AUTOMATED PERIMETRY, COLOR VISION AND CONTRAST SENSITIVITY IN OCULAR HYPERTENSIVES

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Abstract

Purpose: Ocular hypertensives (OHT) are patients with high intraocular pressure (IOP), normal optic discs and visual fields. IOP is the major risk factor for glaucomatous disc damage. These OHT patients are considered ‘glaucoma suspects’ because there is a remote possibility of evolution toward disease. This means that clinical supervision is needed to discover glaucomatous disc damage as soon as possible. In the search for a sensitive diagnostic examination, many clinical tests have been proposed such as achromatic automated perimetry (AAP), short-wavelength automated perimetry (SWAP), spatial contrast sensitivity, and color vision testing. Each of these test a different subset of ganglion cells: P bistratified, P midget, or M. The aim of this study was to verify the results of these clinical examinations in ‘glaucoma suspects’.

Methods: Nineteen eyes of ten OHT patients treated with topical beta-blockers were examined with AAP and SWAP of the Humphrey Field Analyzer and the Farnsworth FM-100 and black/white sinusoidal gratings, both presented on a PC screen. A normal control group of 19 eyes received the same examinations.

Results: In the OHT group, an increase in white light threshold was noted in eight out of 19 eyes (42%), and in 14 eyes (74%) there was an increase in blue light threshold as well. A decreased contrast sensitivity was also present in seven eyes (37%), either for high or for low spatial frequencies. The FM-100 test revealed a protan defect in one eye only.

Discussion: All tests, with the exception of the Farnsworth FM-100, resulted in clear defects. This study suggests that slight functional damage exists even in the early phase of glaucomatous disc damage. The damage is not merely magnocellular, and SWAP revealed the highest sensitivity.

Introduction

Ocular hypertensives (OHT) are patients with high intraocular pressure (IOP), but with normal optic discs and visual fields. IOP is the major risk factor for glaucomatous disc damage. OHT patients are considered to be ‘glaucoma suspects’ because there is a remote possibility of evolution toward disease. Thus, clinical supervision is needed to discover glaucomatous disc damage as early as possible.

Achromatic automated perimetry (AAP) is probably the most specific clinical examination in the diagnosis of glaucomatous disease. However, the first perimetric
defects are revealed when a substantial part of ganglion cells and nerve fibers have already been lost\textsuperscript{5-7}, primarily the largest ones\textsuperscript{8,9}.

In the search for a sensitive diagnostic examination, many clinical tests have been proposed such as: short-wavelength automated-perimetry (SWAP)\textsuperscript{10-15}, contrast sensitivity\textsuperscript{16-18}, and color vision testing\textsuperscript{19,20}. Each of these seems to test a different subset of ganglion cells.

The aim of this study was to evaluate the results of these clinical examinations in ‘glaucoma suspects’.

**Methods**

Nineteen eyes of ten OHT patients, aged 23 to 70 years (average 57 years), were tested with SWAP 24-2 on a Humphrey perimeter, contrast sensitivity test with black/white stationary gratings and spatial frequencies of between two and 18 cycles/degree (c/d), and with color vision test Farnsworth FM-100 made by 90 caps covering the entire color circle. These last two tests were shown on a PC screen using Color Vision Testing software (TwoDocs Inc., New Orleans, LA) that also gave an evaluation at the end of each examination. The OHT patients met the following criteria: IOP >23 mmHg before treatment, treated only with beta-blockers, IOP <18 mmHg after treatment, normal optic discs with c/d ratio <0.6 along the vertical diameter, transparent media, and AAP 24-2 within normal limits. Nineteen normal eyes of patients aged 41 to 61 years (average 49 years) were submitted to the same examinations. Each normal patient had an IOP <18 mmHg and normal optic discs.

Since the sinusoidal grating subtends a visual angle of about 7° at a distance of 66 cm, only the four central thresholds of each visual field were taken into consideration, and an average value was calculated for each subject (macular sensitivity for white and for blue light). From the thresholds of the normal control group, the inferior confidence limit of 1% for AAP and for SWAP was calculated and compared with each macular threshold of OHT.

**Results**

No alteration in contrast sensitivity or color vision was noted in the control group. The macular sensitivity for white light was lower than the confidence limit of 1% in eight out of 19 visual fields (42%). The deviation from normal threshold values was more evident in SWAP, with an abnormal macular threshold being found in 14 visual fields (74%). A decreased contrast sensitivity was present in seven eyes (37%), either for low or for high spatial frequencies. The FM-100 test revealed a protan defect in one eye only. The results are summarized in Table 1.

**Discussion**

The distribution of ganglion cells inside the central area of the visual field, is not equal. P midget elements are much more frequent (90%) than P cells bistratified (1%) and M cells (5%)\textsuperscript{21}. 
Automated perimetry, color vision and contrast sensitivity

Different cell types also have different functional properties. M magnocellular elements are sensitive to low spatial frequencies\(^{22}\) and to high temporal frequencies\(^{23,24}\); P midget cells are sensitive to high spatial frequencies\(^{22}\), low temporal frequencies\(^{24}\), to medium wavelength light (green) and long wavelength light (red) radiations\(^{22}\); P bistratified cells are sensitive to short wavelength light (blue) radiations\(^{25}\), and are therefore stimulated by SWAP.

Table 1.

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Eye</th>
<th>AAP</th>
<th>SWAP</th>
<th>Contrast sensitivity</th>
<th>FM-100</th>
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<td>OO</td>
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<tr>
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<td>R</td>
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<tr>
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<tr>
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<tr>
<td>VM</td>
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<td>L</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>normal</td>
<td>normal</td>
</tr>
</tbody>
</table>

All tests, with the exception of the Farnsworth FM-100, which appeared to be modified in one eye only, resulted in clear defects.

Even though AAP appeared normal when analyzed by the Humphrey perimeter statistical package (StatPac), comparison with values from the normal control group showed frequent light sensitivity reductions, and probable functional defects in OHT as well.

Much more evident are the luminous threshold elevations with blue light. Regarding the early diagnosis of glaucomatous disc damage, the SWAP examination is considered more sensitive than AAP\(^{10-15}\), because of a supposed P-bistratified cell’s early damage, and because of the extreme selectivity of the type of stimulation to which only this small group of ganglion cells is sensitive.

According to common knowledge, a sensitivity reduction in all spatial frequencies has been noted\(^{16-18}\). However, the variety of sensitivity variations to contrast make this a low diagnostic utility test. More accurate methodologies are needed to better isolate responses by different cell types.

A limitation of this study is the slight age difference between the two groups. The OHT patients are usually older, and 11 out of 19 eyes were from people of 60 years
and older. We know that deterioration in various visual functions is common with aging\textsuperscript{26-28}, and this could be one possible reason for the defects seen.

Notwithstanding, we believe that slight functional damage exists, even in the early phase of glaucomatous disc damage. We also believe that this damage is not merely magnocellular\textsuperscript{29} and that SWAP is by far the most trusted test today.

References