of pain sensation is believed to be the primary root of the problem. The second theory is the "hypervascular theory." The assumption of this theory is that autonomic neuropathy damages the sympathetic nerves innervating the small vessels of the foot. This causes a loss of vascular tone resulting in vasodilation and increased peripheral perfusion. Increased perfusion may promote osteoclastic activity and bone resorption.

Charcot foot deformity develops in four stages (Levin, 1995). The first stage starts with minor trauma causing a hot, red, swollen foot with bounding pulses. This is easily confused with cellulitis or osteomyelitis. The treatment at this stage is non-weight bearing of the affected limb. The second stage of the Charcot foot deformity will develop with dissolution, fragmentation, and fractures. The second stage can develop in 2-3 weeks of the initial trauma. The third stage is the development of the Charcot foot deformity due to fractures and collapse of the joints. The hallmark of the third stage is the appearance of the "rocker bottom" foot caused by the collapse of the plantar arch (Fritsch, 2001). During the fourth stage, plantar ulceration, develops if the patient continues to ambulate on the unprotected foot. Ulceration occurs in the area of the arch because the rocker bottom deformity leads to the greatest pressure at this site.

Previous ulceration or amputation. Previous ulceration or amputation has been shown to be a great risk factor for the occurrence of amputation (Frykberg, 1999; Mayfield, Reiber, Nelson, & Greene, 1996; Moss, Klein, & Klein, 1999). Following one lower extremity amputation, there is a 50% incidence of a serious contralateral foot lesion within 2 years and a 50% incidence of contralateral amputation within 2.5 years (Frykberg, 1999). Clearly, this is a risk factor that must be considered in any diabetic foot assessment program.

Other contributing factors. Many studies have shown the duration of diabetes to be a risk for ulceration and amputation (Lehto, Ronneman, Pyorala, & Laakso, 1996; Moss et al., 1999; Selby & Zhang, 1995). In addition, poor glycemic control has been shown to be associated with a higher incidence of lower extremity ulceration (Lehto et al., 1996). A 7-year prospective study conducted in Finland found a twofold risk for amputation in patients with poor glycemic control. There was a dose-response relationship between plasma glucose, HbA1c, duration of diabetes, and the risk of amputation. Even moderate elevations in HbA1c were associated with an increased risk of amputation. Similar results were found in a large case-control study conducted at Kaiser Permanente Medical Care Program (Selby & Zhang, 1995).

Male sex has been linked to an increased risk for ulcers in a number of studies (Lee, Lu, Russell, Bahr, Lee, 1993; Moss et al., 1999). A recent, large, 14-year prospective study of the incidence of lower-extremity amputations revealed an odds ratio of 5.21 (95% confidence interval [CI] 2.50-10.88) in males versus females (Moss et al., 1999). A Finnish 7-year prospective study reported no difference between sexes and the risk of amputation (Lehto et al., 1996). The reason for these differences is unclear.

Clear evidence does not exist for a difference in risk based on ethnicity. Lower extremity amputation rates have been shown to be high among several groups of American Indians (Lee et al., 1993; Nelson et al., 1998). The study was based on findings from a database from the Office of Statewide Planning and Development in California, which identified all hospitalizations for lower extremity amputations (Lavery et al., 1996). A twofold higher risk of amputation was described for Hispanic and African American patients as compared to Caucasian patients. However, a large case control study from Kaiser Permanente, a large health maintenance organization based in California, revealed no difference in amputation rates for African American patients. The researchers concluded that the increased rates of amputation might be the result of reduced access to health care rather than a difference in biological susceptibility (Selby & Zhang, 1995).

Assessing the diabetic foot. Identifying the at-risk patient is probably the most important step in reducing the rate of foot ulceration and amputation. Examination of the feet of diabetic patients should incorporate screening for known risk factors including: neuropathy, peripheral vascular disease, bony deformities, elevated plantar pressures, and a previous history of ulceration or amputation. To this end, various screening devices have been developed and are currently in use. This section of the literature review will evaluate the research regarding the use of screening methods.

Visual assessment of the diabetic foot. A wealth of information can be obtained by simply observing the feet of diabetic patients. Lavery and Gazewood (2000) recommend that when doing a foot assessment, the foot and ankle should be evaluated with the ankle both non-weight bearing and weight bearing since many deformities are more noticeable when the subject is standing.

Several guidelines in the literature provide recommendations regarding conditions to note during the assessment (Frykberg et al., 2000; Lavery & Gazewood, 2000; Mayfield et al., 1998; Pinzur, Slovenkai, & Trepman, 1999; Veterans Administration, 2002). The foot should be inspected for the presence of hallux valgus, bunion deformities, claw or hammer toes, and abnormal bony prominences. The skin should be examined for hydration and scaling. Any areas of erythema should be noted as evidence of abnormal pressure. Calluses on the sole of the feet and corns on the top or sides of toes are important as clues of potential ulceration. A study by Murray, Young, Hollis, and Boult on (1996) showed the presence of a callus was

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associated with an 11-fold increase in the risk of ulcer development.

Dermatologic examination is addressed in a few clinical practice guidelines. Recommendations by Pinzer et al. (1999) include noting the presence of dry, scaly skin and evaluation of the toe web spaces for maceration, cracks, ulcers, or infection. Frykberg et al. (2000) further recommend noting nail appearance including onychomycosis, atrophy, hypertrophy, and paronychia.

In addition to a visual inspection of the foot, a visual inspection of the footwear is recommended according to some clinical practice guidelines (Frykberg et al., 2000; Lavery & Gazewood, 2000; Pinzer et al., 1999). Patients with neuropathy may feel that their shoes fit well in spite of the fact that they are too small. Lavery and Gazewood (2000) recommend tracing outlines of the patient's feet while they stand and then removing the insoles from their shoes and tracing the outline of the insoles over the outlines of the feet. Areas of the shoe that are too small or large may be responsible for corns or calluses. Unusual wear patterns of the shoes may be the result of structural or dynamic deformities. Inspection of the inside of the shoe may show irregularities, prominent seams, or foreign bodies that can cause pressure ulceration (Pinzer et al., 1999).

Assessment of diabetic peripheral neuropathy. Many experts in the field of neuropathy regard the Semmes-Weinstein monofilament (SWM) as a sensitive, reliable tool to evaluate for the presence and progression of sensory changes in the diabetic foot (Pham et al., 2000; Rith-Najarian, Stolusky, & Gohdes, 1992). The SWM is a single nylon fiber attached to a handle that bundles under a specified amount of force. The patient is asked to close his or her eyes, and the SWM is then applied to certain points of the plantar surface of the toes and metatarsal heads. The patient is asked to give a verbal response when the SWM is felt. Inability to feel the SWM in any area is considered a lack of protective sensation (Fritschi, 2001).

Research has demonstrated the SWM as the test of peripheral neuropathy to be most predictive of foot ulceration (Boyko et al., 1999; Pham et al., 2000; Rith-Najarian et al., 1992). Strong evidence of this was seen in a large prospective study of Seattle veterans with diabetes that compared the independent effects of multiple potential etiologic agents for ulceration. Using stepwise Cox regression analysis, foot insensitivity to the SWM was independently related to foot ulcer risk with a relative risk of 2.9 (95% confidence interval, 1.5-3.1) (Boyko et al., 1999). Further evidence of the predictive value of the SWM was seen in a prospective study of a high-risk population for amputation. A total of 248 patients from three large, diabetic foot centers throughout the country were followed for a mean period of 30 months. The combination of clinical exam and SWM testing emerged as the most sensitive method of identifying patients at risk for foot ulceration (Pham et al., 2000).

