Assessment of the vestibular function in patients with multiple sclerosis

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ABSTRACT

Multiple sclerosis is a chronic inflammatory demyelinating disease of the central nervous system. The aim of this work was to study the prevalence of abnormalities of MS patients in both electroneystagmography (ENG) and computerized dynamic posturography (CDP) test results. Also to compare ENG test results with those of CDP in such patients. A total number of 60 subjects were examined. The present study revealed that MS patients had SNHL of mild degree in 80% of the cases affecting mainly the higher frequencies (2-8 KHz). Computerized Dynamic Posturography was abnormal for 70% of the examined MS patients compared to 52% abnormality in Electronystagmography test results. Decreased performance on all conditions of sensory organization tests, specifically 5 and 6 with abnormally prolonged latencies on MCT is the most characteristic pattern on platform posturography. Subtle abnormalities of eye movement most commonly sinusoidal tracking are the most useful vestibular findings for the detection of MS. It was recommended that ENG and CDP to be done routinely on the MS patients complaining of dizziness so that appropriate management and remediation can be achieved. (Egypt J. Neurol. Psychiat. Neurosurg., 2004, 41(1):151-159).

INTRODUCTION

Multiple sclerosis (MS) is a chronic debilitating disease characterized by multiple areas of focal demyelination that occur at different times throughout the white matter of the central nervous system1. The diagnosis of MS requires evidence of CNS lesions disseminated in time and place, as well as the exclusion of other likely causes of these lesions.

Abnormalities in balance system have long been recognized as causing some of the most common symptoms in MS. It was reported that ENG is well suited for detecting abnormalities in well established cases of MS but may miss earlier or more subtle cases, while CDP may detect less obvious cases of MS2. Little research has been done using the platform hand in hand with ENG to analyze the balance system in MS patients. Accordingly, this study was designed to study both ENG and CDP findings in MS patients.

MATERIALS AND METHODS

Subjects:
In this study, a total number of 60 subjects were examined. They had an age range of 16 – 63 years and were of both sexes. The subjects were divided into two groups:
1. **Control Group:**
This consisted of 10 normal subjects (6 males and 4 females having an age range of 30-60 with mean of 43.8±9.8). They were volunteers working at Johns Hopkins School of Medicine. They had no history of ear disease or neurological disorders.

2. **Study Group:**
This group consisted of 50 patients suffering from definite MS according to Poser criteria (21 males and 29 females having an age range of 23-70 with mean of 45.3±11.5). They were selected from The Neurology Outpatient Clinic at Johns Hopkins Hospital according to the following criteria:
- No history of clinically evident ophthalmoplegia or severely reduced visual acuity due to optic neuritis.
- No history of otologic diseases, exposure to ototoxic drugs or hazardous noise.

**Equipment:**
Computerized Electronystagmography: 2 channels, ICS medical chart version 5.70 and Computerized Dynamic Posturography: Neurocom (Equitest system).

**Methods:**
All subjects in this study were submitted to the following procedures: Full history taking, otological examination, bedside examination of the vestibular system, Electronystagmography and Computerized Dynamic Posturography.

### RESULTS

**Table 1.** Bedside examination of the vestibular examination.

<table>
<thead>
<tr>
<th>Test</th>
<th>Number of patients</th>
<th>Type of abnormality</th>
</tr>
</thead>
<tbody>
<tr>
<td>a- Vestibulospinal reflex test results:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Romberg test</td>
<td>28</td>
<td>Excessive sway</td>
</tr>
<tr>
<td>b- Vestibulo-ocular reflex test results:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head thrust test</td>
<td>20</td>
<td>Catchup saccades</td>
</tr>
<tr>
<td>c- Pathologic nystagmus test results:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>spontaneous nystagmus:</td>
<td>2</td>
<td>Downbeating nystagmus</td>
</tr>
<tr>
<td>Positional test:</td>
<td>2</td>
<td>Downbeating nystagmus</td>
</tr>
<tr>
<td>Dix Hallpike (right):</td>
<td>1</td>
<td>Vertical torsional nystagmus</td>
</tr>
<tr>
<td>Post headshaking test:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal nystagmus:</td>
<td>11</td>
<td>6 Leftbeating, 5 rightbeating</td>
</tr>
<tr>
<td>Preverted (vertical) nystagmus:</td>
<td>2</td>
<td>Downbeating nystagmus</td>
</tr>
<tr>
<td>Hyperventilation induced nystagmus:</td>
<td>4</td>
<td>Torsional nystagmus</td>
</tr>
</tbody>
</table>
Table 2. Number and percentage of patients with abnormal ENG test results.

