Electrooculography. Its value in the diagnosis of the patient with a balance disorder

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Abstract: Introduction: Controversy persists on the value of electrooculography (EOG) in the diagnosis of the unbalanced patient. The aim of this study has been to know the utility of EOG in the diagnosis of patients with equilibrium disorders. Material and methods: We have examined 1000 patients in whom EOG test has been performed for unbalance symptoms. Results have been classified in peripheric or central pattern. Those patients included in the central pattern group have been compared with the results of imaging techniques. Results: 45.7% of EOG performed showed pathological signs, 29.2% were of peripheral characteristics and 16.5% of central ones, of whom 6% showed different pathologies in the imaging test. Discussions and conclusions: EOG in now a days of high value in the diagnosis of unbalanced patient, specially in those cases in which other clinical explorations were normal.

Key words: Central vertigo. Peripheral vertigo. Vestibular explorations.

INTRODUCTION

Electrooculography (EOG) or electronystagmography (ENG) is the most extensive test for the study of the functioning of the vestibular system. Even though this technique is currently being substituted by video oculography, the results with regard to registers and figures are similar with either test.

The EOG comprises a set of tests which can be categorized into three groups according to Baloh’s classification system (Table 1). The usefulness of these vestibular tests in the study of patients suffering from vertigo has been indicated in the literature by different authors who base their conclusions on the benefits they can offer us. Amongst other positive properties is the fact that they are non-invasive tests which can offer us an objective sign of the balance disorder, as well as its topographical orientation and the quantification of the deficiency. They also allow us to carry out patient follow-up, to compare and group similar cases, and they are necessary when carrying out scientific studies. From the point of view of the clinical exploration, they detect non-identifiable nystagmus in the non-instrumental exploration and, without a doubt, they have a great capacity for distinguishing between central and peripheral vertigo.

On the other hand, a number of problems have been attributed to these tests: they must be carried out in a technically correct way; it is time-consuming to carry them out and to interpret the traces; their results are non-specific as they do not identify specific etiologies; they can not offer a diagnosis independently of other tests, and their findings must be interpreted together with the totality of clinical data. Furthermore, diagnostic imaging tests offer significant specificity when they are positive in this type of pathology. However, there is a high percentage of patients with balance disorders whose results are negative in imaging tests.

However, it has been recognized that, despite technological advances, the diagnosis of patients with balance disorders is principally based on the study of the patient’s medical history and on the clinical exploration. In the opinion of some authors, when the clinical exploration clearly reveals the identity of the vertigo suffered by the patient the contribution to the diagnosis offered by the EOG is slight and its use is probably unnecessary in these cases.

Nevertheless, the vestibular exploration is a suitable test for the study of patients with vertigo. From the arguments presented so far it can be deduced that the question as to whether or not EOG is useful and worthwhile for the diagnosis of patients with vertigo is still valid. The principal objective of this paper is then to determine the usefulness of the EOG test for the diagnosis and differential diagnosis of balance disorders, and also to
try to determine the concrete indications for its use or those in which the test may offer a greater contribution.

**MATERIAL AND METHODS**

We carried out a retrospective study including 1,000 patients with vertigo or balance loss on whom an EOG had been performed in order to study a balance disorder. The age range of the patients was between 7 and 86 (average age: 45.9). The explorations were carried out with a computerized electronystagmography system (Nicolet Nistarplus ®), which comprises 2 channels for the register of horizontal and vertical ocular movements respectively. The apparatus also included a SR-20® rotary chair for the rotatory tests. The calorimeter used for the bithermal caloric test was a Kent Clearaway® water calorimeter; one was used for cold water (30º) and another for hot water (44º).

**Measurement tests and parameters used**

- Ocular saccades: the test was carried out with random saccades. The patient was told to follow with their eyes, without moving their head, a series of points in the visual field projected onto a luminous bar in front of them. The duration of the test was 20 seconds, 14 stimuli were presented to the right and 14 to the left. The saccades were considered to be normal when latency was less than 250 ms and precision was greater than 70%.

- Slow ocular following: in this test the patient follows with their eyes, without moving their head, the sinusoidal movement of a luminous point. First the test is carried out at a maximum velocity of 40º/s. In cases in which the patients did not follow correctly the first time the test was repeated. If on repetition their following was still incorrect, the velocity of the stimulus was changed to 20º/s. Those followings whose gain was greater than 0.65 were considered to be normal. Qualitative abnormalities of the following were classified according to Corbera’s classic patterns.

