EVALUATION OF WHITE-ON-WHITE PERIMETRY USING SIZE I STIMULUS COMPARED WITH BLUE-ON-YELLOW PERIMETRY

M. TAKADA, M. OSAKO, S. OSAKO, H. GOTO, N. HORIKOSHI and T. OKANO

Department of Ophthalmology, Tokyo Medical University, Tokyo, Japan

Abstract

Purpose: The authors compared the visual field results which were taken by white-on-white (W/W) perimetry using a Goldmann size I stimulus with those of blue-on-yellow (B/Y) perimetry, and evaluated the effectiveness of W/W perimetry using size I stimulus.

Methods: The study objects were 21 eyes of 21 normal persons (NP), 19 eyes of 12 cases with ocular hypertension (OHT), 42 eyes of 30 cases with large cupping (C/D ratio ≥ 0.7) but with no visual field defects (LC), 18 eyes of 15 cases with early glaucomatous visual fields (EG). Program 24-2 of the Humphrey Field Analyzer was performed on all subjects using W/W perimetry (sizes I and III) and B/Y perimetry (size V). The authors compared mean sensitivity (MS), probability symbols, abnormal locations and short-term fluctuation (SF) between these four groups.

Results: The MS for the EG group was less than that for the NP group in all types of perimetry, but the probability level for W/W perimetry using size I stimulus (p < 0.01) was lower than that of B/Y perimetry (p < 0.05). Although the EG group had a larger number of probability symbols than the NP group with W/W perimetry (p < 0.01), there was no significant difference with B/Y perimetry. The EG group had a larger number of abnormal locations than the NP group in all types of perimetry, but the probability level for W/W perimetry using size I stimulus (p < 0.01) was lower than that for B/Y perimetry (p < 0.05). The MS for the LC group was less than that for the NP group for all types of perimetry. With regard to the number of probability symbols and abnormal locations, the difference between the NP and LC groups was only statistically significant for W/W perimetry using size I stimulus. Although the SF of the EG group was greater than that of the NP group on W/W perimetry (p < 0.01), there was no significant difference on B/Y perimetry.

Conclusion: These findings suggest that W/W perimetry, using a size I stimulus, is more sensitive for detecting early glaucomatous visual field damage than B/Y perimetry.

Introduction

Although blue-on-yellow (B/Y) perimetry is expected to detect early glaucomatous visual field loss prior to white-on-white (W/W) perimetry using a Goldmann size III stimulus, it has also been reported that W/W perimetry, using a size I stimulus, is more sensitive for detecting a slight change in the visual field than the size III stimulus. In this study, we...
Table 1. Background of NP, OHT, LC, EG groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Cases/eyes</th>
<th>Age (years)</th>
<th>IOP (mmHg)</th>
<th>Mean deviation (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP</td>
<td>21/21</td>
<td>48.6±6.1</td>
<td>15.2±2.4</td>
<td>0.39±0.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(37~60)</td>
<td>(10~20)</td>
<td>(-1.65~1.67)</td>
</tr>
<tr>
<td>OHT</td>
<td>12/19</td>
<td>48.4±5.5</td>
<td>24.6±2.4</td>
<td>0.16±0.92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(41~58)</td>
<td>(22~31)</td>
<td>(-1.77~2.02)</td>
</tr>
<tr>
<td>LC</td>
<td>30/42</td>
<td>50.3±5.4</td>
<td>14.3±2.9</td>
<td>-0.11±0.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(40~58)</td>
<td>(9~20)</td>
<td>(-2.15~1.82)</td>
</tr>
<tr>
<td>EG</td>
<td>15/18</td>
<td>47.7±7.8</td>
<td>16.1±4.4</td>
<td>-1.98±0.94</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(38~60)</td>
<td>(10~26)</td>
<td>(-2.8~0.13)</td>
</tr>
</tbody>
</table>

**: p <0.01

compared the visual field results on W/W perimetry using a size I stimulus with those on B/Y perimetry, and evaluated the effectiveness of W/W perimetry using a size I stimulus.

Material and methods

The study objects comprised 21 eyes of 21 normal persons (NP), 19 eyes of 12 cases with ocular hypertension (OHT), 42 eyes of 30 cases with large cupping (C/D ratio ≥0.7) but with no visual field loss (LC), and 18 eyes of 15 cases with early glaucomatous visual fields (EG). The characteristics of these groups are shown in Table 1. The intraocular pressure (IOP) in the LC group was below 21 mmHg. Eyes in the EG group, consisting of three with primary open-angle glaucoma (POAG) and 15 with normal-tension glaucoma (NTG), all exhibited either large cupping (C/D ≥0.7) or a nerve fiber bundle defect (NFBD).

