of fresh defects (Fig. 7). If the occurrence of maximal defects were the only sequence occurring in glaucoma then the chances of finding reversible and predictive signs in the visual field would be small and unlikely, but the early incomplete evidence, such as we have at this time, suggests that established defects do undergo change; this gives us hope that by employing more sophisticated physiological parameters of visual function such as spatial, temporal summation, size of receptive field, and their change with states of adaptation may lead to a reliable predictor during a reversible stage. This is being investigated at this time in our laboratories and clinics.

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The Bjerrum area in ocular hypertension

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Circular static perimetry was carried out on preselected points in the Bjerrum area on normal eyes and eyes with ocular hypertension. It was found that in the normal subject there was a decline in sensitivity with age, most particularly marked in the upper field. Eyes with ocular hypertension showed more reduction in sensitivity than normal eyes in the same age group. It is postulated that in ocular hypertension there is premature aging of the field in the Bjerrum area.

We have yet to establish a definition of the glaucomatous state and lacking this we are even less able to define the conditions variously called ocular hypertension, preglaucoma, or glaucoma suspect. For the purposes of this study, ocular hypertension was defined as follows: tension: 21 to 25 mm. Hg, with a 4 to 5 mm. rise on water drinking; tonography: C values 0.12 to 0.20 before or after water drinking, and Po/C values 100 to 150; optic disc: no ophthalmoscopically visible abnormality; visual fields: no abnormality detected on kinetic Goldmann perimetry; family his-

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In this study the visual fields were further investigated in an attempt to discover defects in the Bjerrum area which might not have been detected by our current techniques of kinetic Goldmann perimetry.

There is great individuality in the criteria for calling a field normal. Those who feel most at home with the 1/1,000 white target on the tangent screen know their own criteria of normality and have had these confirmed in practice. Others have accepted screening tests such as the Harrington Flocks and the like, as being clinically, at least, acceptable in large-scale surveys.

The first specific abnormality in the visual field in glaucoma is still uncertain. With highly accurate perimetry Aulhorn and Harms found scotomas in the paracentral area which gradually coalesced and joined the blind spot. Goldmann, Drance, and others have shown that in the Bjerrum area scotomas can be induced by artificial elevation of the intraocular pressure. This area seems to be the most sensitive to the effects of the raised pressure.

In our clinic the Goldmann perimeter is used for routine testing and gives us accurate and easily reproducible fields of the conventional kinetic type. There is, however, the need to survey the central area, and particularly the Bjerrum area, for small discrete scotomas which may be missed by the most fastidious kinetic perimetrist. Therefore, in addition to kinetic records, a static chart is constructed of the 15° isopter in the area most probably affected by the pressure rise in early chronic open angle glaucoma. The results of this examination are analyzed in this paper.

**Method**

Patients are tested with the pupils dilated with Neo-Synephrine 10 per cent; the full noncycloplegic distance correction plus addition for age as designated by Goldmann are used. The patient is adapted to the background perimeter illumination for ten minutes. The intraocular tension is taken at the end of the procedure. Kinetic perimetry is carried out prior to the static. All patients tested had clinically clear media.

The area to be screened by static perimetry is examined every 30° on the 15° isopter (Fig. 1). Static perimetry measures threshold retinal sensitivity on a given area of the retina and this is plotted in our graph as shown (Fig. 2). Since the test is carried out in a clinical setting it was felt advisable that the recording should be done on the readily available Goldmann static perimeter chart. The vertical axis is a log scale of sensitivity and is inverted. The horizontal axis shows the position of the retinal area as defined by the angle...
above or below the 0 to 180 horizontal axis. These values have been added to the standard static chart in the figure. It should be noted that the test is carried out on discrete preselected points in the field and that it is possible that small defects might occur between these and not affect the specific areas examined.

Results

Data were obtained on 33 eyes of normal subjects and 82 eyes of patients with ocular hypertension. The data were analyzed to obtain the mean, 5 per cent and 1 per cent confidence ranges, and t test at the 5 per cent and 1 per cent levels.

