The inverse electro-oculogram

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SUMMARY An electro-oculogram ratio of less than one was found to be caused by limited ocular excursions under photopic conditions in a patient with a rod-cone dystrophy. Because this inverse electro-oculogram ratio was not caused by a decrease in standing potential under photopic conditions, it should be considered an artefact.

The electro-oculogram light-to-dark ratio is the ratio of the standing ocular potential under light-adapted conditions to that under dark-adapted conditions. Normally the standing potential increases under photopic conditions. François *et al.*¹ theoretically defined the opposite situation, a decrease in standing potential under photopic conditions, as an inverse electro-oculogram. However, he did not describe any patients who met these criteria. In a single paragraph Kelsey² reported having seen patients with electro-oculogram ratios less than one. He attributed this to 'severe unilateral eye disease' but did not describe the specific circumstances or patients. This report describes a patient with an inverse electro-oculogram ratio.

Case report

A 31-year-old white female complained of decreasing vision for several years. Her optometrist had recorded a vision of 20/30 in both eyes at age 21 and 20/60 in both eyes at age 25. The patient felt her vision was worst during daylight, though poor at night, and she preferred twilight levels of illumination. One sister had night blindness and an unrecordable electroretinogram, and was diagnosed as having a rod-cone degeneration. Another sister had normal vision. Though both parents were deceased, the sisters suspected there had been parental consanguinity.

On examination the patient's visual acuity was 3/200 in the right eye and 20/200 in the left eye. The anterior segments, applanation tension, pupils, motility, and vitreous were normal. Fundus examination showed thinning of the retinal arteries, waxy pallor of the optic discs, and circumscribed

areas of atrophy of the pigment epithelium in the macula in both eyes. Some perimacular pigment clumping was present.

Fluorescein angiography showed window defects in the pigment epithelium corresponding to the areas of atrophy seen clinically, as well as loss of choriocapillaris in these areas. Goldmann visual fields showed constriction of all isoptres, with large nasal scotomas in both eyes. The patient made 1045 errors on the Farnsworth-Munsell 100 hue test. The electro-retinogram was extinguished under scotopic or photopic levels of illumination. Final dark-adaptation thresholds were assessed by the Tübingen perimeter with an 11 degree central target. The patient's final threshold with broad-band blue light was $-3.86 \log_{10} \text{cd/m}^2$ in the right eye, and $-3.54 \log_{10}$ in the left eye. These final thresholds were approximately 10 times less sensitive than results obtained in normal persons. Final thresholds for the sister with the known rod-cone degeneration were further reduced by a factor of 10.

An electro-oculogram was obtained by standard techniques,³ with instructions to the patient at the beginning of this test sequentially to fixate alternately illuminated light-emitting diode target lights which were separated by 30 degrees. The electro-oculogram light-to-dark ratio was 0.32 in the right eye and 0.51 in the left eye (Fig. 1).

The patient was called back for repeat examination in an attempt to explain the unusual finding of an electro-oculogram ratio less than unity. With independent observation of eye position it was found that monocularly under scotopic conditions she could readily visualise both target lights. However, under photopic conditions she was unable to see one of the 2 target lights. When she was then verbally coached as to when the target light switched sides, the electro-oculogram light-to-dark ratio was found to be 2.33 in the right eye and 2.73 in the left eye (Fig. 2).

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Fig. 1 *Electro-oculogram amplitudes recorded under light and dark conditions. Each response cluster represents approximately 15 seconds of recording. Recordings were obtained at one-minute intervals. Bold arrows indicate the responses used to calculate the electro-oculogram ratio.*

Discussion

The electro-oculogram is performed with the patient sequentially fixating targets separated by 30 degrees. Since the eye acts as a dipole, the electrical potential recorded depends on the amplitude of excursion the eye makes as it sequentially fixates these targets. For alternations of the electro-oculogram to reflect changes in standing potential the eye movements

must be of constant amplitude under all recording conditions.

The patient described had a severe visual deficit, large scotomas, and progressive cone-rod degeneration. Under photopic conditions she had a difficult time seeing one of the light-emitting diode target lights. As the target light she visualised was turned off, she did not easily see the second target light. Therefore the amplitude of her ocular excursion was

Fig. 2 *Electro-oculogram amplitudes recorded as in Fig. 1 except that the patient was verbally coached as to when to change fixation.*

decreased, resulting in the recording of only a small change in potential. Under scotopic conditions, however, she could see both target lights, and the amplitude of her ocular excursions was at least the full 30 degrees. We propose that it was the difference in the magnitude of ocular excursions between photopic and scotopic conditions that resulted in the appearance of an inverse electro-oculogram. Since the inverse electro-oculogram did not represent the physiological occurrence of a decrease in standing potential under photopic conditions, it cannot be considered representative. Indeed it is possible that the normal finding on the repeat electro-oculogram was also unrepresentative. On repeat testing the patient was verbally coached as to when to switch fixation. While unable to visualise one of the target lights under light-adapted conditions, she may have overcompensated, moving her eyes a larger angle than 30 degrees.

We stress the finding of an inverse electro-

oculogram to emphasise the possibility of obtaining unrepresentative electro-oculogram responses when testing any patient who may have a pathological difference between light-adapted and dark-adapted visual thresholds. Independent monitoring of eye position and attention towards maintaining amplitudes of ocular excursion constant during electro-oculogram testing would prevent these misleading results from occurring.

References

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