All the subjects had experience of automated perimetry and had a refraction of less than 5 D sphere, a corrected visual acuity of at least 20/20, no media opacity, and a pupil diameter of at least 3 mm. Fields with FL>33%, FP>20%, or FN>20% were excluded. The diagnostic criteria for early glaucomatous visual field loss were defined as follows: W/W visual field using size III stimulus was considered to be abnormal if five or more individual stimulus locations, or three or more clustered locations, were below the 5% probability level on the total deviation printout. The lower limit for the MD was set at the 2% probability level.

Program 24-2 of the HFA was performed on all subjects using W/W perimetry (sizes I and III) and B/Y perimetry (size V). Comparisons were made of mean sensitivity (MS), probability symbols, abnormal locations, and short-term fluctuation (SF). The probability symbols of the total deviation analysis were used for size III W/W perimetry and for B/Y perimetry, and those of less than 5dB from the mathematically derived normal threshold values were used for the size I stimulus. By calculating the mean sensitivity and the standard deviation (SD) at each location in the normal subjects, a location below the 5% probability level could also be defined.
Size I stimulus compared with blue-on-yellow perimetry

**Results**

**Mean sensitivity**

The MS for the EG group was less than those for the NP, OHT and LC groups for W/W perimetry using sizes I and III stimuli ($p<0.01$). However, a significant difference was only present between the NP and EG groups for B/Y perimetry ($p<0.05$). The MS for the LC group was less than that for the NP group for all three types of perimetry ($p<0.05$; Fig. 1).

**Probability symbols**

The EG group had a larger number of probability symbols than the NP, OHT and LC groups for size I and size III W/W perimetry ($p<0.01$). For B/Y perimetry, the EG group showed a smaller number of probability symbols compared to W/W perimetry, and a
significant difference was only present between the EG and OHT groups \((p<0.05; \text{Fig. 2})\). The LC group had a larger number of probability symbols than the NP group for size I \(W/W\) perimetry. The mean number of probability symbols for the size I stimulus was greater than that for \(B/Y\) perimetry in the EG group \((p<0.01)\), whereas there was no significant difference in the NP group (Tables 2 and 3).

**Abnormal locations**

The EG group had a greater number of abnormal locations than the NP, OHT and LC groups for sizes I and III \(W/W\) perimetry \((p<0.01)\), whereas there was a significant difference between the EG and NP groups for \(B/Y\) perimetry \((p<0.05)\). The LC group had a greater number of abnormal locations than the NP and OHT groups for sizes I and III \(W/W\) perimetry, whereas there was no significant difference among these groups for \(B/Y\) perimetry (Fig. 3). Although the mean number of abnormal locations for size I \(W/W\) perimetry was greater than for \(B/Y\) perimetry in the EG group, there was no significant difference between these types of perimetry (Table 3).

**Short-term fluctuation**

In general, the SF was larger for the size I stimulus and for \(B/Y\) perimetry than for the size III stimulus. The SF for the EG group was larger than that for the NP and LC groups for the size I stimulus \((p<0.01)\); no significant difference was found for \(B/Y\) perimetry (Fig. 4).

**Discussion**

The MS for the EG group was less than that for the NP group for all types of perimetry, but the probability level for \(W/W\) perimetry \((p<0.01)\) was lower than that for \(B/Y\) perimetry \((p<0.05)\). The relationship between the four groups for \(W/W\) perimetry using size I stimulus

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**Table 2. Comparison between size I and B/Y (NP)**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Size I</th>
<th>B/Y</th>
<th>Paired t test</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of probability symbols</td>
<td>2.3±3.1</td>
<td>0.7±1.6</td>
<td>n.s.</td>
</tr>
<tr>
<td>No. of abnormal locations</td>
<td>1.2±2.1</td>
<td>1.3±2.0</td>
<td>n.s.</td>
</tr>
<tr>
<td>SF (dB)</td>
<td>1.5±0.5</td>
<td>1.8±0.6</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

