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Applying Transpalpebral Rheoophthalmography to Monitor Effectiveness of the Treatment of Patients with Glaucoma

Dmitry M. Shamaev[1]*; Petr V. Luzhnov, PhD[1]; Tatyana O. Pika[1]; Elena N. Iomdina, PhD, ScD[2]; Alina P. Kleyman[2]; Alisa A. Sianosyan[2]

[1]Biomedical Engineering Department, Bauman Moscow State Technical University
[2]Moscow Helmholtz Research Institute of Eye Diseases
Moscow, the Russian Federation

Abstract

Assessment of ocular hemodynamics is an important element in diagnosis of all forms of glaucoma. Existing methods, unlike the transpalpebral rheoophthalmography (TP-ROG), evaluate only the posterior eye segment. This study evaluates the opportunities of new TP-ROG technology to assess the effectiveness of the glaucoma treatment. The proposed TP-ROG method is characterized by ease of use and the lack of direct contact between the surface of the eyeball and the electrodes; this method is highly informative and quite accurate, which allows us to objectively assess the state of ocular hemodynamics in patients with primary open-angle glaucoma **(Int J Biomed. 2016; 6(4):287-289.)**

Key Words: transpalpebral rheoophthalmography • ocular hemodynamics • microcirculation • primary open-angle glaucoma

Introduction

It is known that alterations in ocular blood flow play a prominent role in primary open-angle glaucoma (POAG) processes. The main collector of blood flow, performing the function of nourishing the inner shells of the organ of vision is the vascular tract, which contains more than 80% of the incoming blood in the eye. In this connection, the search for the most informative and accurate methods of determining the blood flow in the uvea is important and has continued over the years.[1]

The method of rheoophthalmography (ROG) allows us to objectively assess the state of blood flow in the main hemodynamic system of the eye—the vascular tract. The principle of this method is based on recording the changes in the total resistance (impedance) while passing a high-frequency electric current through the ocular tissue.[2-4] ROG was developed by Katznelson to assess the uveal blood flow currently and is used as a diagnostic test and criterion of effectiveness in treatment of glaucoma, myopia, degenerative diseases of the retina, and traumatic injuries.[1]

***Corresponding author**: Dmitry Shamaev. Biomedical Engineering Department, Bauman Moscow State Technical University, Moscow, Russia. E-mail: shamaev.dmitry@yandex.ru*

In 2012, scientists at the Moscow Helmholtz Research Institute of Eye Diseases and the Bauman MSTU together developed a new method of rheoophthalmography examination, which differs from the classical ROG method in that it lacks direct contact between the eyeball surface and electrodes, which certainly is an advantage of the new method. During TP-ROG, electrodes are superimposed on the closed eyelid and, to improve the accuracy of existing studies, the bipolar technique is replaced by a tetrapolar technique that allows considering features of the anatomical structure of the vascular bed of the eyeball.[4,5] As a result of the recording, processing, and analyzing of recorded signals using specially developed software, the following indexes can be calculated: rheographic index (RI), which shows the value of systolic blood flow and depends on the value of stroke volume and vascular tone; the period of maximum filling (PMF), which increases with increases in the vessel tone and with decreases in the elasticity of blood vessels; and the index of elastic modulus (IEM), which characterizes the structural properties of the vascular wall, its elasticity and tone, as well as other hemodynamic characteristics.[6]

TP-ROG registration is carried out using a tetrapolar lead system. The main elements of this system are four reusable metal electrodes (internal diameter, 4 mm) and a substrate with elements of attachment and positioning. A structure in the form of an elastic hat, which is specially designed for TP-ROG, provides an attachment point for the lead system with the possibility of adjustment and optimization for each patient, the correct positioning, and the desired force to fix electrodes on the upper eyelid.[7,8] During the examination, with the patient in a supine position, the electrode lead system is set on the closed eye and fixed by a knitted hat; the other eye remains open during the investigation in order to reduce the number of involuntary eye movements and the number of artefacts in the recorded signal. TP-ROG signal registration lasts no more than 2 minutes.[4,5] Research of the myopic eye hemodynamics by TP-ROG shows that the new method is characterized by being highly informative and sufficiently accurate; TP-ROG allows us to objectively assess the state of blood supply to the myopic eye.[2]

Despite achieving the target level of intraocular pressure (IOP) with the help of medical or surgical treatment, involution and metabolic disorders, changes in cerebral blood flow, and reduction in the activity of antioxidant systems are responsible for the gradual decline of visual function in POAG patients. To correct the noted disorders during the integrated treatment of POAG, several methods are used: neuroprotective, anti-sclerotic, and vasoactive drugs; vitamins and antiplatelet agents; and various methods of physiotherapy.[1,7] Therapeutic effects of physical factors that are used in the treatment of POAG, aimed at restoring the conduction of optic nerve fibers, improve microcirculation and hemodynamics and affect the regulatory structure of the brain. Physical therapy techniques also provide general sedative, antispasmodic, hypotensive, distracting and analgesic effects, and normalize the functional state of the central and peripheral nervous systems.[1]

In recent years, laser therapy has been widely used in medicine. The physiotherapy impact of low-power laser radiation leads to activation of cellular metabolism, improvement of ocular hemodynamics indicators, and increased trophic support for eye tissues. That is why this kind of feedback can be used as a component of complex treatment of patients with POAG. Currently, we are working on implementing the ROG technique in clinical practice for monitoring the glaucoma treatment.