The SWM has a good interrater (k = 0.72) and intrarater (k = 0.83) reliability in trained observers (Lavery & Gazewood, 2000). The most commonly used monofilament, 5.07/10-gam, is available for approximately $10 from a number of organizations (Mayfield & Sugarman, 2000).

Assessment of vascular disease. "The clinical exam for early peripheral vascular disease remains an inexact art" (Mayfield et al., 1998). A variety of methods for assessing peripheral vascular disease have been proposed and will be considered in this review.

The symptoms of peripheral vascular disease are intermittent claudication or rest pain. Intermittent claudication is pain with walking that is relieved by rest (Fritschi, 2001). Rest pain is defined as pain that occurs at rest and is relieved by dependent positioning of the legs (Mayfield et al., 1998). Claudication and rest pain may be difficult to assess in the person with diabetes because of the frequent coexistence of neuropathy resulting in nocioception or hypersensitivity (Mayfield et al., 1998). In a study of 458 volunteers with diabetes, the symptoms of claudication had a sensitivity of 22% and a specificity of 96% when measured against a gold standard of blood pressures, treadmill, and Doppler studies (Mayfield et al., 1998). A large, multicenter, cross-sectional study conducted at multiple sites throughout the United States revealed that classic claudication was uncommon among patients with peripheral arterial disease (Hirsch et al., 2001).

Absent or diminished pulses are used as another assessment parameter for peripheral vascular disease. Detection of the dorsalis pedis and posterior tibial artery pulses by palpation is greatly affected by room temperature, biological variation, and provider skill (Mayfield et al., 1998). The dorsalis pedis pulse is congenitally absent in up to 12% of the population (Barnhorst & Garner, 1968). In the event that a pulse is absent or diminished, some recommend a second evaluation by another clinician (Fritschi, 2001). Determining whether pulses are present or absent is more reliable (k = 0.2-0.29) than distinguishing the quality of the pulse (k = 0.01-0.15) (Lavery & Gazewood, 2000).

The ankle-arm index (AAI) or ankle-brachial index (ABI) has a high degree of sensitivity and specificity for detecting peripheral arterial disease (Hirsch et al., 2001; Steefel, 2003). The ABI is the ratio of the systolic blood pressure in the ankle as compared with that in the arm measured with a handheld Doppler instrument. Ankle blood pressure should be higher than or equal to arm blood pressure. Typically an ABI less than 0.9 signals peripheral vascular disease and the severity of the disease is correlated with a lower ABI score. An ABI of less than 0.9 is 95% sensitive and almost 100% specific in detecting angiogram positive disease (Mayfield et al., 1998).

Recognizing the difficulties in vascular assessment and diagnosis of peripheral vascular disease, Orchard and Standness (1993) note that the consensus recommendation is for palpation of leg pulses to be performed on an annual basis for all adult
Figure 1
Diabetic Foot Screen

<table>
<thead>
<tr>
<th>DIABETIC FOOT SCREEN</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient's Name (Last, First, Middle)</td>
<td>ID No.:</td>
</tr>
</tbody>
</table>

Fill in the following blanks with an “R,” “L,” or “B” to indicate positive findings on the right, left, or both feet.

- Has there been a change in the foot since last evaluation? Yes____ No____
- Is there a foot ulcer now or history of foot ulcer? Yes____ No____
- Does the foot have abnormal shape? Yes____ No____
- Is there weakness in the ankle or foot? Yes____ No____
- Are the nails thick, too long, or ingrown? Yes____ No____

**Label:** Sensory Level with a “+” in the circled areas of the foot if the patient can feel the 10 gram (5.07 Semmes-Weinstein) nylon filament and “-” if he/she cannot feel the 10 gram filament.

[Image of feet with circles on various areas]

**Draw in:** Callus [ ] Pre-Ulcer [ ] Ulcer [ ] (note width/depth in cm.)

**and Label:** Skin condition with R - Redness, S - Swelling, W - Warmth, D - Dryness, M - Maceration

**Vascular:**
- Brachial Systolic Pressure R_______ L_______
- Ankle Systolic Pressure R_______ L_______
- Ischemic Index R_______ L_______

**Does the patient use appropriate footwear for his/her category?** Yes____ No____

**RISK CATEGORY:**
- 0 No loss of protective sensation
- 1 Loss of protective sensation (no weakness, deformity, callus, pre-ulcer, or Hx. ulceration).
- 2 Loss of protective sensation with weakness, deformity, pre-ulcer, or callus, but no Hx. ulceration.
- 3 History of plantar ulceration.

rev. 5/92 This diabetic foot screen may be reproduced and used without permission.
patients with diabetes. An absent or diminished posterior tibial pulse is an indication for performing an ABI or a referral to a vascular laboratory for evaluation if an ABI cannot be performed. It was further recommended that, whenever possible, the presence of decreased or absent pulses be confirmed by a second observer or repeat examination before referral.

In addition to the assessment parameters above, Fritschi (2001) describes other signs and symptoms of peripheral vascular disease for the examiner to be aware of:

- feet are cold to touch
- blanching on elevation
- delayed venous filling time after elevation (>25 seconds)
- shiny skin
- loss of hair on foot or toes
- thickened nails, often with fungal infection
- atrophy of subcutaneous fatty tissue
- blue toe syndrome (lower extremity occlusive disease)

These are repeated in clinical practice guidelines throughout the literature (Frykberg et al., 2000; Pinzur et al., 1999; Veterans Administration, 2000).

**Foot Risk Classification Systems**

Attempts to quantify the contribution of various risk factors for lower extremity amputation in diabetic patients have developed into foot risk stratification systems (Fritschi, 2001; Mayfield et al., 1996; Peters & Lavery, 2001). Risk stratification systems are a formal method of recognizing, documenting, and cumulating risk factors to predict later outcome (Mayfield et al., 1996). Mayfield et al. (1996) developed a risk classification system that is based on research data rather than clinical impressions. It has several advantages over previous systems including the incorporation of vascular status overlooked in some previous systems. The system equally weighs the presence of a bony deformity, peripheral neuropathy, peripheral vascular disease, or a history of foot ulcers associated with an increase risk of amputation. Each of the four factors are given a score of 0 or 1. The sum of the risk factors is added to become a total of 0-4. From the total score, an odds ratio for amputation can be computed. The odds ratio range from 1.0 for a sum of 0 to 9.7 for a score of 3 or 4. The researchers conclude any of these four conditions should trigger increased surveillance and other preventative actions.

A number of forms have been developed for documentation of risk factors and previous history. Several samples are available for use in the literature (Fritschi, 2001; Umeh, Wallhagen, & Nicoloff, 1999). The Gillis W. Long Hansen Disease Center in Carville, LA, developed a foot screening tool that is reproduced easily and is frequently used in clinics and doctor’s offices (Fritschi, 2001). No permission is required for reproduction of the foot screen (Gillis W. Long Disease Center, 1992). This tool comprehensively covers the areas of risk and is easily obtainable from the Hanson Disease Center. The tool uses an optional vascular section for ankle-brachial indexes. A copy of this tool can be found in Figure 1.

**Summary**

Foot examinations can detect high-risk conditions for which specific interventions have been shown to reduce amputation risk. Demonstrated risk factors for lower extremity amputation include: peripheral and autonomic neuropathy, peripheral vascular disease, altered biomechanics, and a history of previous ulceration or amputation. Duration of diabetes and poor glycemic control are also likely risk factors.

