How do we distinguish loss of vibration sensation due to neuropathy from that due to ageing?

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Received: 18 February 2013
Accepted in revised form: 12 April 2013

Abstract
The aim of this study was to determine whether loss of sensation in the feet due to diabetic neuropathy can be distinguished from age-related changes by testing sensation at more proximal sites.

Vibration perception threshold (VPT) was tested using a biothesiometer at the feet, mid-tibia and knees on participants who had a VPT ≥50 volts. We studied: (i) diabetic patients with a history of neuropathic ulceration (N Ulcer); (ii) elderly diabetic patients with no history of ulceration (E Ulcer); and (iii) elderly non-diabetic controls. The VPT of the N Ulcer group dropped significantly at the level of mid-tibia and knee and was significantly different from the E Ulcer group at both sites and from the elderly controls at the knee (p<0.05). By contrast, the E Ulcer group and the elderly controls tended to have poor vibration perception at all three sites.

The results of this study suggest that diabetic neuropathy is a predominantly distal disease, whereas ageing is associated with a more generalised loss of sensation. This observation may be used to grade more precisely the risk of ulceration in elderly diabetic patients. Copyright © 2013 John Wiley & Sons.

Practical Diabetes 2013; 30(5): 186–188

Key words
diabetic peripheral neuropathy; vibration perception; ulceration; ageing

Introduction
To assess the risk of diabetic neuropathic ulceration, vibration perception threshold (VPT) of the feet – as an index of sensory loss – is often measured using the biothesiometer (BioMed, USA), a device that vibrates at 100Hz. The applied voltage is increased to the point that the patient can feel the vibration. A VPT of ≥50 volts is found in most diabetic neuropathic ulcer patients, although the true reading is not known as the machine is only calibrated to 50 volts.

In elderly people, the usefulness of the biothesiometer in detecting patients at risk of ulceration is limited by the fact that sensation decreases with ageing and many elderly diabetic patients with no history of ulceration also register a VPT of ≥50 volts.1,2 Conceptually, a high VPT in young people with diabetes is indicative of neuropathy,3 whereas in the elderly it is more likely to be due to an age-related loss of sensation. Nevertheless, as Dr Henry Kissinger once said: ‘Paranoids can have enemies too.’ In the context of this study, his observation can be translated to ‘Elderly diabetic patients can have neuropathy too.’ The clinical dilemma is therefore; ‘How do we identify elderly diabetic patients with neuropathy?’

Aims
The aim of this study is to determine whether, in the presence of poor vibration perception in the feet (i.e. VPT ≥50 volts), diabetic patients with a history of neuropathic ulceration can be differentiated from elderly diabetic patients with no history of ulceration by testing sensation at the more proximal locations of mid-tibia and knee.

Methods
The study setting was a diabetes centre in a public hospital in Sydney, Australia. At this centre, a detailed clinical database has been maintained for more than 20 years on attending patients. Information was extracted from this database to show the prevalence of reduced foot sensation with ageing and its relationship to foot ulceration.

For sensory testing, diabetic patients for this study were recruited...
from the diabetes centre. Non-diabetic controls were studied at a nursing home in northern New South Wales. All study participants signed an informed consent form and those with a VPT ≥50 volts were invited to take part.

The following groups of people were studied: (i) 20 diabetic patients with a history of neuropathic ulceration (N Ulcer-ve); (ii) 20 elderly diabetic patients with a VPT ≥50 volts and no history of neuropathic ulceration (E Ulcer-ve); and (iii) 11 elderly, non-diabetic controls (age >70 years) with a VPT ≥50 volts. VPT was measured twice at the great toe, mid-tibia and knee on both sides of the body, by one observer using the same machine.

**Ethical approval**

The study was approved by the Ethics Review Committee of the institution. Permission to approach nursing home residents was obtained from the director of the nursing centre.

**Data analysis**

Continuous data were checked for normality and presented as mean ± standard deviation. The ANOVA test was used to compare means, and the Bonferroni post-hoc test was used to adjust for multiple comparisons. Statistical significance was accepted at p<0.05.

**Results**

According to our database – which includes VPT readings on more than 11 000 diabetic patients – nearly 30% of individuals aged ≥70 years register a VPT ≥50 volts (Figure 1). Information obtained from the database showed that elderly diabetic patients with a high VPT did have a higher risk of ulceration when compared to those with normal sensation, albeit not as high as those who were young and had poor sensation (Table 1).

The clinical characteristics of diabetic and control participants, as well as their biothesiometer readings at different sites, are shown in Table 2. The VPT of the N Ulcer-ve group dropped significantly at the level of mid-tibia and knee, and was significantly different from the E Ulcer-ve group at both sites and from the

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**Figure 1.** Prevalence of biothesiometer reading of ≥50 volts

<table>
<thead>
<tr>
<th>Biothesiometer (volts)</th>
<th>Age (years)</th>
<th>No. of patients</th>
<th>Incidence of ulceration (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>All ages</td>
<td>3081</td>
<td>0.2</td>
</tr>
<tr>
<td>&gt;30</td>
<td>&gt;60</td>
<td>1227</td>
<td>0.3</td>
</tr>
<tr>
<td>≥50</td>
<td>&lt;60</td>
<td>55</td>
<td>5.7</td>
</tr>
<tr>
<td>≥50</td>
<td>&gt;60</td>
<td>250</td>
<td>1.9</td>
</tr>
</tbody>
</table>

**Table 1.** Annual incidence of ulceration – over a mean follow-up period of 3.8 years

<table>
<thead>
<tr>
<th>Variable</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N Ulcer-ve</td>
</tr>
<tr>
<td>No. of patients</td>
<td>20</td>
</tr>
<tr>
<td>Age (years)</td>
<td>59±12</td>
</tr>
<tr>
<td>Duration (years)</td>
<td>17.1±12.0</td>
</tr>
<tr>
<td>HbA1c (%)</td>
<td>9.0±2.3</td>
</tr>
<tr>
<td>Feet – VPT (volts)</td>
<td>≥50.0</td>
</tr>
<tr>
<td>Mid-tibia – VPT (volts)</td>
<td>39.7±10.0</td>
</tr>
<tr>
<td>Knee – VPT (volts)</td>
<td>37.2±10.4</td>
</tr>
</tbody>
</table>

N Ulcer-ve = diabetic patients with a history of neuropathic ulceration.
E Ulcer-ve = elderly diabetic patients with a vibration perception threshold (VPT) ≥50 volts and no history of neuropathic ulceration.
Elderly controls = elderly, non-diabetic controls with a VPT ≥50 volts.
*Different from N Ulcer-ve group; p<0.05.

**Table 2.** Clinical characteristics of the sample (means ± SD)
elderly controls at the knee (p<0.05). By contrast, the E Ulcer−ve group and the elderly controls tended to have poor vibration perception at all three sites.

Discussion

A loss of vibration sensation is common in the elderly, irrespective of the presence of diabetes. Without need of pre-selection according to any criteria, we were able to readily identify 11 elderly, non-diabetic individuals with a biothesiometer reading ≥50 volts who reside in a nursing home. This cohort represented 46% of the ambulant population tested. It could therefore be expected that the number of individuals with impaired sensation would also increase with age among the diabetic population.

Purely from a comparative frequency point of view, severe loss of vibration sensation in elderly diabetic patients is likely to be due to ageing rather than neuropathy. However, there would be a small number of patients with insensate diabetic neuropathy among them.

This has important implications in everyday clinical practice. As non-diabetic elderly individuals with sensory loss do not develop neuropathic ulceration of the type we normally encounter in diabetes, it is generally considered to be a benign condition. By contrast, the small percentage of elderly diabetic patients who have poor sensation due to significant neuropathy would not be immune from increased risk of foot ulceration.

This notion is supported by our data on the annual incidence of foot ulceration (Table 1) which shows that the risk of ulceration in elderly insensate diabetic patients (mainly due to age rather than neuropathy) is higher than those of similar age but with normal sensation, but lower than in younger insensate diabetic patients (who are likely to have true neuropathy). Therefore, the clinical conundrum of how to identify elderly diabetic patients with true insensate neuropathy (rather than age-related sensory changes) is an important one. The ability to do so will not only allow the individuals at risk of foot ulceration to be suitably educated in foot care and followed up, but will also avoid putting unnecessary burdens (such as regular podiatry care and special footwear) on the elderly individuals who are at much lower risk because their sensory loss is due to ageing.

The results of this study suggest that clinical decision making in this regard can be helped by asking the following question: ‘Is the sensation at the knee significantly better than the sensation in the foot?’ If the answer is ‘Yes’, it suggests diabetic neuropathy and therefore an increased propensity to neuropathic foot ulceration. If the answer is ‘No’, it is more likely to be simply due to ageing.

In this cohort of 40 diabetic patients, the chance of having an ulcer is 2.5-fold higher in those with a drop in biothesiometer >10 volts between the feet and the knee. However, a prospective follow up of a larger cohort, selected with no pre-test bias, is required to define more precisely the sensitivity and specificity of this test. The better vibration perception in the proximal limb positions of neuropathic ulcer patients reinforces the notion that diabetic neuropathy is a predominately distal disease. In contrast, ageing is associated with a more generalised loss of sensation. It remains to be determined if other modalities of sensation and testing with different equipment, such as a neurothesiometer, would produce a similar conclusion.

Some limitations of the current study should be mentioned. The N Ulcer−ve group is much younger than the E Ulcer−ve control group. A comparison of age-matched groups would be more definitive. However, there are relatively few elderly diabetic patients who develop neuropathic ulceration for the first time and who survive long enough to be recruited for a study. Only two of the 20 patients in our N Ulcer−ve cohort were older than the mean age of the diabetic E Ulcer−ve control group. The above factors would make recruitment much more difficult. Our data are also a retrospective analysis. To prove our hypothesis definitively, it would be necessary to examine a group of elderly diabetic patients with poor sensation in the feet, document their proximal sensation and then follow them up to see if a larger gradient is predictive of future ulceration. However, from our database, it is evident that the risk of ulceration in this patient group is relatively low. As such, a large number of patients and a long follow-up period would be required. The age and high mortality of these patients would make such a study a difficult proposition.

Despite these limitations, our observations suggest that testing of sensation distally and proximally to examine for a sensory gradient can facilitate more precise determination of foot ulceration risk in elderly diabetic patients with poor vibration perception in the feet. This would help better selection of patients for intensive foot care education.

Acknowledgment

The authors are indebted to the study participants who generously volunteered their time to take part in this study.

Declaration of interests

There are no conflicts of interest declared.

References


Key points

- A loss of sensation in the feet often occurs in healthy elderly individuals. Therefore, such loss of sensation in elderly diabetic patients is not always indicative of peripheral neuropathy
- Age-related sensory loss is generalised and involves more proximal parts of the lower limb, e.g. the knees. In neuropathy-related sensory loss the change is confined to the feet
- This distinguishing feature might be helpful in the diagnosis of diabetic peripheral neuropathy in elderly patients