Department of Veterans Affairs

Journal of Rehabilitation Research and Development Vol. 35 No. 3, July 1998
Pages 335–339

CLINICAL REPORT

Incidence of Peripheral Neuropathy in the Contralateral Limb of Persons with Unilateral Amputation Due to Diabetes

Patrick J. Potter, MD, FRCPC; Oleh Maryniak, MD, FRCPC; Ray Yaworski, RT(EMG); Ian C. Jones, BMath MA

Department of Physical Medicine and Rehabilitation, Parkwood Hospital, University of Western Ontario, London, ON N6G 5J1 Canada; Department of Physical Medicine and Rehabilitation, St. Joseph's Health Centre, University of Western Ontario, London, ON N6G 5J1 Canada

Abstract—Eighty persons with first-time, nontraumatic amputation, mean age 66.7 yrs ±12.6 (1 SD) were examined to determine the extent of peripheral neuropathy (PN) present in the intact limb. Thirty-eight (47.5%) of the subjects had confirmed diabetes mellitus (DM); in those subjects, vibration sense (73.3%), temperature sense (42.1%), and nociception (71.1%) were decreased or absent in the intact limb. The prevalence of sensory impairment was significantly less in nondiabetic subjects in whom vibration sense 46.5% ($p<0.02$), temperature sense 16.3% ($p<0.01$), and nociception 32.6% ($p<0.02$) were decreased or absent. Using a scale that stages the severity of PN, a significant difference ($p<0.001$) in the distribution was found between these two groups. Only one person with known DM had no evidence of PN. Twenty-eight out of 42 nondiabetic subjects had evidence of PN. Eighty percent of all subjects had PN. This study confirms the significant potential for PN in persons with DM and presents new evidence of a significant incidence of neuropathy in nondiabetic individuals with amputation. The finding of unexpected peripheral nerve compromise is an important consideration in the treatment of persons with peripheral vascular disease who are at risk for amputation and for persons with amputation who depend on the intact limb for stability and ambulation.

Key words: *amputation, diabetes, electromyography, neuropathy.*

Address all correspondence and requests for reprints to: Dr. P. J. Potter, 801 Commissioners Road East, London, ON N6A 4G5, Canada.

INTRODUCTION

The most common etiology for amputation in North America is peripheral vascular disease (1). Lower limb amputations are commonly performed due to the sequelae of peripheral vascular disease complicated by trauma or diabetes mellitus (DM). In the 2 years following successful surgical amputation, the contralateral limb has a 50 percent risk of amputation (2). Local infection or ulceration that does not heal in the presence of compromised circulation contributes to eventual amputation in persons with peripheral vascular disease. Peripheral neuropathy (PN) is considered to be a major factor in the occurrence of foot ulcers in persons with DM (3,4). In those with foot ulcers secondary to DM, an association between sensory and motor neuropathies and outcome, including amputation, has been documented (5). Clinical experience in the treatment of persons with unilateral amputation not affected by DM suggests that sensory loss may play an important role in the impairment seen in the intact limb. Such sensory loss may also have been a contributing factor prior to amputation. More recent work has demonstrated progression of PN in the presence of peripheral arterial disease, suggesting further evidence of peripheral nerve impairment in subjects with vascular diseases that lead to amputation (6).

Hypotheses

We postulated that, in a group of persons with unilateral amputation, the incidence of PN and, in particular, sensory impairment would be greater in the intact limb of those with diabetes than in those without. We also postulated from clinical experience that the incidence of PN and sensory impairment in persons without diabetes would be present in the majority of this population. If such a sensory impairment were present in a large number of nondiabetic persons with amputation, then it is therefore important to consider this population at risk.

Knowing the extent to which PN was present in such a population would provide a stronger argument for extending the preventative measures of limb care utilized in those persons with DM to all persons with amputation and clinical evidence of neuropathy, to prevent loss of the intact limb. Sensory and motor deficits are known to contribute to the incidence of foot ulceration and other lower limb trauma, thereby increasing the risk of amputation. This study was undertaken to identify to what extent PN was present in a consecutive population of persons with unilateral amputation.

METHODS

Subjects

This was a prospective study of 80 consecutive persons with first-time, nontraumatic amputation admitted to a Rehabilitation Unit that services a regional area of approximately 1 million population. The majority of new clients with amputation are fitted on an inpatient basis. Individuals with traumatic etiologies and bilateral amputations were excluded from this study.