A visual inspection of the foot and footwear is the initial step in obtaining information regarding the diabetic foot. Research has demonstrated the SWM to be the test most predictive of foot ulceration. The SWM is an inexpensive, reliable tool for assessing the risk of amputation due to diabetic neuropathy. The assessment for peripheral vascular disease is more difficult. Experts recommend palpation of leg pulses to be performed on all patients with diabetes on an annual basis. An absent or diminished posterior tibial pulse is indication for an ABI or referral to a vascular lab. In addition many visual characteristics may be indicative of peripheral vascular disease.

**Nursing Implications**

The impact of a lower extremity amputation is devastating both in terms of finance and impact on the lifestyle of a patient with diabetes. Foot complications have been shown to be more prevalent in patients with diabetes and CKD. Patients with diabetes and CKD undergoing dialysis have frequent contact with health care providers and many opportunities for foot care assessment and education. Nephrology nurses armed with knowledge are in a favorable position to reduce the alarming number of amputations in patients with diabetes and CKD.

The use of foot care assessment to identify risk factors of lower extremity amputation can enable the nephrologist nurse to detect high-risk conditions early enough for referrals and intervention to prevent amputations. The ultimate success of a foot care assessment program, however, is dependent on proper follow-up and management of problems when they are diagnosed and requires a team approach with cooperation from patients, staff nurses, and physicians.

**References**


Gillis W. Long Hansen's Disease Center.


Preventing Amputations in Patients with Diabetes and Chronic Kidney Disease


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Editorial

continued from page 9

First, we need to learn the language associated with the study of genetics. Cashion and Driscoll have provided us with a great starting point in their article. There are also great resources online such as the Department of Energy Human Genome Project Information site (www.doegenomes.org), which even provides educational presentations to download, and the National Human Genome Research Institute site (www.genome.gov). With the progress in genetics moving so fast, the CDC also offers a Genomic Weekly Update to provide information about the impact of human genetic research on disease prevention and public health (http://www.cdc.gov/genomics/update/current.htm).

Next, we need to learn what has been found during the genetic mapping process about genetics in kidney diseases and in other diseases frequently present in ESRD patients, and apply this information to our practice. An example is diabetes where a gene has already been linked to the risk of type 2 diabetes and shows promise in helping scientists develop further knowledge about the disease as well as making advances in treatment.

Let’s Explore This New Frontier!

We need to explore the associated ethical and social issues and determine how our patients can and will be affected. Open discussions in local units and at ANNA meetings can help nephrology nurses better understand these issues and together we can develop nursing approaches that address them.

Genetics truly represents a new frontier, a frontier in which nurses should be pioneers. Nephrology nurses are experienced at going where others have not yet gone, having often been pioneers as we advanced our own specialty, and should now seek to be on the cutting edge of genetics in medicine.
1. An objective for persons with diabetes of Healthy People 2010 is a reduction in lower extremity amputations
   A. By 25%.
   B. By 55%.
   C. To 2.5 per 1000 patients with diabetes per year.
   D. To 4.1 per 1000 patients with diabetes per year.

2. The rate of amputations for patients with diabetes and CKD is 10 times greater than the diabetic population at large. Factors that contribute to this increase may include:
   A. Loss of contact with primary care physicians only.
   B. Loss of contact with primary care physicians and lack of preventive foot care only.
   C. Loss of contact with primary care physicians, and lack of preventive foot care and early detection of foot problems only.
   D. Loss of contact with primary care physicians, lack of preventive foot care and early detection of foot problems, and lack of follow-up foot care.

3. In the review of the literature, which statement best describes the effect of diabetic foot examinations in reducing the risk of amputations?
   A. Mayfield, Reiber, Nelson, and Greene (2000) showed foot examinations reduced the risk of amputations in Pima Indians with type 2 diabetes.
   B. A study by Del Aguila, Reiber, and Koepsell (1994) at the Seattle VA Medical Center showed primary care providers were more likely to refer when given guidelines on foot-related risk factors.
   C. In a study by Rith-Najarian, et al. (1998) in American Indians, screening high-risk individuals and targeting them with simple interventions resulted in the biggest risk in amputation rates.
   D. In research by Mazze et al. (1994) implementation of a Staged Diabetes Management Program resulted in little improvement over simple low cost foot screening.