<table>
<thead>
<tr>
<th>Type of abnormality</th>
<th>Number</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spontaneous nystagmus test:</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Saccade test:</td>
<td>(4), (5), (5)</td>
<td>(16), (20), (20)</td>
</tr>
<tr>
<td>Pursuit test:</td>
<td>16</td>
<td>64</td>
</tr>
<tr>
<td>OKN:</td>
<td>14</td>
<td>56</td>
</tr>
<tr>
<td>Positional and positioning tests:</td>
<td>(2), (1)</td>
<td>(8), (4)</td>
</tr>
<tr>
<td>Caloric test: (UW)</td>
<td>11</td>
<td>22</td>
</tr>
</tbody>
</table>

*There was more than one abnormality in most patients.

Table 3. Comparison of mean sensory organization tests of the MS and control subjects.

<table>
<thead>
<tr>
<th>Sensory condition</th>
<th>Study group Mean</th>
<th>Control group Mean</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S.D</td>
<td>S.D</td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>81.87</td>
<td>90.47</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>C2</td>
<td>65.08</td>
<td>88.66</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>C3</td>
<td>58.06</td>
<td>88.47</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>C4</td>
<td>54.24</td>
<td>83.16</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>C5</td>
<td>19.12</td>
<td>70.20</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>C6</td>
<td>12.01</td>
<td>61.74</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Composite</td>
<td>41.20</td>
<td>78.40</td>
<td>&lt;0.05*</td>
</tr>
</tbody>
</table>

C = sensory condition (1-6), P<0.05* = significant

There was statistically significant differences in the SOT between the study and the control groups in all sensory conditions.

Fig. (1): Scatterplot of Pearson’s correlation of the duration of illness vs. the composite equilibrium scores in MS patients.

There was a negative correlation between the duration of illness vs. composite scores. The mean composite scores decreased with increased duration of illness.
Fig. (2): Scatterplot of Spearman’s correlation of equilibrium scores vs. strategy scores in the control and MS groups.

The left scatterplot demonstrates that irrespective of the equilibrium score value, the subject uses both the hip and ankle strategy in maintaining balance. The right scatterplot demonstrates that the lower the equilibrium score value, the patients become abnormally dependent on ankle movements for maintaining balance.

Fig. (3): Comparison of the mean latency scores of the MS and the control subjects.

There were statistically significant differences in latency scores of backward and forward perturbations between the MS and the control subjects.
The bedside vestibular examination includes an evaluation of the static vestibular balance, dynamic vestibular function and the effects of provocative maneuvers. Static vestibular balance tests that showed abnormality were spontaneous nystagmus test and sharpened Romberg test. Spontaneous nystagmus was present in 2 patients with a downbeating axis of rotation. This abnormal axis of rotation is attributed to simultaneous stimulation of the same canals on both sides thus reflecting a central lesion. Abnormal test results in Romberg test was evident in 28 patients, this abnormality also reflects a static imbalance in the vertical canals.

The response of the VOR to low and high frequency head rotations provides a measure of dynamic vestibular function. An ideal VOR produces a rotation of the eyes in the orbits that compensates exactly for the head movement, maintaining the eyes fixed in space. At the bedside, the head thrust test was positive in 20 patients reflecting the dynamic imbalance in the vestibular system. Post head shaking nystagmus was positive in 13 MS patients. This test is another way of looking for an imbalance in the dynamic balance of the labyrinth and the integrity and symmetry of the velocity storage mechanism. Asymmetry of peripheral inputs during high velocity head rotations will generate more activity toward the intact side than toward the affected side according to Ewald’s second law. This asymmetry leads to an accumulation of activity within the central velocity storage mechanism during head shaking and the nystagmus following head shaking reflects the discharge of that activity. The cross coupled response (downbeat nystagmus after horizontal head shaking) that occurred in 2 of the 13 patients is sought to be the result of cerebellar disorders.

Hyperventilation may induce nystagmus in patients with a variety of vestibular lesions. In this study, it was present in 4 patients. The presumed mechanism involves the effect of hyperventilation on the physiology of partially demyelinated axons. CSF PH rises due to reduction of the arterial levels of carbon dioxide (CO2) leading to reduction of the extracellular ionized calcium. Axonal conduction improves transiently as a result of lowering of the extracellular calcium and thereby increasing the tonic discharge emanating from the peripheral labyrinth.

