Diabetic Polyneuropathy May Increase the Handicap Related to Vestibular Disease

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Background and Aims. We undertook this study to assess the influence of diabetic peripheral neuropathy on self-reported disability and postural control during quiet stance of patients with peripheral vestibular disease, before and after a standardized program of vestibular rehabilitation (Cawthorne & Cooksey exercises).

Methods. Twenty patients with peripheral vestibular disease participated in the study (mean age 56 ± 7.8 years), 10 with and 10 without peripheral neuropathy (age matched). The Dizziness Handicap Inventory and static posturography (eyes open/closed and firm/soft surface) were evaluated prior to rehabilitation and at week 7 of follow-up.

Results. Compared to patients without neuropathy, patients with neuropathy had more time elapsed since the diabetes was diagnosed, higher glycemia and HbAc level and higher composite scores on the Dizziness Handicap Inventory, but similar results on static posturography. After rehabilitation, although scores on the Dizziness Handicap Inventory decreased in the two groups, the difference between them persisted. In patients with neuropathy, static posturography showed improvement of postural control only with the eyes closed and soft surface, whereas in patients without neuropathy the postural control improved during all sensory conditions (eyes open/closed and firm/soft surface).

Conclusions. In diabetic patients with peripheral vestibular disease, peripheral neuropathy contributes to self-reported disability and may interfere with complete balance recovery. © 2009 IMSS. Published by Elsevier Inc.

Key Words: Diabetes mellitus, Peripheral neuropathy, Vestibular disease.

Introduction

Postural control is dependent upon integration of signals from the vestibular, visual and somatosensory systems to generate the motor responses that maintain upright position and adjust to destabilizing forces (1). Under altered sensory conditions, the central nervous system reweights each sensory input, enhancing the influence of those senses providing accurate information and suppressing the conflicting or inaccurate input (2). In general practice, the most frequent cause of balance disorders is vestibular disease.

During passive stance, regions of the feet that are more anterior receive the most mechanical pressure in supporting the body against gravity (3). This provides a mapping of body orientation to the upright. Although plantar sensation is of moderate importance for the maintenance of normal standing balance, the impact of reduced plantar sensitivity on postural control is expected to increase with the loss of additional sensory modalities such as the concomitant proprioceptive deficits commonly associated with peripheral neuropathies (4). Furthermore, in patients with peripheral polyneuropathy, evidence suggests that visual and vestibular inputs may not be sufficient to compensate for impaired somatosensation (5,6).

The most frequent known cause of peripheral neuropathy is diabetes mellitus; symptomatic degrees of polyneuropathy may occur in ~15% of patients with...
insulin-dependent diabetes mellitus and 13% of patients with non-insulin-dependent diabetes mellitus (7,8). Diabetic neuropathy is a long-term complication. The mean fasting blood or plasma glucose concentrations during long term follow-up are higher in patients in whom polyneuropathy develops than in those in whom polyneuropathy does not develop (9).

Compared with diabetic patients without neuropathy, diabetic patients with neuropathy report 15 times more injuries during gait (10). Evidence has shown that diabetic distal neuropathy is related to postural instability (11,12). Even with vision, postural mechanisms at ankle level are impaired during quiet stance (13), and the postural control deficit is greatest when visual or vestibular input is absent or degraded (11). In these studies, posturography has been useful to disclose failure of postural control related to diabetic neuropathy.

The increasing prevalence of diabetes mellitus entails that the co-occurrence of vestibular disease and diabetic peripheral neuropathy may increase. This study was designed to assess the influence of diabetic peripheral neuropathy on self-reported disability and postural control of patients with peripheral vestibular disease before and after a standardized program of vestibular rehabilitation (Cawthorne & Cooksey exercises).