Eighty subjects, consecutively admitted to the Rehabilitation program, mean age 66.7 yrs ±12.6 (±1 SD) with unilateral amputations were examined with informed consent. There were 23 (28.8 percent) females and 57 (71.2 percent) males. Thirty-eight (47.5 percent) of the subjects had confirmed DM. Of those with DM, 17 (44.7 percent) were not insulin dependent and 21 (55.3 percent) were insulin dependent with a mean duration of 162±96.6 months of diabetes (median 156; range 2–240). The mean duration of insulin use for those insulin-dependent diabetics was 109.6±92.9 mo (median 120 mo; range 2–420 mo).

Clinical Examination

All subjects were examined by the same physician. In the contralateral limb, vibration sense, temperature sense, nociception (pinprick), and strength were examined. Temperature sensation was determined by contact of the dorsum of the foot with similar metal containers of two distinct temperatures (warm= 25 °C and cold=12 °C). Vibration sense, temperature, and nociception were graded on a scale of 0 to 2 by the subject's appreciation as follows: sensation absent=0, decreased=1, or normal=2, tested at the level of the first metatarsal phalangeal joint, ankle, mid-shin, and knee. Vibration sense was examined using a tuning fork (128 Hz) applied to boney prominences at the levels described. Nociception was examined by determining the ability to discriminate pinprick. Strength was examined using the Medical Research Council Scale (7). Foot temperature was recorded on the dorsum of the foot, using a surface thermometer (Surface Probe, Model 49TA, Yellow Springs Instrument Company Inc., Yellow Springs, OH 45387). Foot temperature measurements were used to ensure no significant confounding effect of a cool dysvascular limb on the nerve conduction measurements.

The preceding clinical evaluation techniques were used to allow for more direct extrapolation of the results of this study to the usual care of persons with amputation.

Electrodiagnostic Examination

Nerve conduction studies performed on the contralateral limb included peroneal motor, and sensory and sural nerve evoked potentials and H-reflex studies (8,9). These were recorded and analyzed using a 4-channel electromyograph (Model 7400, Cadwell Laboratories Inc., Kennewick, WA 99336). Electromyographic sampling was done of the tibialis anterior and medial gastrocnemius using a monopolar needle (Model MF-37, TECA Corporation, Pleasantville, New York 10570). The surface reference, located within 3 cm of the insertion point, was a 10 mm stainless steel disk, (TECA Model 922-6030-1). Dual stainless steel disks on 30-mm centers in a plastic mount were used for nerve conduction studies (TECA model 922-6030-1). The ground electrode for all tests was a 32 mm stainless steel disk (TECA Model 922-6008). These electrodiagnostic techniques have been previously used and described by the authors (10).

Electromyographic sampling was not done of the intrinsic muscles of the foot, due to a known incidence of abnormal findings that may be present for causes other than PN. Results of the nerve conduction studies were incorporated with the examination data to grade the severity of the neuropathy (**Table 1**).

Analyses

Severity of PN was graded (**Table 1**) using a modification of previously recorded criteria for PN (8,11,12). Diabetic and nondiabetic groups were contrasted using Chi Square analysis.

Table 1.
The extent of PN was estimated using a modified version of previously described scales.

Grade	Extent of Neuropathy
0	No symptoms, no clinical neurologic deficits, normal nerve conduction and normal electromyographic examination.
1	Sensory symptoms or decreased sensation with normal nerve conduction studies and normal electromyographic studies.
2	Abnormal nerve conduction, abnormal clinical examination and normal electromyographic examination.
3	Abnormalities in all categories.

RESULTS

In those subjects with diabetes, vibration sense (73.7 percent), temperature sense (42.1 percent), and nociception (71.1 percent) were decreased or absent in the intact limb. The distribution of similar sensory impairments was significantly less ($p<0.02$) in non-diabetic subjects in which vibration sense (47.6 percent), temperature sense (11.9 percent), and nociception (45.2 percent) were decreased or absent (**Figure 1**).

Only one person with known diabetes had no evidence of PN on history, clinical examination, or electrodiagnostic testing. Twenty-eight out of 42 nondiabetic subjects had evidence of PN (66.7 percent). Eighty percent of all subjects had evidence of PN.

The majority (97.5 percent) of the examined population had required their amputation due to a peripheral vascular impairment or associated complication. Mean foot temperatures were 31.3° (range 26.1–35°). There was no statistically significant difference in the distribution of amputation sites between the diabetic and nondiabetic groups. Thirty-two (84 percent) diabetics had transfemoral amputation, six (16 percent) had transtibial amputations. Twenty-seven (67.5 percent) of nondiabetics had transtibial amputations and 13 (32.5 percent) had transfemoral amputations. There were 2 foot amputations, both nondiabetic.

Electromyographic changes indicative of an axonal neuropathy (denervation potentials) were present in the majority of subjects with concurrent DM (97.1 percent) compared to a 58.3 percent incidence of electromyographic abnormalities seen in nondiabetics.

DISCUSSION

Given that the most common etiology for amputation in North America is peripheral vascular disease (1), our findings support a high incidence (80 percent) of PN in the intact limb of a high percentage of such clients. Excluding that population with DM, 28 out of 42 subjects had PN of which they were not aware, as suggested in our original hypothesis. These findings confirm and extend previous reports (13) that suggest that one-half to two-thirds of patients with atherosclerotic disease of the lower limbs will have sensory changes and impairment of reflexes suggestive of PN (**Figure 2**).

In this study, those with concurrent DM presented more frequently with a PN that included axonal loss, suggesting a greater risk of tissue damage as a consequence of PN. More importantly, a high incidence of unexpected PN was demonstratable in most persons examined. Therefore, PN should be considered as a frequent concurrent impairment when treating persons with amputation.

Lower limb amputations are most commonly done due to the sequelae of peripheral vascular disease or DM complicated by local tissue trauma (1,14). In the 2 years following successful surgical amputation, the contralateral limb has a 50 percent risk for amputation (2). Our study results support a significant degree of impairment in the intact limb of such persons, suggesting an increased potential for preventative medicine to be effective. A common problem contributing to amputation in an individual with peripheral vascular disease is local infection or ulceration that does not heal in the

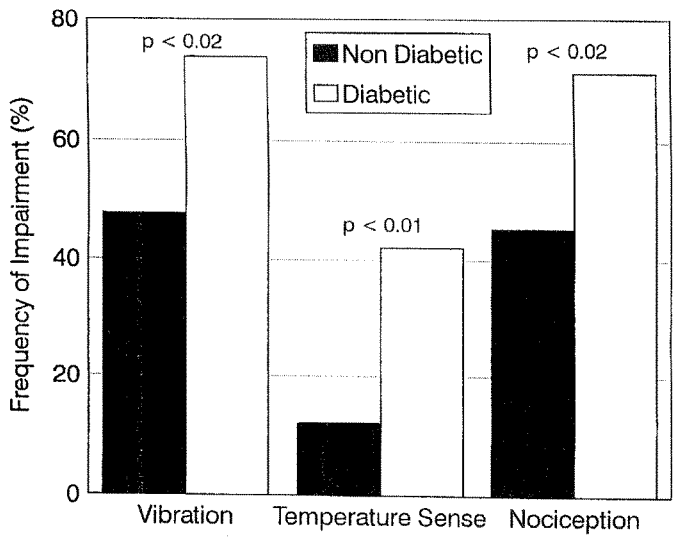

Figure 1.
Extent of sensory impairment as defined by decreased ability to sense vibration, temperature, and nociceptive stimuli.

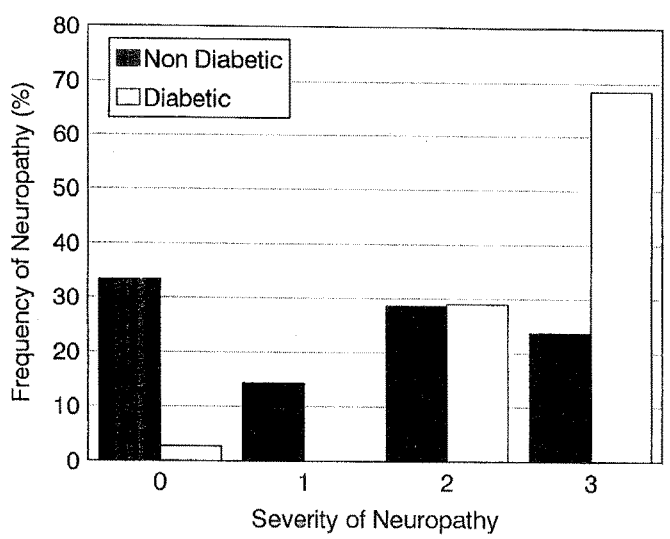

Figure 2.
Severity of neuropathy for the nondiabetic and diabetic populations studied. There is a significant difference ($p<0.001$) in the distribution between the two populations of subjects.

presence of compromised circulation. PN is felt to be a major factor in the occurrence of foot ulcers in diabetics (3,4,15). An association between sensory and motor neuropathies and outcome in persons with diabetic foot ulcers has been documented (5). In a review of these ulcers, it was found that precipitating trauma was a major cause of foot ulceration in 82 percent of the cases. The most common factors identified were ill-fitting shoes or socks, recent mechanical trauma, pressure, and paronychia. Distal sensory or motor abnormalities were present in 96 percent of the 314 subjects presenting with foot ulcers associated with DM (5). Rieber et al. (16) identified insufficient cutaneous circulation, absence of lower limb vibratory sensation and proprioception, low levels of high density lipoproprotein, and no diabetic education as risk factors for amputation in people with DM. Given the high incidence of PN in our study, such education would also appear appropriate for a more general population with amputation. Treatment of the insensitive foot has been shown to reduce the rate of amputation (3,11,17). Recognizing people with DM as a high risk group, programs directed toward better foot care, education, and appropriate footwear have been shown to reduce the incidence of amputation (14,17).

