Symposium on glaucoma

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Interpretation of tonometry and ophthalmoscopy

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I am asked to orient my presentation to the practicing ophthalmologist in developing general operational guidelines for interpreting tonometric and ophthalmoscopic findings. I shall focus my attention on the adult primary glaucomas and briefly allude to some secondary forms. In discussions of this nature, it is customary to speak of open-angle glaucoma because of the complexity of its detection and management as well as its insidious and virtually asymptomatic course. However, it is important to keep in mind that closed-angle glaucoma is not any less threatening to visual function of the adult and deserves equal attention because of its amenability to cure by a simple surgical procedure. Therefore, I shall point to findings that should arouse suspicion of this entity.

Key words: tonometry, ophthalmoscopy, glaucoma, optical pressure level, visual field

We have come to realize that open-angle glaucoma is not defined by ocular pressure level or by the appearance of the optic nerve head alone, albeit they play a major role in the assessment of the disease. The disease in its definitive stage is one in which a type of visual function loss becomes manifest and can be demonstrated in the visual field; one may add here that enlargement of the optic cup in the ocular hypertension is also evidence of glaucomatous ocular damage. Yet, ocular pressure alone does not always ex-
plain why one individual develops a glaucomatous field defect while another with a similar or higher pressure level fails to exhibit such loss. Clinical studies\(^1\text{–}^8\) have suggested that other factors, ocular and extraocular, influence the vulnerability of visual function to increased ocular pressure. Knowledge of these factors and of their presence in a given individual will markedly influence our assessment of tonometric and ophthalmoscopic findings and should, therefore, become part of the information that we seek in each patient.

**Examination**

We may consider our examination in two stages: The first, which is performed on each patient when he first consults an ophthalmologist, has the objectives of determining a level of suspicion of the likelihood that glaucoma—primary or secondary—may be present or is likely to develop and, in addition, taking into account those conditions that influence the validity of a tonometric reading. The second consists of special tests that are suggested by the findings of the initial examination.

**The first stage.**

**A. History.**

1. Personal information: age, sex, occupation, etc.

2. Ocular: history of trauma, surgery, inflammation, symptoms of acute ocular hypertension (blurred or reduced vision, halos around lights, headaches, redness of the eye, ocular pain, etc.), past suspicion of or therapy for glaucoma, and history of topical administration of medication containing glucocorticoids.

3. General: history of diabetes, thyroid dysfunction, systemic arterial hypertension and its treatment, conditions that are likely to produce arterial hypotension or severe anemia (chemotherapeutic agents, peptic ulcer, ulcerative colitis, shock, etc.), history of drugs that modify ocular pressure such as systemic steroid therapy and the recent ingestion of alcohol.

4. Familial: history of glaucoma or unexplained blindness.

**B. Visual acuity determination and refraction.** This is performed to detect the high myope and the hyperope.

**C. Ophthalmoscopy.** Our attention is focused on the optic nerve head and optic cup. An examination of the dimensions of the optic cup in relation to the disc and a careful comparison of the two eyes provide important information with respect to glaucoma detection. In this regard, the optic cup may be usefully described in terms of the C/D ratio\(^9\) (the ratio between the horizontal diameter of the cup and that of the disc). This ratio was shown to be genetically determined in the normal eye and related to ocular pressure and outflow facility; a C/D ratio greater than 0.3 occurs more frequently with high ocular pressure and with low tonographic C-values.\(^10\)

Studies of the earliest stage of open-angle glaucoma show that a C/D ratio greater than 0.3 occurs in 61 per cent, whereas in normal eyes its frequency is 15.3 per cent.\(^3\) Furthermore, in the normal state, the C/D ratio is equal for the two eyes; a difference between the two eyes of 0.1 or more occurs in 33 per cent and of 0.2 or more in 8 per cent. On the other hand, in early glaucoma, inequality in C/D ratio occurs at a much greater frequency (53 per cent and 41 per cent, respectively), indicating that acquired enlargement of the optic cup occurs early in the disease. Inequality of the C/D ratio is also seen in closed-angle and secondary glaucoma.