Subjects and Methods

Participants

Twenty patients with peripheral vestibular disease and type 2 diabetes mellitus (T2DM) accepted to participate in the study as follows: Group 1—10 patients with T2DM without diabetic peripheral neuropathy, all women (mean age 54.9 ± 7.5 years old). The mean time elapsed since diabetes was diagnosed was 5.9 ± 3.4 years, and the evolution time of the balance symptoms was from 2 months to 3 years (median 3 months). Five patients had a history of medically controlled high blood pressure (50%). Group 2 was comprised of 10 patients with T2DM and diabetic peripheral neuropathy, seven women and three men (57.2 ± 8.3 years old). The mean time elapsed since diabetes was diagnosed was 13 ± 10.3 years, and the evolution time of the balance symptoms was from 2 months to 10 years (median 18 months). Three patients had a history of high blood pressure under medical control (30%).

All patients were selected at a neurotology outpatient clinic and were invited to participate when there was no clinical evidence of middle ear disease, musculoskeletal compromise, neurological disease other than diabetic neuropathy, rheumatic disease or a history of alcohol abuse. Patients with benign paroxysmal positional vertigo or Ménière’s disease were not included in the study. The study protocol was evaluated and approved by the local research committee, and informed consent was obtained from all the subjects prior to participation.

Procedures

Patients reported their balance symptoms using a standardized questionnaire (14), which includes the symptoms shown in Figure 1. Because symptom duration was long in the majority of patients, an accurate etiological diagnosis was not possible. None of the participants had spontaneous nystagmus either in the light or in darkness but had abnormal results on a 30°C and 44°C caloric test. In this study, unilateral hypofunction was defined as an asymmetry of ≥ 20% between right and left responses to 30°C and 44°C caloric stimuli, and bilateral hypofunction was defined as absent responses to both 30°C and 44°C caloric stimuli. Caloric test showed unilateral hypofunction in all but one patient without neuropathy who had bilateral hypofunction. Directional preponderance was not evident in any case.

After evaluation by a physician specialized in internal medicine who administered the Michigan diabetic neuropathy score (15), a blood sample was obtained to assess HbAc, glucose, cholesterol and triglycerides. Diabetic retinopathy was investigated by an ophthalmologist, and a physical medicine and rehabilitation physician performed nerve conduction studies using standardized techniques with temperature control and fixed distances. Nerve conduction velocity was evaluated on the median, ulnar, tibial, peroneal and sural nerves (Spirit, Nicolet, Madison, WI).

At day 1 (before starting the rehabilitation program) and at week 7 of follow-up, an evaluation was performed using the Dizziness Handicap Inventory (16) and static posturography (Posturolab 40/16, Medipacteurs, Cedex, France).

Cawthorne & Cooksey Rehabilitation Program

This program is based on a series of exercises of increasing complexity, which include movements of the head, tasks requiring coordination of the eyes with the head, total body movements and balance tasks (17,18). All patients were given written instructions with diagrams describing the exercises. After explaining the premise of the program, the level of complexity to start the program for each patient was evaluated. All patients were instructed to carry out the exercises for at least 10 min twice daily and to keep practicing the same group of exercises for as long as the vertigo persisted and progress to the next level whenever they were able to tolerate the exercises. Patients were also instructed to use a visual focal point whenever dizziness started. Each week the same physician evaluated treatment compliance by patient self-report.

None of the patients underwent any other type of treatment for their vestibular disorder while they participated in the study. All patients reported regular practice of the exercises, and all made progress on the exercise performance during follow-up.
Dizziness Handicap Inventory

Twenty five questions are subgrouped into three content domains representing functional, emotional, and physical aspects of dizziness and unsteadiness. A "yes" response is scored 4 points, "sometimes" is scored 2 points, and a "no" response is scored 0 points. Thus, the composite score ranges from 0 to 100, whereas lower scores are closer to normal (16).

Static Posturography

Body sway during 25.6 sec of quiet upright stance was recorded with a force platform (Medicapteurs). Subjects were asked to stand upright and barefoot on the platform with arms at their sides and remaining as still as possible. Recordings were made under the following conditions: standing with eyes open or closed on either a hard or a soft surface made with a layer of foam rubber (5-cm thick, density 2.5 pfc).