Multiple sclerosis can cause a myriad of abnormalities on electro-oculographic testing. Nevertheless, Vestibular and oculomotor findings in MS patients disappear rapidly as the acute effects of the plaque resolve. In this study, 50% (25/50) of the patients had normal ENG test results. Of the remaining 50% of patients, 16 (64%) of them had central ENG findings, 6 (24%) patients showed unilateral peripheral lesions and only three (12%) patients had both abnormalities.

Spontaneous nystagmus was positive in 2 MS patients under Frenzel’s lenses showing a downbeat nystagmus in the primary gaze position. The commonest saccadic abnormality is internuclear ophthalmoplegia (INO) which unfortunately was not detected due to the recording limitations (inability to record each eye separately). Thus detection of this abnormality which is strongly suggestive of MS was not incorporated in this study. Other abnormalities in saccade testing included prolonged latency, inaccuracy, and decreased velocity in 4/25 (16%), 5/25 (20%) and 5/25 (20%) respectively.

Other investigators reported that 40% of the 61 patients had such abnormalities. Similar results were also shown in other studies. Such abnormalities in saccadic eye
movements as prolonged latency and decreased peak velocity are believed to be indicative of brainstem or cerebellar lesions. Smooth pursuit was symmetrically abnormal in the form of reduced gain in 16/25 (64%) of patients, and this was by far the commonest central finding in this study group. Four of them had abnormal pursuit pattern in the form of saccadic pursuit. Abnormalities in smooth pursuit are believed to be due to cerebellar lesions. OKN abnormality was lower than that of the pursuit test 14/25 (56%). This was not surprising, since OKN test is less sensitive than smooth pursuit test, presumably because OKN is the sum of the two tracking mechanisms, namely, the smooth pursuit system and the saccadic system.

Only two of the patients 2/25 (8%) demonstrated positional nystagmus that was downbeat in nature in the supine position. It sought to be an exacerbation of the existing spontaneous nystagmus in those patients. One patient (4%) showed positioning nystagmus during right Dix Hallpike test. This was a typical case of right posterior canal BPPV that coincided with multiple sclerosis in that patient.

Forty four percent of our (11/25) patients showed abnormalities on caloric testing. None of them demonstrated abnormalities in fixation suppression. These findings were similar to other studies. He explained these findings by the vicinity of the vestibular nuclei to the fourth ventricle, as plaques are common in periventricular areas. MRI has confirmed this impression by showing frequent and sometimes extensive lesions in the floor of the fourth ventricle in patients with vestibular complaints.

Balance disturbances represent an early and frequent problem in MS and are among the most disabling symptoms in patients able to walk. The non uniform involvement of vestibular, visual and somatosensory systems in the pathogenesis of multiple sclerosis creates a challenge for developing an objective assessment of vestibular impairment. CDP is the only method available to the clinician that can estimate the relative contribution of the three sensory inputs and neuromuscular systems to postural and balance control in a given individual.

In the present study, 30% (15/50) had normal posturography patterns (SOT and MCT). Of the 70% who had abnormal posturography patterns (35/50), six patients (17%) had abnormal SOT with normal MCT. Combined abnormality of both SOT and MCT in 63% (22/35). Normal SOT with abnormal MCT was found in 20% (7/35). The abnormal SOT results were further subdivided into 14 patients showing a broad sensory integration deficits, 14 had a vestibular dysfunction pattern, 7 showed a predominantly somatosensory or visual vestibular dysfunction pattern. The total portion of the study group with distinct type of vestibular impairment, therefore, was 28%. This was in agreement with other researchers.

The SOT is the expansion of the Romberg test and is considered the only method available that can estimate the relative contribution of the three sensory inputs and neuromuscular systems to postural and balance control in a given individual. The MS patient showed lower equilibrium scores (ES) compared to the control group and was statistically significant across all of the SOT conditions. The largest increase in sway (lowest ES) with respect to the mean normal value was in conditions 5 and 6. This was supported by previous studies.
Clinical research trials has shown that this multisensory pattern usually occur as a result of demyelination of the vestibulospinal tracts either unilaterally or bilaterally at different times during the development of the disease. These tracts carry fibers from the vestibular nuclei to the muscles that are responsible for posture control. Thalamic projections that are believed to be the conscious sensation of balance are sought to be affected also in the disease process. Another added explanation is the inability of the cerebellum to integrate multiple sensory inputs.