The purpose of this study was to determine the capabilities of TP-ROG in monitoring the effectiveness of POAG treatment.

Materials and Methods

There are 4 stages of glaucoma. In formulating a diagnosis, the stages are designated by Roman numerals: from I - early-stage up to IV - end-stage. In this case, the state of the visual field and optic disc are taken into account. Stage I: peripheral visual field (PVF) is normal, but there are defects in the central field of vision; excavation of the optic disk is expanded, but does not reach the edges. Stage II: PVF is narrowed with the nasal side of more than 10°; the observed changes in excavation do not reach the edge of the optic disc. Stage III: PVF is narrowed concentrically (the nasal side up to 15° or less from the point of fixation); subtotal excavation reaches the edge of the optic disc. Stage IV: complete loss of vision or saved light perception with irregular light projection. The light perception may be a small island of the residual field of vision in the temporal sector.

Low-level laser therapy (LLLT) was conducted in 11 patients (17 eyes) aged between 58 and 76 years with POAG stages II and III; the IOP normalization was reached without antihypertensive regime.

Before LLLT (from 6 to 18 months), patients underwent sinus-trabeculectomy. Prior to surgery, all patients were on maximal hypotensive mode. Postoperatively, all patients had a course of conservative therapy, including anti-oxidants, vitamins B, antiplatelet agents, and neuroprotective agents. LLLT was performed using MACDEL-08, the operating principle of which consists in the activation of neuronal cells of the retina and optic nerve by observing the patient moving a speckle formed by helium-neon laser radiation (λ=0.63 um). During TP-ROG signal processing, three main hemodynamic parameters are calculated: RI, PMF, and IEM.[6,9,10] Before TP-ROG, all patients underwent a comprehensive eye exam: visometry, computer perimetry, gonioscopy, ophthalmoscopy, pneumotonometry, tonography, morphometric analysis of optic disc parameters using the Heidelberg Retina Tomograph (HRT), and the determination of the critical flicker fusion frequency (CFFF).

The exclusion criteria were as follows: a) pathology of the organ of vision associated with impaired intra-ocular blood flow: vascular occlusion, diabetic retinopathy, etc.; b) the terminal stage of POAG; c) secondary glaucoma; d) inflammatory diseases and injuries of the eyeball; e) ophthalmic treatment at least 6 months prior to the survey; f) severe pathology of systemic hemodynamics, including atrial fibrillation, heart failure (>2A degree), clinically significant carotid artery stenosis., etc. MACDEL-08 is used for laser treatment of sensory disorders in ophthalmic practice. The operating principle of this device is projecting the laser speckle pattern on the retina. The laser speckle pattern is contrast, and the size of speckle is perceived even at reduced function (up to 0.02-0.03).

This study was performed in accordance with the Declaration of Helsinki and was approved by Local Committee of Biomedical Ethics of the Moscow Helmholtz Research Institute of Eye Diseases. Written informed consent was obtained from all participants. The statistical analysis was performed using the statistical software Statistica 6.0. The Wilcoxon criterion was used to compare the differences between the paired samples. A probability value of $P<0.05$ was considered statistically significant.

Results

In our study, we formed 2 groups: Group A included 9 eyes (POAG stage II) and Group B included 8 eyes (POAG stage III). Visual acuity before the LLLT course was as follows: Group A - from 0.4 to 0.9 (0.70±0.17); Group B – from 0.1 to 0.8 (0.53±0.25). The LLLT course using MACDEL-08 was well tolerated by all patients. Seven patients reported subjective improvement in visual acuity on the 3rd and 4th days after initiation of therapy. All patients showed improvement of visual acuity after the LLLT course: from 0.6 to 1.0 (0.87±0.16) and 0.3 to 1.0 (0.69±0.25) in Groups A and B, respectively; $P<0.05$ on both cases.

Both groups showed a statistically significant increase in the RI level (from 12.81±1.12 mOhm to 14.58±1.05 mOhm in Group A and from 9.57±0.89 mOhm to 11.31±1.29 mOhm in Group B; $P<0.05$ in both cases) and a statistically insignificant decrease in levels of PMF (from 0.27±0.02 sec to 0.23±0.02 sec in Group A and from 0.31±0.03 sec to 0.28±0.02 sec in Group B; $P>0.05$ in both cases) and IEM (from 0.31±0.03 sec to 0.28±0.02 sec in Group A and from 0.33±0.03 sec to 0.29±0.03 sec in Group B; $P>0.05$ in both cases). The achieved levels of rheogram indicators remained unchanged throughout the period of observation. Increased RI indicates an improvement in microcirculation. The dynamics of PMF and IEM indicate no significant effect on the elastic properties of intraocular vascular walls.

In conclusion, the proposed TP-ROG method is characterized by ease of use and the lack of direct contact between the surface of the eyeball and the electrodes; this method is highly informative and quite accurate, which allows us to objectively assess the state of ocular hemodynamics in POAG patients. The TP-ROG method has shown its capabilities to monitor the effectiveness of POAG treatment.

Competing interests

The authors declare that they have no competing interests.

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