Statistical Analysis

Statistical analysis was performed after comparing data distribution with the normal distribution (Kolmogorov-Smirnov test). According to data distribution and scale of measurement the following tests were used: Wilcoxon test, Mann-Whitney U test, t-test for means, t-test for proportions and analysis of covariance (CSS Statsoft, Tulsa, OK); p values <0.05 were considered significant.

Results

Compared to patients without neuropathy, as expected, patients with neuropathy had more time elapsed since diabetes was diagnosed, higher glucose and HbA1c levels, longer evolution time of balance symptoms, and higher scores on the Michigan diabetic neuropathy score (p <0.05) (Table 1). Patients with neuropathy showed slower nerve conduction velocity for all nerves tested (upper and lower limbs) than patients without neuropathy (t-test, p < 0.01); sensory/motor polyneuropathy was identified in all but one patient who showed mainly a motor component. Additionally, diabetic retinopathy was identified in three patients with neuropathy and none of the patients without neuropathy.

Table 1. Clinical characteristics of 20 patients with type 2 diabetes mellitus (T2DM)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>No neuropathy</th>
<th>Neuropathy</th>
<th>p**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>30.6 ± 4.3</td>
<td>28.2 ± 4.8</td>
<td></td>
</tr>
<tr>
<td>Glucose (mg/dl)</td>
<td>138 ± 16</td>
<td>185 ± 52</td>
<td>0.01</td>
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<tr>
<td>HbA1c (%)</td>
<td>6.4 ± 0.4</td>
<td>7.9 ± 1.3</td>
<td>0.002</td>
</tr>
<tr>
<td>Cholesterol (mg/dl)</td>
<td>200 ± 38</td>
<td>225 ± 38</td>
<td></td>
</tr>
<tr>
<td>Triglycerides (mg/dl)</td>
<td>186 ± 76</td>
<td>224 ± 103</td>
<td></td>
</tr>
<tr>
<td>Michigan diabetic neuropathy</td>
<td>10.8 ± 6.8</td>
<td>24.1 ± 8</td>
<td>0.0005</td>
</tr>
<tr>
<td>score</td>
<td></td>
<td></td>
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SD, standard deviation; BMI, body mass index.
*Ten without and 10 with peripheral neuropathy.
**t-test.
Balance symptoms reported by each group are shown in Figure 1. Frequency and score of symptoms were similar for the two groups. Median score was 6 (Q1–Q3: 5–8.5) for patients without neuropathy versus median score of 7.5 (Q1–Q3: 7–8.75) for patients with neuropathy (Mann-Whitney U test, p > 0.05).

At the first evaluation, the Dizziness Handicap Inventory showed higher composite scores for patients with neuropathy than for those without it. Median score was 67 (Q1–Q3: 45–81) vs. median score of 37 (Q1–Q3: 18–49), respectively (Table 2) (Mann-Whitney U test, p < 0.01). At this time, static posturography showed similar results for the two groups on the length and area of oscillation and the Romberg coefficient during all conditions (Table 3) (Mann-Whitney U test, p > 0.05). Although the anterior/posterior and mediolateral position of the center of pressure of the two groups was also similar during recordings with eyes open on a hard surface, the variance of the anterior/posterior position of the center of pressure was less in patients without neuropathy than in those with neuropathy. Median values were 9.3 mm (Q1–Q3: 8.7–12.8) vs. 20.3 mm (Q1–Q3: 17.2–40.1) (Mann-Whitney U test, p > 0.02). Additionally, for all patients, covariance analysis including group, age, time elapsed since diabetes was diagnosed and evolution time of the balance symptoms showed that the duration of both diabetes and balance symptoms were consistently correlated with the length of oscillation either with the eyes open or closed during the hard surface conditions (adjusted whole model $R^2 = 0.5$, $p = 0.002$), whereas β values were positive for the time elapsed since diabetes was diagnosed but negative for the time of evolution of the balance symptoms. During the soft surface conditions, the length of oscillation was correlated just with the time elapsed since diabetes was diagnosed (adjusted whole model $R^2 = 0.33$, $p = 0.02$).

After 7 weeks, within each group the composite scores and the scores of the three content domains decreased (Wilcoxon test, $p \leq 0.01$) (Table 2); a decrease of the composite score of at least 18 points was observed in six patients from each group. However, the difference between groups on the Dizziness Handicap Inventory persisted. At this time, in patients with neuropathy static posturography showed a decrease of the area of oscillation only when the eyes were closed while standing on a soft surface (Table 3), whereas in patients without neuropathy posturography showed a decrease of the oscillation during the four sensory conditions (Table 3). Additionally, only in patients without neuropathy, a decrease of the Romberg coefficient during the soft surface conditions was observed. For the whole group, the correlation between the length of oscillation and the duration of both diabetes and balance symptoms was similar to the correlation observed at the first evaluation.

**Discussion**

Study results show that a combined deficit of vestibular and somatosensory input may preclude adjustments to postural control and increase the handicap during activities of daily life. Although the balance symptoms reported by each group were similar compared to patients without neuropathy, in vestibular patients with peripheral neuropathy the postural control improved less and the disability was always higher.

Though diabetes per se has no effect on postural stability (11), diabetic neuropathy may compromise postural control (11,12). Evidence has shown that diabetic neuropathy leads to a decrease in rapidly available ankle strength (19) and ankle movement perception (20), which are very important for anterior/posterior balance during side-by-side upright stance (21). The larger variance of the anterior/posterior position of the center of pressure observed on patients with neuropathy during recordings with the eyes open on a hard surface suggests the use of additional muscular activity in order to keep the center of pressure within the limits of stability. The positive correlation between the length of oscillation and the time elapsed since the diabetes was diagnosed can be explained by the fact that diabetic neuropathy is a long-term complication, whereas the negative correlation with the evolution time of balance symptoms may indicate that the patients learned to exploit anticipatory postural strategies.

Although at the beginning of the study static posturography showed similar results for the two groups, after vestibular

<table>
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<th>Domain</th>
<th>No neuropathy</th>
<th>Neuropathy</th>
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<tr>
<td></td>
<td>Median Q1–Q3</td>
<td>Median Q1–Q3</td>
</tr>
<tr>
<td></td>
<td>Day 1</td>
<td>Week 8</td>
</tr>
<tr>
<td>Physical</td>
<td>10 (4–16)</td>
<td>4 (4–10)</td>
</tr>
<tr>
<td>Emotional</td>
<td>6 (4–26)</td>
<td>6 (2–11)</td>
</tr>
<tr>
<td>Functional</td>
<td>8 (6–17)</td>
<td>4 (2–11)</td>
</tr>
<tr>
<td>Total score</td>
<td>38 (18–49)</td>
<td>14 (9–30)</td>
</tr>
</tbody>
</table>

*Ten without and 10 with peripheral neuropathy.

**Wilcoxon test.
rehabilitation patients with peripheral neuropathy showed improvement only when the eyes were closed and the surface was soft, when vestibular information would be more essential to use. This finding may be attributed to a better use of vestibular signals with no change in the combined use of somatosensory, visual and vestibular information. In contrast, patients who had adequate somatosensory information available showed an oscillation decrease during the four sensory conditions. Better use of the vestibular signals combined with an enhanced ability to interpret somatosensory and visual input may have improved their static postural control, either when the surface was hard or soft.

The results suggest that in patients with peripheral vestibular disease and diabetic peripheral neuropathy, a standardized program of vestibular rehabilitation may improve the vestibular dysfunction with no effect on the additional deficit related to peripheral neuropathy. Further studies are needed to design the best approach to rehabilitate balance in patients with combined vestibular and somatosensory deficits.

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References