- Optokinetic nystagmus (ON): a system of lines of lights projected at a constant velocity of 40 º/s was used for this test. The patient was told to look at the central lines and not to follow them with their gaze, with the objective of obtaining a true optokinetic reflex. The existence of asymmetry was decided by the formula for the average velocity of the slow phase of optokinetic nystagmus: \[ \text{OFI} = \frac{\text{NI}-\text{ND}}{\text{ND}+\text{NI}} \times 100, \] when the difference was greater than 15%.

- Spontaneous nystagmus (SN) and gaze-evoked nystagmus (GEN): Those nystagmuses whose angular velocity of the slow phase was greater than 6 º/s were registered.

- Position change nystagmus: Dix-Hallpike maneuvers were carried out to detect the presence of benign positional paroxystic vertigo (BPPV) of the posterior canal. The results were classified according to Coats’ criteria: complete classic response, incomplete classic response, and non-classic response. The McClure maneuver or rotational maneuver was carried out to detect the presence of positional vertigo of the horizontal canal.

- Position nystagmus: The supine decubitus, right lateral decubitus and left lateral decubitus positions were used. The patient remained in each position for 20 seconds. The tests were carried out without fixation. The nystagmus were classified as direction-fixed nystagmus or direction-changing nystagmus (geotropic or ageotropic). The nystagmuses were considered to be characteristic of centrality when they were not accompanied by vertigo, latency, exhaustion or fatigue.

- Caloric Tests: the bithermal caloric test was carried out with 4 stimulations. Each ear was stimulated with water, first at 44º and subsequently at 30º, using 125 ml for 20 seconds in each irrigation and allowing 5 minutes to pass between each one. After 120 seconds the patient was told to fix their gaze to test the suppression of the nystagmus. It was considered that there was failure of fixation suppression (FFS) when the ocular fixation index (OFI) was greater than 0.50. \[ \text{OFI} = \frac{\text{VFLmx fix}}{\text{VFLmx}} \] (normal OFI <0.50). The responses were classified as: canal paresis or hypovagolocy: difference of interlaberynthine excitability measured in Jongkees’ formula for the maximum angular velocity of the slow phase greater than 22%. Unilateral areflexia: tested with ice water. Bilateral hyporeflexia (sum of the velocities in the four irrigations lower than 20º/s). Directional Preponderance: difference between right and left responses greater than 28%.

- Rotatory Test: the pendular rotatory test was used, with a maximum velocity of 120º/s in a total of 8 alternate turns to the right and left. Asymmetry was considered to exist when the difference between right and left nystagmic responses was greater than 20%. The test was then carried out with fixation. The patient was told to...
look at a point drawn on a piece of paper that they themselves held while the rotations lasted.
Once the tests had been reviewed, a topographical classification of the results was made for each of the patients: results of peripheral, central or mixed characteristics.
A. We considered the following results to be of peripheral characteristics:
   A. 1. Abnormal ocular movements: peripheral type SN, positive in the Dix-Hallpike or McClure maneuver, position nystagmus of peripheral characteristics.
   A. 2. Vestibulo-ocular tests: canal paresis or areflexia in the caloric test and asymmetry in the rotatory test.
   B. Results of central characteristics:
   B. 1. Disturbance of visual-oculomotor tests: saccades, slow ocular following, optokinetic nystagmus.
   B. 2. Abnormal ocular movements: central type SN, presence of GEN, position nystagmus with central characteristics.
   B. 3. Vestibulo-ocular tests: FFS in the caloric or the rotatory test and hyperreflexia vestibular in the caloric test.
   C. Patients with results showing both peripheral and central characteristics were considered to have mixed characteristics.
In those patients in whom the EOG test obtained a result of central or mixed characteristics it was verified if in the imaging technique used (in our series these were computed tomography or magnetic resonance) there were any findings or if on the other hand this test was negative.

**RESULTS**

457 patients of the total of the series that is to say 457/1000 (45.7%) had an abnormal EOG.
The distribution of patients with an abnormal EOG according to the characteristics shown in the results was:
- Patients with peripheral characteristics: 292/1000 (29.2%)
  - Patients with mixed characteristics: 89/1000 (8.9%)
  - Patients with central characteristics: 76/1000 (7.6%)
Results according to the type of abnormality by order of frequency:
1. Abnormality of caloric tests: 338/1000 (33.8%):
   - Canal paresis: 310/1000 (31%)
   - Unilateral areflexia: 20/1000 (2%)
   - Bilateral hypoxectitability: 3/1000 (0.3%)
   - Unilateral hyperexcitability: 3/1000 (0.3%)
2. Positional Nystagmus: 153/1000 (15.3%)
3. Position nystagmus: 137/1000 (13.7%)
4. Abnormality of slow following: 61/1000 (6.1%)
5. Abnormality of the saccades: 58/1000 (5.8%)
6. Abnormality of the rotatory test: 36/1000 (3.6%)
7. FFS: 29/1000 (2.9%)
8. SN: 13/1000 (1.3%)