4. In a study by Pecoraro, Reibber, and Burgess (1990) a combination of factors leads to amputation. A leading factor in amputations listed in this study was:
   A. Initial minor trauma.
   B. Gangrene.
   C. Ill-fitting shoes.
   D. Ischemia.

5. Diabetic neuropathy is an important risk factor in the etiology of diabetic lower extremity ulcerations in amputation. Which statement concerning diabetic neuropathy is true?
   A. Pain and hyperesthesia of peripheral neuropathy usually leads to development of ulcers.
   B. Hypoesthesia or lessened sensation is the major stumbling block to early problem recognition.
   C. The sensory component of neuropathy contributes to hammer toe and the development of pressure points leading to ulcer.
   D. The motor component of polyneuropathy results in atrophy of the subcutaneous glands and skin prone to damage from minor trauma.

6. Identification of the foot at risk is critical in preventing amputations. Increased risk of ulcerations results from:
   A. Altered biomechanics only.
   B. Altered biomechanics and increased plantar pressure only.
   C. Altered biomechanics, increased plantar pressure, and bony abnormalities only.
   D. Altered biomechanics, increased plantar pressure, bony abnormalities, and limited joint mobility.

7. Charcot foot deformity, which develops in 4 stages,
   A. May be confused with osteoporosis in its early stage.
   B. Takes years to develop the fractures in the second stage.
   C. Is due to decreased vascular perfusion.
   D. Is due to fractures and collapse of the joint.

8. Research regarding screening methods for assessing the diabetic foot has shown that foot insensitivity to the Semmes-Weinstein monofilament (SWM) is:
   A. The test of vascular disease most predictive of foot ulceration.
   B. Independently related to foot ulcer risk.
   C. Not as predictive of foot ulcer risks as the vibration perception threshold.
   D. A complicated but reliable method to predict vascular disease.

9. You are doing a foot assessment on Mrs. Bentley. What would be a sign of peripheral vascular disease (PVD)?
   A. Bounding pulses.
   B. Increased fatty tissue.
   C. Thickened nails.
   D. Excessive hair growth.

10. In Mayfield’s (1996) foot risk classification system, which risk factor(s) should trigger increased surveillance and other preventive actions?
    A. Bony deformity only.
    B. Bony deformity and peripheral neuropathy only.
    C. Bony deformity, peripheral neuropathy, and peripheral vascular disease only.
    D. Bony deformity, peripheral neuropathy, peripheral vascular disease, and history of foot ulcer.
ANNNJ402
Preventing Amputations in Patients with Diabetes and Chronic Kidney Disease
Annette Broersma, MSN, RN, NP-C, CNN

Posttest Instructions
• Select the best answer and circle the appropriate letter on the answer grid below.
• Complete the evaluation.
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Posttest Answer Grid (Please circle your answer choice):
1. a b c d 3. a b c d 5. a b c d 7. a b c d
2. a b c d 4. a b c d 6. a b c d 8. a b c d

Evaluation
1. The objectives were related to the goal.
2. Objectives were met
   a. Discuss the impact of amputation in diabetics with end stage renal disease (ESRD).
   1 2 3 4 5
   b. List risk factors for the increased incidence of lower extremity amputations among diabetics with ESRD.
   1 2 3 4 5
   c. Describe assessment methods and a foot classification system to reduce amputations.
   1 2 3 4 5
3. The instructions were clear to complete this activity.
4. Minutes required to complete self-study, including the posttest

GOAL Nurses in the dialytic arena will identify their unique position to positively impact the high rate of amputations among dialysis patients with diabetes.

6. I verify that I have completed this activity:
   ____________________________ (Signature)
   Comments ____________________
   Suggested topics for future articles? ________________

   64

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