In addition, clinical studies suggest that the C/D ratio influences the vulnerability of visual function in the ocular hypertensive patient, such that eyes with large C/D ratios are more likely to become associated with glaucomatous field loss.\(^4\) This valuable predictive information can be obtained from careful ophthalmoscopy and comparison of the two eyes. This is especially important since tonometry be-
cause of technical considerations and/or variability of ocular pressure may not always yield a high pressure reading in the glaucomatous eye.

D. Slit lamp examination. Examination of the anterior segment is most important for proper assessment of the validity of tonometry and for detection of evidence of ocular hypertension or conditions likely to become associated with ocular hypertension. One should look for corneal scarring, irregularity of the corneal epithelium, edema of the cornea, endothelial disease, pigmentation on the posterior surface of the cornea, chamber depth, pupil irregularity and reaction, synechiae, iris contour and abnormalities, glaucomflecken, and pseudoxfoliation. Estimation of the chamber-angle width with the use of the method of Van Herick and associates with the slit aimed at the temporal limbus is especially useful for suspected angle closure susceptibility. In this method, the distance between corneal endothelium and iris is expressed as a fraction of corneal thickness; angle closure susceptibility should be suspected when this fraction is \( \frac{1}{4} \) or less.

E. Tonometry. Initial tonometry whether by Schiötz or Goldmann applanation tonometer is subject to the limitations of technique, test conditions, and the variability of ocular pressure in a given individual. In evaluating the significance of a given reading, one must take into account the above factors as well as those uncovered by history, refraction, ophthalmoscopy, and slit lamp examination. On the basis of this assessment we may end up diagnosing secondary glaucoma, suspecting closed-angle glaucoma or suspecting the presence of open-angle glaucoma or its likelihood in the future.

The second stage. On the basis of the above routine examination, we may elect to do one or more special tests depending upon the direction of our suspicion. If we suspect closed-angle glaucoma, we perform gonioscopy and, if necessary, a provocative test. This suspicion is not based usually on high tonometric readings but is evoked by findings in the history and slit lamp examination.

There remains the suspicion that open-angle glaucoma is present or is likely to develop in a given patient. It is obvious that in a disease such as open-angle glaucoma, the development of general guidelines based on tonometry and ophthalmoscopy is fraught with the danger of inevitable oversimplification. With this clearly in mind, I shall attempt to describe my performance in this respect.

On the basis of the initial examination, I like to develop the following categories based on applanation pressure readings:

A. Pressure readings of 20 mm. Hg or more. This group is the one in which a glaucomatous field defect must be suspected and should be ruled out specifically by visual field examination such as selective perimetry. The yield of glaucomatous defects in this group may be seen in Table I. The frequency of defects increases with age and with applanation pressure level. In this group, selective

<table>
<thead>
<tr>
<th>Group applanation pressure (mm. Hg)</th>
<th>Age (years)</th>
<th>No. eyes</th>
<th>No. eye defects</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-25</td>
<td>30-39</td>
<td>117</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>40-49</td>
<td>275</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>50-59</td>
<td>321</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>60-69</td>
<td>101</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>814</td>
<td>55</td>
</tr>
<tr>
<td>26-30</td>
<td>30-39</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>40-49</td>
<td>91</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>50-59</td>
<td>163</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>60-69</td>
<td>32</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>291</td>
<td>36</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>30-39</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>40-49</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>50-59</td>
<td>29</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>60-69</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>53</td>
<td>15</td>
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</table>
perimetry should be performed irrespective of other findings. In addition, gonioscopy should be performed for the proper classification of the chamber angle and consequently of the glaucoma, once it is definitely established. Should selective perimetry fail to demonstrate a glaucomatous defect such as a nasal step, paracentral scotoma, or pressure-dependent contraction of the isopter, the patient is classified as ocular hypertensive requiring special follow-up.

