

Farmers with Diabetes: Risks for Lower Extremity Injury and Disability

Janice A. Neil, RN, PhD

ABSTRACT. There are over 15 million persons with diabetes mellitus in the United States. Amputation of the feet and legs due to the complications of diabetes is one of the biggest threats to persons with diabetes and can result in permanent disability. Extrinsic factors including improper footwear, mechanical trauma, and thermal injury increase the risk of ulceration in the insensate foot. Farming is well known to be one of the most hazardous occupations. The complex farm environment poses extra threats to those with diabetes. This paper discusses some of these threats and suggestions for prevention of lower extremity ulcers. *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-342-9678. E-mail address: <getinfo@haworthpressinc.com> Website: <<http://www.HaworthPress.com>>]*

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There are over 15 million persons with diabetes mellitus in the United States, and they are at high risk for foot or leg ulcers due to vascular changes and diabetic neuropathy.^{1,2,3} Further, amputation of the feet and legs due to osteomyelitis or severe wound infection is one of the biggest threats to adults with diabetes. Diabetes now is the leading cause of lower extremity amputation among persons aged 18-65 in the United States, with 50,000-60,000 performed annually. It

Janice A. Neil is Assistant Professor, East Carolina University, School of Nursing, and Member of the North Carolina Agromedicine Consortium.

Address correspondence to: Janice A. Neil, RN, PhD, East Carolina University, School of Nursing, Rivers #115, Greenville, NC 27858.

is well known that farming is one of the most hazardous occupations. Today's complex farm environment can pose many threats to persons with diabetes. These risks are discussed in this paper.

SCOPE AND BASIS OF THE PROBLEM

Approximately 15% of people with diabetes develop foot and leg ulcers.⁴ The three mechanisms involved in the formation of diabetic ulcers are ischemia, neuropathy and infection. These three mechanisms work together in a complex interplay. As diabetes progresses, people are at high risk for developing peripheral vascular disease and peripheral neuropathy. Peripheral vascular disease causes ischemia because of inadequate perfusion. This leads to cellular death as a result of the lack of tissue oxygenation.

Diabetic neuropathy, nerve damage that affects sensory, motor, and autonomic nervous systems occurs in 60-70% of people with diabetes. The physiological basis is a complex interrelationship of the sensory, motor, and autonomic nervous systems. Hyperglycemia causes the myelin sheaths of the nerves to demyelinate slowing nerve conduction and causing an impairment of sensory function. Neuropathy also involves loss of Achilles and patellar reflexes and decreased vibratory sensation. Neuropathy may be the most important precursor to ulcer development.⁵ Distal symmetric polyneuropathy, leads to reduced thermal and pain sensation, numbness, and painful paresthesias.⁶ Decreased motor nerve function results in atrophy of the small muscles of the foot which in turn leads to an imbalance of flexor and extensor muscles. Clawing, a typical foot posture in peripheral neuropathy, shifts the foot position making the metatarsal heads more prominent. Ulcers are more prone to develop on the areas underlying the metatarsal heads because of the maldistribution of pressure. When an insensate foot is subjected to even minor trauma or to increased pressure, an ulcer may develop.

Another consequence of neuropathy is a mechanism called diabetic anhidrosis, a sudomotor dysfunction that results in the absence of sweat in the feet. This makes the feet dry, and the resulting dry cracked skin makes it easier for ulcers to develop. Almost all persons with peripheral neuropathy experiences diabetic anhidrosis that predisposes them to foot ulceration and infection.⁵

Ulceration, infection, and gangrene are leading causes of hospital-

ization with an annual cost of one billion dollars in the United States.⁷ Hyperglycemia impairs the host defenses against infection by dulling the inflammatory response and causing abnormal action of the phagocytes. This causes wound healing to be slower and allows for infections to get worse. Infection of chronic ulcers is a major cause of gangrene and in turn amputation.

