REPEATABILITY OF ABNORMALITY AND PROGRESSION IN GLAUCOMATOUS STANDARD AND SWAP VISUAL FIELDS

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Abstract

Purpose: To evaluate the repeatability of the designations ‘abnormal’ and ‘progressed’ on standard (SAP) and short-wavelength (SWAP) visual fields.

Methods: From the authors’ longitudinal database of patients with both SAP and SWAP visual fields, 60 patients were identified with primary open-angle glaucoma or suspected glaucoma and multiple field tests (mean number of fields ±SD, 6.72 ± 2.51) with at least one abnormal standard visual field. Abnormal fields were defined as those outside the normal limits on the glaucoma hemifield test or with a corrected pattern standard deviation (CPSD) \( \leq 5\% \) of normal. Progression was based on a new scotoma with two adjacent previously normal points now at the 0.01 level, or two points adjacent to or in an existing scotoma depressed by 10dB or more.

Results: First time ‘converts’ (normal fields followed by two abnormals) remained converted in 44% for SWAP and 28% for SAP. Abnormality (including eyes abnormal on first visit) was repeatable for SWAP in 65%, and for SAP in 57%. A percentage of eyes with two abnormals in sequence returned to normal, but rarely did this occur after three abnormal designations. Progression was identified in 50% on SAP and 40% on SWAP. It was repeatable in 71% on SWAP and 67% on SAP.

Discussion: Variation in the field designations from normal to abnormal may be due to early physiological variation due to glaucoma, to the inherent variability in psychophysical testing, or to the use of less than optimum criteria for designating abnormality and progression. These are important issues for future research in glaucoma.

Conclusion: Abnormality by SWAP may be more repeatable over time, and identification of abnormality and progression improves with repeated testing.

Introduction

Identification of true progression of visual field defects is an important aspect of glaucoma management, yet it remains one of the most subjective. There is no gold standard for identifying progression, and there are few published studies which address this issue. However, several multi-center clinical trials involving visual fields...
have been initiated in the past few years, each using different definitions and algorithms for determining true change in the visual field. In the future, the results from these studies may assist us in formulating better definitions of visual field abnormality and progression. Currently, our challenge is to determine true change from that associated with the significant long-term fluctuation present in visual field testing. In this report, we evaluate the repeatability of results with a currently used definition for abnormality and another for progression.

Methods

To evaluate the repeatability of the designations ‘abnormal’ and ‘progressed’ on visual fields, we selected from our longitudinal database all patients with both standard automated perimetry (SAP) and short-wavelength automated perimetry (SWAP). In addition, we selected those patients with primary open-angle glaucoma or suspected glaucoma and multiple field tests (mean number of fields ±SD, 6.72 ± 2.51), who had at least one abnormal standard visual field, and who met the inclusion and exclusion criteria listed below.

Subjects

Each subject in our longitudinal study has undergone annual complete ophthalmological examinations, which included relevant medical history, best-corrected visual acuity, slit-lamp biomicroscopy (including gonioscopy), applanation tonometry, dilated fundoscopy, and stereoscopic ophthalmoscopy of the optic disc with a 78 D lens. Subjects were optimally refracted for all tests, and had pupil sizes equal to or greater than 3 mm.

Inclusion criteria

All subjects had best corrected acuity of 20/30 or better, spherical refraction within ±5.0 D, cylinder correction within ±3.0 D, and open angles. All subjects had reliable standard Humphrey 30-2 or 24-2 visual fields defined as <25% false positives, false negatives, and fixation losses on both SAP and SWAP. One eye was selected randomly from each subject, except in cases where only one eye met the study criteria and then that eye was included.

Exclusion criteria

Subjects were excluded who had a history of intraocular surgery, secondary causes of elevated IOP (exfoliation syndrome, pigment dispersion, corticosteroid use, iridocyclitis, trauma), intraocular eye disease, other diseases affecting visual field, or problems other than glaucoma affecting color vision.

Subjects for this study were primary open-angle glaucoma patients (n=42) and visual field converts (n=18) who had converted from normal to abnormal standard visual fields. Primary open-angle glaucoma was defined according to the presence of glaucomatous optic discs based on masked analysis of stereoscopic optic disc photographs showing either cup/disc asymmetry between two eyes ≥0.2, rim defect, notch-
Glaucomatous standard and SWAP visual fields

ing, excavation, or nerve fiber layer defect. In addition, these eyes had an initially abnormal Humphrey 24-2 standard visual field (verified by a second field) with a CPSD outside 95%, or glaucoma hemifield test (GHT) outside 99% of age-specific norms.

Converts had intraocular pressures $\geq 24$ mmHg on at least two separate occasions, normal or suspicious optic discs based on the above criteria, and initially normal standard visual field results defined as a CPSD within the 95% limits and a GHT within normal limits.

This study was approved by the Human Subjects Committee of the University of California, San Diego, and was undertaken with the understanding and consent of each subject.

Procedures

Both SAP and SWAP fields were obtained using a Humphrey 640 Visual Field Analyzer and Program 24-2. The perimetrist monitored fixation to increase the reliability of testing and to reduce errors which may result from relying on the Heijl-Kraau blind spot monitoring technique. Subjects were realigned and re instructed as necessary.