B. Pressure readings of 18 or 19 mm Hg.

The justification for this category lies in the fact that a significant portion of patients with field defects may have an initial pressure reading lower than 20 mm Hg. While it may be argued that performing selective perimetry on the large number of individuals in this category is impractical, one should, nevertheless, select those individuals with high glaucoma risk for this procedure. High-risk factors in this group will include older age, the presence of family history of glaucoma, high myopia, Krukenberg spindle, large C/D ratio, pseudoexfoliation, and one or more of the systemic factors that influence the vulnerability of visual function to increased pressure, be they vascular, metabolic, or endocrine. In addition, one may further reduce the number in the high-risk group by performing tonography or water provocative tests and selecting those with low C-values and a positive provocative test for selective perimetry.

If this subgroup fails to demonstrate a defect by selective perimetry, the high-risk individuals should be subjected to a yearly follow-up to ascertain that their ocular pressure level does not reach that of the first category and that their optic cup does not demonstrate an acquired enlargement.

C. Pressure reading less than 18 mm Hg.

While this group may not, for practical considerations, require any special examination, it should not, however, be considered as one free from future glaucoma risk. The high-risk members (described above) should be followed up by yearly examination to ascertain their ocular pressure status.

There remains members of the first group who fail to demonstrate glaucomatous field loss and in whom evidence of acquired enlargement of the optic cup cannot be definitely obtained on a single initial examination. Management of this group is, in general, one of regular careful follow-up for evidence of a damaging effect of ocular pressure, be it functional (field defects) or at the tissue level (enlargement of optic cup). These individuals are not at equal risk in this regard. High-risk factors are similar to those described above and include higher ocular pressure, greater age, positive family history of glaucoma, high myopia, large C/D ratio, inequality of C/D ratio, and the presence of the systemic factors defined previously. Individuals at higher risk are subjected to a greater frequency of follow-up. In general, individuals with applanation pressures of 20 to 25 mm Hg are seen every six months, whereas those with pressure readings greater than 25 are seen at three-month intervals. Follow-up includes monitoring ocular pressure level, appearance of the optic cup and the visual field. While appearance of the optic cup may be assessed by ophthalmoscopy and documented by detailed drawing on the patient's record, it is more objectively determined by fundus photography and, in particular, by stereophotography with fixed image separation.12

Our interest is to detect evidence of enlargement of the optic cup or reduction in the neural tissue of the optic disc. This latter may be uniform and affect a large segment of the rim or may be localized, in which case monitoring the course of the blood vessels becomes especially important in demonstrating change. Stereophotography provides a permanent three-dimensional record and thus greatly improves the sensitivity for detecting a change in
the dimensions of the optic cup. Such a capability greatly enhances confidence in conservative management of ocular hypertension and reduces markedly the number of individuals likely to be treated on the basis of suspicion alone.

Examination of the visual field should be performed by a competent individual, who is knowledgeable in the types of defects that we should be looking for in glaucoma and who has demonstrable ability in their detection. Selective perimetry in this regard is especially helpful for its high yield in the glaucomatous individual and its short performance time in the normal individual (six minutes on an average). When this type of follow-up can be enforced, conservative management is warranted. One may then use as his criterion for mandatory therapy of ocular hypertension, the development of field defect or of acquired enlargement of the optic cup.

Inevitably the question arises as to whether these are the only conditions that indicate therapy for ocular hypertension, and it must be answered in the negative. For such a recommendation can be made only in as much as reliable and sensitive monitoring of visual fields and optic nerve head is feasible and can be rigidly enforced.

If for any reason, be it referable to the eye, to the patient, or to the ophthalmologist, this regimen cannot be instituted or upheld, therapy for ocular hypertension may be recommended without the benefit of definitive diagnosis. In this case, however, our zeal in selecting the type or frequency of therapy should take into account the unfavorable circumstances that led to this decision. It will be greatly influenced by our assessment of the glaucoma risk in such patients, taking into consideration the factors that influence the development of glaucomatous damage.

REFERENCES