Extrinsic factors including improper footwear, mechanical trauma, and thermal injury from burns increase the risk of ulceration of the insensate foot. In the normal foot, discomfort from extrinsic factors would cause a change in gait and use of a different part of the foot to bear the stress. These compensatory mechanisms shift weight off the area of discomfort and would allow the foot to remain intact. However, in the foot that is insensate, the person's inability to feel pain increases the susceptibility to further injury. Even minor trauma can cause ulceration and infection.⁵

Farm injuries come with significant costs when a person is unable to perform the work required on the farm. Costs are especially large in crop production situations when timeliness is important. Planting and harvesting delays during this critical time can be devastating.⁸ Farming is one of the most hazardous of occupations. The complex farm environment poses serious threats which have increased with mechanization.⁹ This threat has worsened with confinement buildings used for poultry, hogs and cattle. Farmers risk foot injuries that include lacerations, punctures, crush injuries, traumatic impact blows, bites from animals, insects, and reptiles, burns, falls, skin rashes and traumatic amputations. Since even a small break in the skin can result in a chronic wound, these risks of farming are serious threats to those with diabetes. For farmers with diabetes who have neuropathy, and especially those who are insensate, the risks of foot injuries are high. Also, diabetic farmers who are on medications are at higher risk for farm injuries. Often those who have developed vascular problems are on heart and circulatory system medications. Persons on these medications were more likely to sustain a farm injury.¹⁰ Diabetic retinopathy is a leading cause of vision loss and blindness.³ Of course, decreased visual acuity can be responsible for accidents as well.

Awareness of potential foot injuries and strategies to prevent chronic wound development and disability in farmers and farm workers with diabetes are vital to healthy individuals.

POTENTIAL CAUSES OF FOOT INJURIES

Livestock

Animals are involved in many thousands of farm injuries and death every year. A recent summary of farm accidents from 15 states indicates that animals were a factor in about one of every eight injuries reported. The largest number of injuries came from cattle and hogs and occurred in farm buildings and adjacent lots.¹¹

Working with cows and bulls whose behavior is unpredictable poses a great hazard for foot injuries because they often kick, push and step on workers' feet and legs. The size and unpredictable behavior of cows and bulls make them especially dangerous. When a sudden movement or unfamiliar situation startles cows, they may kick, push, knock down, or fall on workers' feet. Working in confined situations such as milking stalls adds to the danger. Bulls account for 25% of animal-related farm injuries.¹² Bull injuries can be very serious, and there is a high risk of injury when they are being dehorned. Their size and strength can cause a great deal of pressure on the feet of workers who are stepped on or kicked. In a study by Browning, Truszczunska, Reed and McKnight, a sample of 998 farmers revealed an injury rate of 9%.¹³ One of the leading causes was animal related events. Those working with beef cattle had significantly higher rates of injury than other farm workers.

Also, hogs can bite with tremendous force, and they have enough weight to cause crush injuries if they step on feet. Likewise, sheep and rams can cause butting injuries. Any operations involving restraint should involve solid facilities. Ropes are hazardous to workers and can lead to serious leg injuries. Any injury caused by an animal kicking or stepping on the feet of a person with diabetes should be evaluated as soon as possible.¹¹

Chemicals

Modern farming involves the use of many chemical products including herbicides, fungicides, insecticides, rodenticides, and pesticides. Farmers usually prepare their own equipment and are exposed to a variety of solvents and fuels. Many of these products can cause serious skin reactions leading to contact dermatitis. Fungicides in

particular cause severe itching and peeling skin.¹⁴ Defatting of the skin or chemical burns may occur after prolonged contact. Anhydrous ammonia, a source of nitrogen stored in liquid form in pressurized tanks forms a strong alkaline solution that can cause severe burns. Animal feeds and medications can also cause contact dermatitis. Moving animals may cause medications to be injected into the farmer and result in severe skin reactions. Skin that is irritated or itchy becomes a prime target for wound development and cellulitis. Chronic wounds often develop from these areas of irritation, especially in people with diabetes who have impaired healing abilities. Scratching irritated skin allows the normal skin flora to invade and cause wounds.