Definitions

Each standard visual field is graded as it is completed, and the information is placed in the database. The grading does not rely on classifications based on disc appearance or intraocular pressure, or previous visual fields, but solely on the results of the particular visual field in question. Abnormal fields were defined as those outside the normal limits on the glaucoma hemifield test or with a CPSD $\leq 5\%$ of normal, and with a cluster of $\geq 3$ points at the 5% probability, or worse. A visual field conversion required an initially normal field followed by at least two consecutive abnormal fields. Visual field progression was based on a new scotoma with two adjacent previously normal points now at the 0.01 level, or two points adjacent to or within an existing scotoma depressed by 10dB or more.

Results

First time converts (normal fields followed by two abnormals) remained converted in 44% (8/18) with SWAP and 28% (5/18) with SAP (Table 1). When a third follow-up was available, SWAP fields remained abnormal in 57% (8/14) and SAP fields remained abnormal in 38% (5/13).

Abnormality (at least two in a row, including eyes abnormal on the first visit) was repeatable for SWAP in 65%, and for SAP in 57%. See Table 2 for the pattern shown for all 60 eyes. A percentage of eyes with two abnormal fields in sequence returned to normal, but rarely did this occur after three abnormal designations. Some eyes showed several flips between normal and abnormal before remaining repeatedly abnormal.

Progression was identified in 50% of the eyes with SAP (21/42) and 40% (17/42) with SWAP. It was repeatable in 67% (28/42) with SAP and 71% (30/42) with SWAP (Table 3).
Discussion

The results of this study highlight the difficulties inherent in the use of visual field results to identify the presence of abnormal visual function and the progressive loss of visual function associated with glaucoma. The conversion from a normal visual field to an abnormal visual field identified with SWAP may be more repeatable than when found with SAP; and, the stability of the designations ‘abnormal’ and ‘progressed’ improves with more repeats. However, even with conservative criteria for conversion and progression, such as those employed in this study and others, a fair percentage of eyes will revert to previous baseline values.

These findings are consistent with those of other studies. Demirel and Johnson found that conversion was stable in 80% of ocular hypertensive eyes tested with SWAP (22/28) and 45% of eyes converted on SAP (13/29). Their definition of conversion was similar to

Table 1. Percentage of eyes that converted on SAP or SWAP

<table>
<thead>
<tr>
<th></th>
<th>Remained abnormal</th>
<th>Returned to normal</th>
<th>No third field</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAP</td>
<td>28% (5)</td>
<td>44% (8)</td>
<td>28% (5)</td>
</tr>
<tr>
<td>SWAP</td>
<td>44% (8)</td>
<td>31% (6)</td>
<td>25% (4)</td>
</tr>
</tbody>
</table>

Above the line, only one repeat was necessary (n=18); below the line, percentages were verified by a third follow-up

Table 2. Repeatability of abnormal fields ≥1 on SAP and SWAP (n=60)

<table>
<thead>
<tr>
<th>Field grade</th>
<th>SWAP</th>
<th>SAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal ≥3×</td>
<td>39</td>
<td>36</td>
</tr>
<tr>
<td>Abnormal 3×, then normal</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Abnormal 2×, then normal</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Abnormal 2×, no third field</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Flip-flops with eventual 2×</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Abnormal 1× only</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Abnormal 1×, no retest yet</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Flip-flops</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Categories above the line were for those with two abnormals in a row and a third field to verify

Table 3. Percentage of eyes with or without progression on SAP or SWAP and percentage repeatably identified so (n=42)

<table>
<thead>
<tr>
<th></th>
<th>Yes (%)</th>
<th>No (%)</th>
<th>Repeatable (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAP</td>
<td>50</td>
<td>50</td>
<td>67</td>
</tr>
<tr>
<td>SWAP</td>
<td>40</td>
<td>60</td>
<td>71</td>
</tr>
<tr>
<td>Both the same</td>
<td>72</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Glaucomatous standard and SWAP visual fields

ours. The results from the seventh year of the Advanced Glaucoma Intervention Study indicated that 33% of SAP visual fields returned to normal even after three consecutive six-month follow-up visits showing change. In this case, the definition for progression was based on the AGIS scoring method.

To further understand these results and to improve the stability of a given definition, we must use several approaches. The repeatability of abnormality or progression in visual fields is influenced by the type of field test, true physiological variability, variability inherent in the test procedure, the timing between tests, and the stage of disease. Well-managed long-term studies are extremely important. Within these, comparisons of different progression algorithms and evaluation at different stages of visual field severity may help us determine whether our algorithms should be adjusted as the field progresses. Improved diagnostic procedures with less inherent fluctuation would be very useful. And finally, comparison of field results with other measures of glaucomatous progression, such as changes in optic nerve appearance, may further increase the ability to accurately identify true glaucomatous change.

Acknowledgment

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Bibliography

The EMGT Investigators: The early manifest glaucoma treatment trial. www.nei.nih.gov: