Calculation of the Circularvection Times in a Population With Vestibular Pathology: Influence of Visual Stimulus

Julio Rama-López,a Francisco Guillén-Grima,b and Nicolás Pérez a

a Departamento de ORL, Clínica Universitaria de Navarra, Pamplona, Navarra, Spain
b Unidad de Medicina Preventiva, Clínica Universitaria de Navarra, Pamplona, Navarra, Spain

Objective: To describe the results obtained for circularvection times (tCV) in a study of the phenomenon of visual-vestibular interaction for a population with vestibular pathology and to analyze differences in its calculation among patients reporting a worsening of their symptoms with visual stimuli.

Material and methods: A detailed case history was taken for all patients, followed by a sensory organization test using computerized dynamic posturography and the calculation of their tCV.

Results: The mean tCV results were: tCV2 = 6.32 ± 3.17 s; tCV3 = 6.57 ± 3.68 s; tCVr = 6.27 ± 6.02 s. Significant differences were obtained in tCV2 (P = .046) and tCVr (P = .023).

Conclusions: tCV is a diagnostic test using simple tools that can help differentiate patients in whom the visual stimulus is influenced.

Key words: Circularvection times. Visual vertigo. Posturography.

INTRODUCTION

The combination of visual and vestibular signals to maintain balance is known as visuovestibular interaction. This is a specific aspect of a complex phenomenon of sensorial integration that occurs at multiple levels.

The relation between subjects and their surroundings may change in many different ways: the object may move with respect to the subject, or vice versa or both may be moving simultaneously. The visual and vestibular information must act synergically to keep the gaze stable in all these situations, although when there is a conflict, visual information dominates.1 In short, we can say that an efficient and normal vestibulo-oculomotor reflex (VOR) contributes to maintaining correct visual function and, at the same time, sight optimizes the function of the VOR. However, VOR is not enough to ensure satisfactory and accurate vision; we must take into account other elements and systems (ocular tracking, optokinetic nystagmus, movement prediction and planning, cervico-oculomotor reflexes) that are capable of improving
the VOR’s operation, together making up the so-called visuo-
vestibulo-ocular reflex (VVOR). 2

The phenomenon of visuo-vestibular interaction has been studied and widely described in many studies, and its expression in the brain has currently been shown thanks to new imaging tests such as positron emission tomography (PET) and functional magnetic resonance. It implies the correct operation of many structures at both the peripheral and central levels and allows an adequate response by the body to different stimuli affecting it and requiring changes of posture. Its “action and flexibility” is of fundamental importance in the performance of the activities of daily life.

According to Jeka et al, 3 the information obtained from the speed of the perceived stimulus is the most important variable for maintaining stable posture at rest and the information from the visual system is therefore a key element. Once movement begins, the vestibular information detecting acceleration has to interact correctly with the visual system. This interaction between both systems is fundamental for correct balance and, if it is absent, it is impossible to maintain this necessary functional interaction is maintained in patients when the vestibular function is insufficient, thus demonstrating the plasticity of the phenomenon of maximum visuo-vestibular interaction. In these pathological situations, this phenomenon continues to adapt to the information received. There is an increase in the thresholds for response to stimuli in movement, thus avoiding oscillopsia, 12 or a lower degree of activation or deactivation depending on the need for postural control. 13

The goal of this study is to describe the results obtained in a wide population of patients with vestibular involvement in the performance of a test studying the phenomenon of visuo-vestibular interaction, namely circular vection times (CVt), and to analyze the possible existence of differences in their calculation in patients reporting a worsening of their symptoms due to visual stimuli.

MATERIAL AND METHOD

The present study was performed on a sample of 200 consecutive patients seen at the ORL department for presenting some type of peripheral vestibular disease manifested by vertigo, dizziness or instability.

The diagnoses for this series of patients are shown in Table I. A detailed history was taken from all of the patients including a specific reference to the possible influence of visual stimuli on their clinical condition, a sensorial organization test (SOT) using computerized dynamic posturography (CDP) with the Smart Equitest System version 7.0 (Neurocom International, Inc., Clackamas, Oregon, United States) and calculation of the CVt.