Petroleum products such as fuels and lubricants as well as fertilizers can be toxic and cause serious burns. Work clothes saturated with chemicals from spills provide opportunities for skin absorption with resulting burns or dermatological conditions. Fertilizers containing anhydrous ammonia are extremely alkaline and can cause severe burns. In the insensate person, chemical spills may go unnoticed. Neuropathy often involves the hands as well, and unsteady hands cause spills of toxic chemicals.

Standing Water

Farmland often has standing water or shallow ponds. As a participant in one study stated, "My feet are always wet."¹⁵ Stagnant water harbors multiple aerobic and anaerobic organisms that can easily invade open wounds, even small cuts in the skin. When bacteria invade these wounds, infection often results. Fungal infections can also result from wet feet. These fungal infections often invade the toenails. Fungal infections are hard to heal in the diabetic with impaired wound healing. The added shear of wet feet allows pressure areas to form more rapidly and can result in a wound within hours. In one study, a patient with diabetes developed a chronic wound after one day of having wet feet while fishing.¹⁶

Tractors and Farm Machinery

Injuries related to farm machinery are a leading cause of morbidity and mortality among farmers.¹⁷ Farm machinery can be responsible for crush injuries and lacerations. Feet, leg, hands, and arms accounted

for 50% of the farm injuries in a study of 980 workers in 1989. Feet and legs can become entangled in machinery as well. Tractors account for the majority of fatal farm injuries.^{18,19} Richardson, Loomis, Wolf, and Gregory found that 54% of fatal farm injuries were caused by tractor crush injuries. There are many parts of a tractor that become extremely hot. Brakes and bearings, exhaust systems, and hydraulic lines and pumps can cause significant burns. The farmer is at risk with these systems under the seat and under the feet. Hydraulic lines have been known to rupture releasing oil at high pressures. This would not only cause a burn, but a puncture injury that contains bacteria and oil.²⁰ Severe infections can result. A farmer who is insensate due to neuropathy may have prolonged contact with a heat source of a tractor and not be aware that a burn occurred. In addition, Noel, Holtz, Savolainen, and Depairon found that exposure to vibration while maneuvering a tractor caused a vibration syndrome that resulted in neurovascular injuries.²¹ For a person with diabetes who is prone to develop neuropathy, this could add to the problem.

The pathology of the diabetic process, trauma from accidents and pressures, and skin and tissue injuries from ill-fitting shoes can all contribute to ulcer formation. Attention to environmental circumstances and hazards, and conscientious attention to diabetic treatment regimes is paramount in preventing the complications of diabetes that can lead to lower extremity ulceration. Noncompliance with treatment regimes and medications may further contribute to the progression of the disease, and increase the likelihood of diabetic neuropathy.

ULCER PREVENTION

All persons with diabetes should have a thorough foot examination with each visit to the health care provider. The Semmes-Weinstein monofilament test is an effective method of evaluating sensory deficits. Calibrated monofilaments are used to test the client's ability to feel a point of pressure on the plantar surfaces of the foot. The monofilaments range in size from 1.65 to 6.65. The higher the number, the harder the monofilament is to bend, and therefore more force is required. The lighter the force the client can identify, the more intact the sensory component is. When Masson et al. assessed the extent to which patients with diabetes were aware of risk factors, they found that only 29% of people with foot ulcers and 59% without foot ulcers consid-

ered themselves at risk for foot ulceration.²² Most did not realize they had a loss of sensation. Our study of foot care practices of insensate people with diabetes found that many did not know they had sensory impairment because they could still "feel their feet."¹⁶ When feet are insensate, they are not in the forefront of consciousness. Patients need to be informed that they are insensate and are at high risk for injury and ulcer development.

