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Transient reduction of the ocular perfusion pressure and the oscillatory potentials of the ERG

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Abstract

Purpose. To evaluate the changes of the Oscillatory Potentials (OPs) of Electroretinogram (ERG) caused by short-term hypertension in human subjects, and their relationship with ocular perfusion pressure (OPP).

Methods. Suction cup technique in 12 normal volunteers with OPs simultaneously recording.

Results. Scotopic and photopic OPs were altered during OPP drop. Scotopic OPs showed more sensitiveness, with higher reduction (from 21% to 47%), when compared to the basal value, than in photopic recordings (from 14% to 34%). In both conditions, the relationship between OPP and OPs presented a steady amplitude before the trough after the +30 step, and rapid recovery after OPP normalisation. ANOVA and correlation analysis confirmed the data.

*Conclusion.*The ERG OPs seemed to reflect the OPP modification. The features of OPs amplitudes suggest involvement of the retinal autoregulation mechanism and support development for further clinical studies.

Keywords: Electroretinogram; Ocular hypertension; Ocular perfusion pressure; Oscillatory potential; Pressure test

1. Introduction

When a biological system is stimulated under stress condition, it usually exhibits stable responses in a more or less wide range; then it shows a decline of the response. That is considered as autoregulatory adaptation of the system.

Studies in normal human eyes with artificially increased intraocular pressure, demonstrated functional autoregulation in the retina (Riva, Grunwald, & Petrig, 1986) and the optic nerve (Riva, Grunwald, & Sinclair, 1982), while studies in glaucomatous eyes suggested a deficient autoregulation (Grunwald, Riva, Stone, Keates, & Petrig, 1984). Even if biochemical autoregulation at cellular level can not be excluded, (Kang Derwent & Linsenmeier, 2000), there is a general agreement that the autoregulation is mainly driven by vascular mechanisms in the retina and the optic nerve head (Alm, 1992), triggered by a reduction of the ocular perfusion pressure (OPP). If the intraocular pressure (IOP) increases and the perfusion pressure is thus reduced, there is a concomitant reduction in vascular resistance, so that the blood flow is more or less unchanged.

Many electrophysiological attempts were performed to study the relationship between artificially raised intraocular pressure and the retinal blood flow, but they had to challenge unwanted methodological side-effects: blurring, dazzling, alteration of the visual field, induced astigmatism (Stodtmeister & Pillunat, 1990).

The Oscillatory Potentials (OPs) of the Electroretinogram (ERG), rhythmic wavelets superimposed on the b-wave, seem to be a good tool for the study of the retinal

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autoregulation in case of intraocular pressure (IOP) increase for many reasons: (a) they are sensitive to disturbances of retinal circulation (Lovasik & Kergoat, 1993; Speros & Price, 1981), probably because of their generators at the level of the amacrine and interplexiform cells fed by retinal vessels (Heynen, Wachtmeister, & Van Norren, 1985); (b) they are thought to be independent from the optic nerve function (Wachtmeister, 1987); (c) moreover, non-structured stimuli as xenon flashes elicit the OPs so their recording cannot be influenced by the aforementioned disturbances.

The aim of the research is to relate OPs variation with OPP changes induced by suction cup technique and then to find some hints for a demonstration of retinal autoregulation mechanism.

2. Materials and methods

We present the results obtained in 12 volunteers, 8 males and 4 females, ranging from 22 to 35 years, presenting normal visual acuity (1.0) and ocular pressure between 12 and 16 mm Hg. They were recruited from the resident physicians and technicians of the University Eye Clinic of Palermo. None of the subjects reported history of retinal detachment, ocular trauma, acute conjunctivitis, infective ocular diseases; myopia, when present, was less than five diopters. Systemic arterial pressure was within the normal range (70/110–85/125 mm Hg). The research followed the tenets of the Declaration of Helsinki.

2.1. OPs recording

In preparation for the test, we measured the systemic blood pressure and the ocular pressure in each subject. The pupils were dilated with 5.0% phenylephrine HCl and 0.8% tropicamide; maximal dilatation was obtained in about 20 min after medication and its diameter was $\geq$7 mm.

The responses were recorded by Ag–AgCl hook electrodes applied to the inferior lid conjunctiva after topical anaesthesia with oxibuprocaina 4%. The reference electrodes were Ag–AgCl electrodes applied on the forehead; the common ground electrode was mid frontal. Impedance was less than 5 kΩ for each electrode.

Each subject was dark-adapted for 30 min, while light adaptation was performed with exposition to 800 lux for 10 min. The scotopic and photopic OPs were monocularly recorded with our routine method, elicited by xenon white flashes in a BM Elettronica ganzfeld at a frequency of 0.1 Hz (scotopic) and 3 Hz (photopic) (Anastasi, Lauricella, & Ponte, 1995). Due to technical reasons, we used two ganzfeld devices with different diameters, therefore flash intensity was 2.7 cd/s/m^2 (scotopic) and 5.4 cd/s/m^2 (photopic) in the first group (SL, CP, SS, DF) and 3.5 cd/s/m^2 (scotopic) and 17 cd/s/m^2 (photopic) in a second group of subjects (TI, AV, SF, CF, LS, FE, VM, CA). All the other parameters were kept constant. Paired t-test applied to the OPs of the two groups was underscored both for amplitudes and peak times, ($0.061 < p < 0.372$, $0.154 < p < 0.868$ respectively), showing no statistical significance. Therefore the two groups of data were analysed together as a whole.

Analogic bandpass was set between 50 and 1000 Hz; artefact rejection was used on acquisition and later digital filtering between 70 and 160 Hz was applied. The first response was rejected; averaging was used and all signals were stored on magnetic disks for further analysis. We applied the Averager V 9.5 X BM Elettronica program for recording, storing and processing data (Ponte, Anastasi, & Lauricella, 1989).

We studied three scotopic OPs (SOP1, SOP2, SOP3) and four photopic OPs (POP1, POP2, POP3, POP4) (La Chapelle, Little, & Palomeno, 1983). We considered an OP as "not recordable" when it was impossible to identify any oscillation between the statistical limits ($x \pm 2$SEM) of two contiguous wave peak times or when amplitude was lower than 3 μV. The amplitude and peak time of each single wavelet were measured by means of the electronic cursors of the computerised system, as were the voltage difference between the negative and positive peak of each wave and the time elapsed from the stimulus presentation to the peak of each response; when there were double peaks, we took into account the peak with the nearer time to the value reported in the literature (La Chapelle et al., 1983). Mean data standard error (SEM) was reported. Statistical analysis was performed by means of coupled-data Student t-test and one-way analysis of variance (ANOVA) test (significance $p < 0.05$). Correlation coefficient was also evaluated.

2.2. Method for IOP rising

We obtained the reduction of the OPP by raising the IOP with the suction cup technique (Stodtmeister & Pillunat, 1990), modified for ERG recording.

The cup (11 mm ∅) was applied with gentle pressure to the temporal sclera 1 mm behind the corneal limbus. A Saugnapf-Dynamometer (model ODM Taberna Pro Medicum) generated the increase of the IOP by means of negative pressure difference. Suction-induced depression raised the baseline IOP of 10, 20, 30, 40 mm Hg at each step respectively. The relationship between the negative pressure of the system and the pressure increase applied to the sclera is known (Stodtmeister & Pillunat, 1990; Ulrich, Ulrich, & Bohne, 1986). The impossibility of calibrating the effects of suction on each eye in a clinical trial implicates the application of a single general