The CVt is determined by the different movement sensations experienced by a subject when subjected to a visual stimulus in movement. Subjects looking at a moving object may have a perception of remaining still in space (egocentric perception of movement) or they may feel that the surroundings are stable while they are moving (rotating or circular vection). A uniform movement completely covering all of the visual field generates a sensation that the subjects themselves are moving, and this sensation is indistinguishable from true movement. Once the stimulus starts, rotating vection begins with a latency of a few seconds, slowly increases in apparent velocity up to saturation point, may last for longer than the visual stimulus and depends on the density of randomly distributed movement contrasts within the field of vision and its total area. 14

For the assessment of and measurement of these variables, patients were placed inside an acoustically insulated room in which, in darkness, they were stimulated by an optokinetic projection (OKN) in clockwise or anti-clockwise direction capable of covering the entire field of vision. Patients kept their gaze fixed to the front attempting not to follow the lines. In this way it is possible to measure 4 different stages of circular vection depending on the sequential perception of movement (Figure 1).

- Circular vection time 1 (CVt1): fraction of time in which the patient, after having been subjected to optokinetic visual stimulation, begins to perceive exocentric movement (perception of movement only of the surroundings).

Since this is a sensation that is triggered almost instantly and is therefore difficult to measure, it was not included in subsequent analyses.

- Circular vection time 2 (CVt2): fraction of time after which the perception of exocentric and egocentric movement begins (perception of self-movement), this is the patients’ sensation that they are moving in the opposite direction from that of the optokinetic stimulation.

<table>
<thead>
<tr>
<th>Table I. Clinical diagnoses of the study population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Diagnosis</td>
</tr>
<tr>
<td>--------------------------------</td>
</tr>
<tr>
<td>Menière’s disease</td>
</tr>
<tr>
<td>Positional vertigo</td>
</tr>
<tr>
<td>Instability</td>
</tr>
<tr>
<td>Spontaneous recurrent vertigo</td>
</tr>
<tr>
<td>Vestibular schwannoma</td>
</tr>
<tr>
<td>Paroxysmal headache</td>
</tr>
<tr>
<td>Post-traumatic vertigo</td>
</tr>
<tr>
<td>Otosclerosis</td>
</tr>
<tr>
<td>Vestibular neuritis</td>
</tr>
<tr>
<td>Ototoxicity</td>
</tr>
</tbody>
</table>

Acta Otorrinolaringol Esp. 2007;58(2):56-60
– Circular vection time 3 (CVt3): fraction of time when the subjects report only a perception of egocentric movement or, in other words, that they are moving but not the visual stimulus. The sensation of movement is in the opposite direction from that of the optokinetic stimulation (OKN).
– Residual circular vection time (rCVt): fraction of time when the subjects continue to have a perception of self-movement (egocentric) after withdrawal of the visual stimulus. To calculate rCVt, the lights were switched off 20 seconds after CVt3 and the duration of the perception of self-movement was measured.

The entire experiment was conducted 3 times to calculate the mean value.

Creation of Groups
Two groups of patients were created depending on the influence of various visual stimuli on their clinical condition. Thus, patients were placed in the groups “VIS+” and “VIS–.”

The patients included in the VIS+ group complied with at least one of the following criteria, allowing detection of an influence of the visual stimulus: a) influence of the visual information on the patients’ symptoms by acting as a trigger or aggravant; b) visual preference pattern in PDC,15 and c) sole or combined visual deficit in the performance of the SOT in PDC.16

The rest of the patients, who did not comply with any of the three criteria, were included in the VIS– group.

Statistical Analysis
This was conducted using the SPSS statistical programme (version 11.5) and we then proceeded to conduct a descriptive study of the population’s CVt and a comparative analysis of the 2 groups created using Student’s t test. In addition, the rCVt’s sensitivity and specificity were studied using ROC curves in order to obtain a cut-off to allow patients to be classified by the influence of the visual stimulus on their clinical condition. An unconstrained, asymptotic, population age-, and gender-adjusted multivariable logarithmic regression analysis was also performed.