Exercise is an important step in the rehabilitation of persons with amputation. Recent work (6) suggests that exercise in persons with peripheral arterial disease results in increased strength without contributing to any increase in the severity of the PN, although the natural history of the neuropathy continues.

In this study, there is a retrospective bias with respect to the etiology of the amputation. This information was obtained from the subjects prior to examination. Examination of the contralateral limb provides indirect evidence of PN in both limbs, but is not conclusive. There is the potential for the PN to have worsened between the original amputation and the examination of the contralateral limb; therefore, inferences regarding the extent of neuropathy in the amputated limb may not be exact. Only the lower limbs were examined, as this was the focus area for the hypotheses. Based on the differing pathophysiologies of diabetic neuropathy and that due to peripheral vascular disease, examination of the upper limbs would likely have demonstrated evidence of a generalized neuropathy in those persons affected by DM, contrasting with the neuropathy being localized to the lower limbs when due to peripheral vascular disease (13).

In spite of these limitations, this study provides insights into the multifactorial etiology of limb amputation. Understanding all of the contributing factors may allow for an increased ability to prevent or postpone limb amputation due to peripheral vascular disease and DM. In particular, already successful preventive measures identified in the diabetic population may be of benefit to patients with known peripheral vascular

disease, based on the high proportion of PN seen in the nondiabetic population. Equally important, the remaining limb is shown to be at risk; therefore, the same principles should be continued after amputation.

REFERENCES

1. Fylling CP, Knight DR. Amputation in the diabetic population: incidence, causes, cost, treatment and prevention. J Enterostom Ther 1989;16:247–55.
2. Bodily KC, Burgess EM. Contralateral limb and patient survival after leg amputation. Am J Surg 1983;146:280–3.
3. Edmonds ME, Blundell MP, Morris ME, Thomas EM, Cotton LT, Watkins PJ. Improved survival of the diabetic foot: the role of a specialised foot clinic. Q J Med 1986;60:763–71.
4. Boulton AJM, Kubrusly DB, Bowker JH, et al. Impaired vibration perception and diabetic foot ulceration. Diabetic Med 1986;3:335–7.
5. Apelqvist J, Larsson J, Agardh CD. The influence of external precipitating factors and peripheral neuropathy on the development and outcome of diabetic foot ulcers. J Diabetes Complications 1990;4:21–5.
6. England J, et. al. Progression of neuropathy in peripheral arterial disease. Muscle Nerve 1995:18:380–7.
7. Medical Research Council. Aids to the examination of the peripheral nervous system. Toronto: Bailliere Tindall; 1986. p. 1–2.
8. Dyck PJ. Detection, characterization, and staging of polyneuropathy: assessed in diabetics. Muscle Nerve 1988; 11:21–32.
9. Maryniak O, et. al. Intramuscular recording of H reflexes from muscles of the posterior compartment of the lower leg. Amer J Phys Med Rehabil 1991;70:34–9.
10. Maryniak O, Yaworski R. H reflex: optimum location of recording electrodes. Arch Phys Med Rehabil 1987;68:798–801.
11. Juntunen J. Alcoholic polyneuropathy. Acta Med Scand Suppl 1985;703:265–72.
12. Ward JD. Diabetic neuropathy. Br Med Bull 1989;45:111–26.
13. Daube JR, Dyck PJ. Neuropathy due to a peripheral vascular diseases. In: Dyck PJ, et al., editors. Peripheral neuropathy. 2nd ed. Philadelphia: Saunders; 1984. p. 1458–78.
14. Bild DE, Selby JV, Sinnock P, Browner WS, Braveman P, Showstack JA. Lower-extremity amputation in people with diabetes: epidemiology and prevention. Diabetes Care 1989;12:24–31.
15. Nelson RG, Gohdes DM, Everhart JE, et al. Lower-extremity amputations in noninsulin dependent diabetes. 12-yr follow up study in Pima Indians. Diabetes Care 1988;11:8–16.
16. Reiber GE, Pecoraro RE, Koepsell TD. Risk factors for amputation in patients with diabetes mellitus. Ann Int Med 1993;117:97–105.
17. Knighton DR, Fylling CP, Fiegel VD, Cerra F. Amputation prevention in an independently reviewed at-risk diabetic population using a comprehensive wound care protocol. Am J Surg 1990;160:466–72.

Submitted for publication March 6, 1996. Accepted in revised form September 18, 1996.