Footwear

Ensuring that patients wear proper footwear is an important part of a treatment program for people with diabetes, even for those in the earliest stages of the disease. Good footwear is the mainstay of prevention of diabetic foot ulcers. If there is evidence of neuropathy, wearing the right footwear is crucial. Shoes must accommodate dorsal deformities and cushion areas of high pressure. Footwear should relieve excessive pressure on areas that are prominent such as the metatarsal heads in the Charcot foot. Shoes must also reduce shock, or the vertical pressure on the bottom of the foot due to the weight of the person, and shear, or the horizontal movement of the foot within the shoe. Deformities of the foot resulting from loss of fatty tissue, hammer toes, and toe amputations must also be accommodated. Many of these deformities need to be stabilized to relieve pressure and avoid further destruction. Ulceration is often due to the magnitude of the pressure.²³ Limiting the motion of certain joints in the foot can decrease inflammation, relieve pain, and result in a more stable and functional foot.²⁴

Special shoes are costly, but some athletic shoes and "comfort shoes" can provide pressure relief.¹⁹ High quality walking or athletic shoes with prescription insoles are necessary, but finding the right footwear prescription can often be a matter of trial and error. In achieving proper shoe fit, the shape and size of the foot must be considered. Shoes with laces are preferable, with a 3/8 to 1/2-inch space between the end of the shoe and the longest toe.²⁰ The guidelines suggest that two pairs of shoes are desirable, because they should be changed in the middle of the day to avoid moisture build-up. Safety shoes should be standard equipment on any farm. The metal-toed shoes with rugged soles can afford some protection against animal hooves, dropped items, and sharp objects. Extra care must be taken to examine the foot for pressure areas, especially when wearing new

footwear. Care must be taken to avoid wet feet, to check feet frequently, and to change work shoes and socks when they become wet.

Farm safety factors that prevent leg and foot injury include adequate space lighting, and keeping the noise level as low as possible to avoid startling animals. An adequate number of handlers when working with animals can also help avoid injury. Agricultural workers must be encouraged to wear protective clothing, even in hot weather, to practice good personal hygiene, and to wash pesticide or chemical contaminated clothing immediately to avoid skin contact.

CONCLUSION

Education is an essential component in the prevention of foot problems among persons with diabetes. However, research has revealed that foot care is often ignored or not done regularly. Foot screening using monofilament testing should be done at every health care visit. Also, people need to be informed that they are insensate. Hazards related to farming should be emphasized. Table 1 emphasized the major injuries and the possible results for persons with diabetes. Many farmers are not aware of the special hazards that farming poses to their feet and legs. Work boots or shoes should be changed every few hours or

TABLE 1. Specific risk factors for farmers with diabetes

Risk	Possible result for person with diabetes
Livestock: cows, bulls, hogs, horses: Stepping on feet, kicks, pushing, biting	Open wounds, puncture wounds, with delayed healing, possible chronic wound formation
Chemicals: pesticides, rodenticides, herbicides	Skin reactions, rashes, dermatitis, itching peeling skin, chronic wound formation
Standing water: wet feet	Increased incidence of fungal growth, increased incidence of shear to the foot with wound formation, possible chronic wound formation
Farm machinery: burns, oil injection, crush injuries, roll over accidents	Crush injuries, slash and gash injuries, burns, vibration syndrome with increased peripheral neuropathy. Chronic wound formation
Improper or ill-fitting footwear	Blister formation, increased shear, chronic wound formation

whenever they get wet enough to soak through to the socks. Wet feet are at high risk for fungal development and provide an excellent atmosphere for bacterial growth. Also, there is increased shear associated with wet feet, which could cause ulcers in people with diabetes. New shoes should be custom-made and the feet should be checked twice daily for pressure areas that the insensate person would not normally notice. Foot injuries should never be ignored. Any injury or pressure area should be dealt with promptly by careful washing with soap and water, drying and bandage protection. Regular foot assessment, evaluation, and education are the mainstays of ulcer prevention in farmers and farm workers with diabetes in order to prevent chronic wounds and permanent disability.

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