RESULTS
The mean values for the study population were: CVt2=6.32±3.17 s; CVt3=6.57±3.68 s; rCVt=6.27±6.02 s.

In the comparative analysis of the groups, statistically significant differences were obtained when the results of the CVt2 (P=.046) and rCVt (P=.023) were analyzed, as these were longer than those in the VIS– group. The differences were not significant on analysis of the CVt3 (Figure 2).

In the ROC curve analysis (Figure 3) of the sensitivity and specificity for rCVt, the area under the curve was 0.4121. By establishing the cut-off point at 7 seconds, the rCVt presents a sensitivity of 49% and a specificity of 90%.

Table II shows the result of the unconstrained, asymptotic, multivariable logarithmic regression analysis of the population analyzing the variable rCVt adjusted by gender. It can be seen that the adjusted rCVt variable presents an OR of 0.914 (P=.027). Thus, for each second of reduction in the rCVt, the possibility of being VIS+ increases by approximately 8%. The multivariable model obtained is not modified by the introduction of the rest of the CVt.

DISCUSSION
The methodology used for this study was an innovation in terms of the logistics, but its physiological bases have been widely described for some time. All of the authors who have studied the phenomenon of circular vection agree that there is an evident visuovestibular interaction in which the visual stimulus provokes a series of postural variations.
through a complex interaction with the vestibular system,\textsuperscript{17} which is really in charge of detecting accelerations. More recent papers have highlighted the important role of the cerebral cortex for interpreting this complex illusion of movement.\textsuperscript{18,19}

We must point out that this is a methodology that, despite requiring special attention and dedication from the personnel performing the vestibular tests, is perfectly capable of being added to those currently performed in a laboratory to study patients with balance disorders.

The times measured in our population, as they are patients with vestibular involvement, are longer than those found in a normal population such as that described by Brandt et al.\textsuperscript{14} This is due to the fact that the interaction of the signals received at the vestibular nuclei is defective because of the vestibular damage sustained by our study population.

The times in the VIS+ group differ significantly from those in the VIS– group. This indicates that this methodology is effective in the identification of subjects with a visual dependency phenomenon, an aspect manifested in the analysis of the test using an ROC curve. This analysis shows that the CVt that differ significantly from the remainder of the patients present a high degree of specificity for the detection of the influence of a visual stimulus. This has also been shown in the multivariable analysis detecting (after an appropriate gender adjustment) that the variations in rCVt represent an evident risk of visual dependency.

The analysis of the CVt absolute values also provides us with other interesting findings supporting the theory of the phenomenon of visual dependency\textsuperscript{20} as a compensating strategy. As has already been mentioned, the vestibular deficit, due to the presence of a dysfunction, entails higher times reflecting the defective system. According to this, patients experiencing a visual dependency phenomenon should objectively have even higher CVt. However this is not the case as shown by our results. Quite the contrary, what we have seen is that the CVt in VIS+ patients are significantly shorter than in the VIS– group. This description of “visual dependency” as a compensating phenomenon derived from the vection study coincides with the considerations made by Thurrel and Kuno. Thus, the phenomenon of circular vection, that is to say, the perception of self-movement generated by a visual stimulus, induces greater corporal oscillations than the perception of movement in objects. In this way, VIS+ subjects, as they have a greater sensorial prevalence due to the greater visual stimulus that those in the VIS– group, will start with the sensation of vection sooner and so have greater corporal oscillations. Here the compensating strategy favours the cessation of this sensation and the reduction of the oscillations. This is shown in their logically shorter time values. For this reason, CVt (determined when the subjects detect movement in the visual environment and cease to perceive their own movement) is not significantly different and is even greater in the VIS+ group.

This complex process cannot be explained other than from the standpoint of a series of compensation mechanisms that are well known to take place in the central nervous system, the only element capable of inter-relating sensations, deficit and the need for compensating mechanisms.\textsuperscript{21}

From the results of this study we can conclude that the calculation of CVt is a diagnostic test that can be performed in a vestibular test laboratory using simple instruments and...
allows differentiation of patients in whom visual stimuli influence clinical condition, thus constraining future therapeutic decisions.

REFERENCES