9. Abnormality of ON: 13/1000 (1.3%)
10. GEN: 7/1000 (0.7%)
165 patients exhibited central characteristics (89 with mixed characteristics and 76 with central characteristics). Of these cases, only in 10 did the imaging technique show any pathological finding (6.6%).
The correlation between EOG and pathological findings in the imaging test of these patients was the following:
- 1 case of pendular ataxia and bilateral vestibular areflexia. The image showed cerebellar atrophy
- 4 cases showed positional nystagmus with central characteristics. The findings of the imaging technique were: two cases of cerebellar degeneration, primitive cerebellar tumor, and cerebellar metastasis from a mammary gland neoplasia.
- 1 case of bilateral labyrinthine hypoxectitability with degenerative disease of the CNS in the imaging technique.
- 2 cases of a saccadic disorder as a consequence of cranoencephalic traumatisms.
- 1 case of a saccadic disorder and FFS in the rotatory test with degenerative disease of the CNS in the imaging technique.
- 1 case with incomplete classic Dix-Hallpike maneuver was of a multi-infarct dementia in the imaging test.

**DISCUSSION**

In the series presented, the EOG was abnormal in 45.7% of the patients. In other series of similar characteristics that were consulted the percentages of abnormal EOG vary considerably. They range from 75% in Baker’s series of 261 patients to 26.2% in Lipp’s series of 375 patients. This variability is due to a great extent to the moment in which the vestibular exploration was performed. If it is carried out the moment in which the patient suffers from vertigo, the percentage of abnormal EOGs will be greater than if some time has passed between the onset of the disorder and the performance of the test.

In our study the results obtained from the EOG were principally of peripheral characteristics which appeared in 29.2% of cases compared with the results of central characteristics at 7.6% or mixed at 8.9%. These results corresponded with those of other series in which the finding of peripheral characteristics was also more frequent. As we have already stated, the time that passes between the onset of vertigo and the performance of the test is a determining factor that would explain the low proportion of peripheral findings obtained in our series, compared with that of other series in which it is at around 45%. It would also explain the fact that the central and mixed findings, which are types of vertigo that
typically last longer, are found with the same frequency as in other series.

On comparing the results of the EOG and the imaging test it was observed that in the latter, significant findings were only detected in 6% of the cases that had presented a central disturbance in the vestibular test. A diagnosis was reached for this low number of cases as they are highly specific tests. However, there is a high percentage of patients with balance disorders for whom, if we had only used the imaging test, we would not have obtained any information on their disorder. For this reason, while we must admit its lack of specificity, the EOG does tell us whether or not these patients suffer from a balance disorder; it gives us information about its topography and about the quantitative parameters that allow us to measure the deficiency; it allows us to study the nystagmus, etc... We can therefore say that EOG is of great usefulness in these cases.

In the literature consulted and in reference to the use of EOG the opinions of different authors are of two distinct tendencies: on the one hand those who would recommend the use of EOG as a routine examination on all patients with balance disorders and, on the other hand, those authors who would prescribe against its use in certain cases. Some studies indicate that the use of EOG as a routine examination barely adds any variations to the clinical diagnosis, even though they admit that in certain cases it is necessary. These circumstances comprise: the need for documentation,imators, confirmation of the clinical diagnosis, spontaneous nystagmus of low intensity, vertigo of unknown etiology, research, or prior to surgery.

Different authors recommend the use of the EOG in cases of non-specific vertigo, that is to say, those in which the patient’s medical history and clinical exploration do not reveal conclusive signs about the balance disorder that the patient suffers from. It is worth mentioning the study carried out by Gordon, who in a group of patients with clinically non-specific vertigo and normal imaging tests found 67% with abnormal EOGs. The author indicates that the vestibular test is especially useful for those patients in whom no sign of vertigo other than the data from the vestibular exploration is observed.

Taking into account the opinion of the different authors and the results of this paper, we can conclude that we have verified the usefulness of EOG in the diagnosis of patients with balance disorders and we would define our stance with regard to determined clinical situations in the following form: a) there are clear indications for the use of EOG: simulators, scientific studies, prior to surgery or need for documentation. b) Its use is not necessary in those cases in which the clinical diagnosis is clear. c) We would like to stress that we would also use EOG in those cases in which the clinical exploration does not offer conclusive data and other complementary explorations are negative, these being the cases in which EOG makes the greatest contribution to the diagnosis.

References