Correlation between the duration of illness and the composite score revealed that the mean composite score decreased with increased duration of the disease. This was expected and could be explained by the nature of the disease (dissemination in time and space) as most patients had a relapsing remitting course with general deterioration over time.

Information about the patient’s ability to react to unexpected perturbations in their center of mass position is obtained with the motor control protocol. This study is used less as a functional evaluation than the SOT, and more to evaluate the long loop pathway that begins with inputs from the ankle region then projects to the motor cortex and back to the various muscles of postural control. The short backward and forward displacement latencies were not included in this study because it was reported in the clinical literature that the short segmental reflex arc (40-45 msec.) have little if any effect on balance and should be done only as training trials prior to the medium and long latency ones.

The latency scores in the MCT were significantly longer in backward and forward displacements. Interesting enough, 9 patients showed a bilateral bidirectional abnormality that indicates a global CNS lesion, 7 showed bilateral unidirectional abnormality that points to an efferent CNS lesion of the long loop system and 3 showed a unilateral prolongation that indicates a local CNS lesion (Zee, personal communication, 2002).

A high correlation between latency studies and CNS lesions implicate pathology in medium and long loop latency automatic response pathways. These pathways are believed to be triggered by muscle proprioceptive inputs, and modulated through brainstem and subcortical pathways. In patients with MS, these arcs may be disrupted by plaques in the cerebral hemispheres, the brainstem or the spinal cord.

**Sensitivity of ENG AND CDP in diagnosing MS:**

In the present study, comparison between ENG and CDP testing of 50 MS patients revealed the following conditions:

I- Abnormal CDP with normal ENG: Computerized dynamic posturography demonstrated abnormalities of the balance system in many of the patients who had normal ENG (24%). This is in agreement with other studies. This could be explained by the difference of the evaluated neural circuit (VOR or VSR). It also may be due to the difference in the stimulated semicircular canal (the lateral semicircular canal is tested mainly in the ENG, while the vertical canals are included in CDP as a result of pitch rotation produced by the footplate.

II- Abnormality in both CDP and ENG: Twenty five out of fifty patients (50%) had abnormality in both CDP and ENG.

III- Normal CDP and normal ENG: This occurred in thirteen out of fifty MS patients (26%).
From the above, it was concluded that CDP was abnormal for (74%) of the examined MS patients compared to (50%) abnormality in ENG test results. This is agreement with other studies\(^8\), who reported 83% abnormality in CDP results compared to 42% abnormal ENG results. Another study\(^9\) to describe the sensitivity and specificity of CDP and ENG for detecting vestibular abnormalities, and stated that the level of sensitivity of each of these tests was considered to be low. He also concluded that combining posturography with other tests of vestibular function increased the overall sensitivity for detecting vestibular lesions.

This study indicated that CDP has merit when used in the evaluation of patients with undifferentiated balance complaints. Moreover, CDP testing was less time consuming (10 minutes) as compared to ENG testing (45 minutes). Although CDP was less annoying to the patient than ENG, ENG is still needed in cases of vestibular dysfunction to establish anatomical level and laterality of lesions\(^20\).

### REFERENCES


الملخص العربي

تقييم وظائف التوازن في مرضى التصلب المتانئر

يعتبر مرض التصلب المتانئر التهاب مزمن يصاحب إزالة لغشاء الميلين في الجهاز العصبي المركزى. وتهدف الدراسة إلى إظهار التغيرات المصاحبى لمريض التصلب المتانئر في جهاز قياس الجهد الحركي للعين وجهاز التوازن الدينياميكى وكذلك لمقارنة نتائج الجهازين معاً.

وقد تم تقييم ستين مريضاً منهم 52% قد ظهرت تغيرات في قياس الجهد الحركي للعين و 70% في جهاز التوازن الدينياميكى.

وقد أوضحت الدراسة أن الشكل المميز في مرض التصلب المتانئر هو نقص كفاءة اختبارات التنسيق الحسى في جهاز التوازن الدينياميكى.

ولذلك ننصب على القيام بالاختبارات في مرضى التصلب المتانئر المصابين بثاثان من أجل الوصول إلى العلاج الامل لهذه الحالات.