**Table 3. Comparison between size I and B/Y (EG)**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Size I</th>
<th>B/Y</th>
<th>Paired t test</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of probability symbols</td>
<td>10.2±6.9</td>
<td>3.3±6.1</td>
<td>(p &lt;0.01)</td>
</tr>
<tr>
<td>No. of abnormal locations</td>
<td>8.8±7.9</td>
<td>6.9±10.0</td>
<td>n.s.</td>
</tr>
<tr>
<td>SF (dB)</td>
<td>2.3±0.9</td>
<td>1.8±0.6</td>
<td>(p &lt;0.05)</td>
</tr>
</tbody>
</table>
Size I stimulus compared with blue-on-yellow perimetry

Fig. 3. Comparison of abnormal locations. Upper graph: W/W perimetry using the size III stimulus; middle graph: W/W perimetry using the size I stimulus; lower graph: B/Y perimetry. NP: normal person, OHT: ocular hypertension, LC: large cupping (C/D ratio ≥ 0.7), EG: early glaucoma.

Fig. 4. Comparison of short-term fluctuation (SF). Upper graph: W/W perimetry using the size III stimulus; middle graph: W/W perimetry using the size I stimulus; lower graph: B/Y perimetry. NP: normal persons, OHT: ocular hypertension, LC: large cupping (C/D ratio ≥ 0.7), EG: early glaucoma.

was very similar to that using size III stimulus. It was felt that the visual field tests using size I were as reliable as those using size III.

The MS for the LC group was less than that for the NP group for all types of perimetry (p<0.05). The LC group can be divided into physiological disc cupping and pre-NTG. Considering the racial etiology, and that NTG is seen in about two-thirds of all glaucoma patients in Japan, it is speculated that the proportion of NTG in this group was high.

It has been reported that abnormalities of B/Y perimetry in ocular hypertensive eyes are correlated with C/D ratio and with age. In the OHT group, only four eyes exhibited large disc cupping (C/D ratio ≥ 0.7), but 15 eyes did not have any obvious signs of change in disc appearance. This may be related to the similarity between the NP and OHT groups for all types of perimetry.
With the HFA, the normal values of sensitivity as a function of age for the size I stimulus are not commercially available. Therefore, the probability analysis for the size I stimulus was based on a mathematically derived normal threshold database. Zalta and Burchfield reported that the probability analysis for a size I stimulus could detect abnormalities to the same degree as that for a size III stimulus. Our study substantiates these findings, and it is thought that the probability analysis used for the size I stimulus is also effective for the observation of LC. During B/Y perimetry, there was no significant difference between the NP and EG groups, and probability analysis was not as useful as that for the size I stimulus.

Using the normal sensitivity of each location based upon the mean and SD for the sizes I and III stimulus, Uyama et al. reported that, in ten of 36 eyes (31%), size I was more sensitive in detecting early glaucomatous visual fields than size III. Our data also showed that perimetry using size I stimulus was similar between the four groups to that using size III stimuli, but the mean number of abnormal points for size III was more than that for size I in the EG group (Fig. 3). In this study, as the normal subjects were chosen strictly on the visual field and clinical findings, it can be speculated that the value of the SD at each location was less than that of the normal population, with a variety of changes in the optic disc. Therefore, the range of normality for the NP group was likely to have been narrower than that for the normal population, and may have accounted for the difference in the results between the probability analysis and the abnormal locations.

The SF is influenced by retinal sensitivity, the number of false-positive and false-positive responses, and the fatigue effect. In this study, the subjects with high FP or FN were excluded. The SF in W/W perimetry using the size I stimulus and in B/Y perimetry was generally greater than standard W/W perimetry using size III stimulus. It is thought that the low visibility of the small stimulus and bright background of B/Y perimetry could induce the fatigue effect. However, caution must be exercised in the interpretation of the SF in that the formula used to calculate the SF for size III W/W and B/Y perimetry includes a proprietary weighting factor for each type of perimetry to account for the increase in fluctuation with increase in eccentricity. The formula used to derive the SF for size I perimetry contained no such weighting factor. However, the inclusion of the weighting factor for size III perimetry is of little clinical significance.

In the EG group, the SF was greater for size I than for size III W/W perimetry; there was no significant difference between the NP and EG groups on B/Y perimetry. Although our subjects were well used to W/W perimetry, most of them were undergoing B/Y perimetry for the first time. This fact may be related to the high SF in the NP group for B/Y perimetry and the similarity between the four groups.

Comparison between W/W perimetry using size I and B/Y perimetry, suggests that W/W perimetry using size I is more sensitive in detecting early glaucomatous visual field than B/Y perimetry. For LC and EG, it will be necessary to determine whether the results obtained with size I stimulus will be reflected in the visual fields determined at follow-up.

References