Study of Microcirculation of the Ocular Ciliary Body in Experimental Kidney Disease


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We studied disorders in ciliary body microcirculation in experimental chronic glomerulonephritis with tubulointerstitial nephritis and evaluated the hemodynamic effects of low-frequency pulsed electromagnetic field in this pathology. Laser Doppler flowmetry demonstrated vasospasm with reduced nutrient blood flow in the ciliary body of animals with experimental chronic glomerulonephritis with tubulointerstitial nephritis. The exposure to low-frequency pulsed electromagnetic field using developed technology will lead to significant reduction of the vascular tone and improve arterial blood supply to the microcirculatory bed.

Key Words: microcirculation; laser Doppler flowmetry; chronic glomerulonephritis with secondary tubulointerstitial nephritis; pulsed low-frequency electromagnetic field

An important role in the pathogenesis of glomerulonephritis along with renal impairment is played by extrarenal factors, for instance, pathological changes in small vessels and capillaries. Microcirculatory disturbances are involved in the pathogenesis of ophthalmic manifestations of nephrology pathology [2]. The similarity of renal glomeruli and ocular vascular tract (complex of choriocapillaris, Bruch’s membrane, and retinal pigment epithelium) consists in abundant vascularization, high volume flow rate per weight unit, and the presence of IgG Fc-receptors and receptors for complement C3 fragments on renal glomerular cells and endothelial cells (quoted by [2]).

The studies of microcirculation of the eye during glomerulonephritis are scarce and inconsistent.

We propose a method for the treatment of progressive myopia combined with extraocular pathology (inflammatory diseases of kidneys) in children [4], which consists in the use of frequency pulsed electromagnetic field (PEMF). Pathogenetic effect of PEMF is determined by its regulatory effect on microcirculation [4], which makes relevant the study of the microcirculation of the ciliary body in experimental renal pathology.

We analyzed disturbances of microhemodynamics of the ciliary body in experimental chronic glomerulonephritis with tubulointerstitial nephritis and evaluation of the hemodynamic effects of PEMF in this pathology.

MATERIALS AND METHODS

The study was conducted on 10 male Chinchilla rabbits weighing 2.0-2.5 kg (vivarium of the Research Institute for Fundamental and Applied Biomedical Research). In the experimental group (n=5; 10 eyes), chronic inflammatory pathology (chronic glomerulonephritis with secondary tubulointerstitial nephritis) was modeled [3]. Control group comprised 5 intact rabbits (10 eyes).

For modeling renal pathology in experimental animals, normal horse serum (BioloT) heated to 37°C was injected into the ear vein in a dose of 12-15 ml/kg body weight. For desensitization and prevention of allergic shock, the same serum was injected in a dose...
of 1 ml/kg 24 h prior to serum administration (preimmunization).

Starting from experimental day 28, the heads of experimental animals were exposed to PEMF generated by an INFITA device for 10 days; the emitter was located at a distance of 20 to 30 cm from the eyes. Field strength in the affected area was 1-2 mV/cm²; field exposure at the same frequency 9 min. Pulse repetition rate was changed daily [4].

Microcirculation in the ciliary body of the eye was evaluated by direct-contact laser Doppler flowmetry (LDF) using LAKK-02 analyzer (LAZMA, Biofizika) with λ=0.63 μ He-Ne transmitter. Probed tissue volume was up to 1 mm³.

The main indicators of ocular hemodynamics were evaluated: microcirculation perfusion index, standard deviation of pulse amplitude fluctuations, and coefficient of variation [1]. A wavelet transform of LDF blood flow signals was used in calculations after preliminary correction of the segments of LDF signals. The amplitudes of the oscillations related to endothelial, neurogenic, and myogenic activity, respiration rate, and HR in the range of 50-180 oscillations per minute were evaluated quantitatively. The neurogenic and myogenic tone and bypass index were also calculated [1].

In experimental animals, the parameters of microcirculation in the ciliary body were recorded before and on days 5 and 10 after the PEMF exposure. In control animals, the microcirculation parameters in the ciliary body were recorded only once.

Microhemodynamics of the ciliary body in animals was examined under general anesthesia. Double anesthesia was used. Rometar (2% solution xylazine hydrochloride) was injected intramuscularly for premedication. In 10-15 min, Zoletil 50 in a dose of 6.6 mg/kg body weight was administered intravenously in marginal ear vein. For LDF recording of the ciliary body, the sensor was positioned 2–3 mm from the limbus in the upper part of the eyeball (projection area of the ciliary body) at the maximum eye opening.

Statistical analysis was performed using Statistica 6.0 software.

**RESULTS**

In experimental group, microcirculation tended to decrease (p>0.05) and the significant reduction in the standard deviation of pulse amplitude fluctuations indicating a decrease in blood flow modulation were revealed before PEMF exposure (Table 1). Significant decrease in correlation coefficient in the experimental group before PEMF exposure reflected the deterioration of microcirculation [1].

Analysis of amplitude and frequency spectrum of perfusion oscillations conducted using wavelet transform of blood flow signals showed a significant decrease in endothelial, neurogenic, and myogenic

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Control group</th>
<th>Experimental group</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>before the exposure</td>
<td>day 5 after exposure</td>
</tr>
<tr>
<td>M, PU</td>
<td>21.64±0.67</td>
<td>20.49±0.86</td>
</tr>
<tr>
<td>σ, PU</td>
<td>1.19±0.08</td>
<td>0.64±0.03*</td>
</tr>
<tr>
<td>Cv, %</td>
<td>5.49±0.30</td>
<td>3.12±0.13*</td>
</tr>
<tr>
<td>AE, PU</td>
<td>0.36±0.02</td>
<td>0.17±0.02*</td>
</tr>
<tr>
<td>AN, PU</td>
<td>0.53±0.05</td>
<td>0.26±0.02*</td>
</tr>
<tr>
<td>AM, PU</td>
<td>0.61±0.04</td>
<td>0.30±0.02*</td>
</tr>
<tr>
<td>AR, PU</td>
<td>0.59±0.05</td>
<td>0.29±0.01*</td>
</tr>
<tr>
<td>AC, PU</td>
<td>0.38±0.04</td>
<td>0.21±0.01*</td>
</tr>
<tr>
<td>NT</td>
<td>2.24±0.17</td>
<td>2.48±0.11</td>
</tr>
<tr>
<td>MT</td>
<td>1.96±0.05</td>
<td>2.15±0.03*</td>
</tr>
<tr>
<td>BI</td>
<td>0.87±0.06</td>
<td>0.87±0.05</td>
</tr>
</tbody>
</table>

**Note.** M: microcirculation index; σ: standard deviation of pulse amplitude fluctuations, Cv: variation coefficient; AE: amplitude of endothelial activity; AN: amplitude of neurogenic activity, AM: amplitude of myogenic activity; AR: amplitude of respiratory oscillations, AC: amplitude of heart rhythm within the range of 50-180 oscillations per minute, NT: neurogenic tone, MT: miogenic tone, BI: bypass index, PU: perfusion units. p<0.05 in comparison with *the control group, +values before the exposure, **values on day 5 after the exposure.