Normal subjects. The results in normal subjects were grouped in four decades and the values for each decade plotted. Fig. 3 shows the technique of plotting with the means, 5 per cent and 1 per cent confidence ranges marked on the standard Goldmann perimetry static chart. Fig. 4 is a plot of the mean of four age groups and illustrates the decrease in sensitivity to the test with increasing age. This decrease in sensitivity with age does not show t significant at the 1 per cent level. However, at the 5 per cent level there was a significant difference between the 40 to 49 age group and the 60 to 69 group. These differences were greater between the 40 to 49
Fig. 5. Comparison of normal subjects and suspects, aged 40 to 49.

Fig. 6. Comparison of normal subjects and suspects, aged 50 to 59.

Fig. 7. Comparison of normal subjects and suspects, aged 60 to 69.
Suspects. It was disappointing that no cases were found in which circular static perimetric screening of the 15° isopter picked up a scotoma which had not previously been discovered kinetically. I would emphasize, of course, that small scotomas which may be much closer to the fixation point would not have been picked up by our predetermined screening points.

Normal subjects and suspects. These were compared on the basis of age.

Normal subjects and suspects, 40 to 49 years old (Fig. 5). Twenty-eight suspects were analyzed; the mean of the suspects fell below the mean of the normal subjects and most are outside the 5 per cent confidence interval. The t test was not positive at the 1 per cent or the 5 per cent level.

Normal subjects and suspects, 50 to 59 years old (Fig. 6). Thirty-four suspects were analyzed and again t was not significant at the 1 per cent or 5 per cent levels, but the mean of the suspects was outside the 5 per cent confidence range in the upper field.

Normal subjects and suspects, 60 to 69 years old (Fig. 7). Twenty suspects were analyzed and the mean of the suspects fell outside the 5 per cent confidence range in the upper field.

No suspects were found in the 70 to 80 age group.

Normal subjects with Po/C greater than 190 (Fig. 8). Studies were carried out of “supersuspects.” In these, 10 eyes with Po/C greater than 190 were compared with their mean age group. It is interesting that the hydrodynamically worse eye shows no greater change from the normal than the eyes with lesser Po/C values.

These findings may be summarized by noting that in each age group the retinal sensitivity of the suspect is below that of normal subjects of his age group and that the upper field is more particularly affected.

Discussion and conclusions

Circular static perimetry is a useful and easily performed test when carried out by a well-trained and intelligent technician.

In normal subjects aging changes in the field are illustrated and these may be interpreted as follows: (1) a decrease in retinal sensitivity with age, and (2) reduction in transmission of light through aged media. The former has been detected in many retinal function tests and is, in fact, probably the true explanation. The latter is, I think, eliminated because of the care in selecting patients in the older age group.
who had clear lenses and clear media. All sources of artifact such as pupil size, refraction, etc., were carefully controlled so that errors of this type did not enter. The effect on the upper field is unlikely to be a lid effect since the test is done on a circular area and is only 15° from fixation. It is evident from these findings that, with the decline in sensitivity in the Bjerrum area, particularly superiorly, baring of the blind spot may occur with physiological aging.

The patient with ocular hypertension shows reduced sensitivity in the Bjerrum area in comparison to normal subjects of his age group. This is particularly notable in the upper field. This result agrees with the observed effects of artificially raised intraocular pressure on the visual fields, and leads to the hypothesis that patients with ocular hypertension show field changes of aging in advance of their chronological age. The accelerated aging change could result in blind spot baring at an earlier age than it may occur physiologically.

There was no increase in scotoma detection in the Bjerrum area with this technique.

The value of this screening technique in the diagnosis of glaucoma will become apparent only with sequential testing of this group of suspects. One will expect to see the normal aging pattern develop and the normal versus pathological rates for this will have to be established. Specific changes due to the glaucomatous process will be expected to be superimposed on the physiological ones. Currently decisions on individuals cannot be made until standards are established and more experience is obtained.

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REFERENCE


Differential diagnosis of the arcuate scotoma

David O. Harrington

Any discussion of the etiology and differential diagnosis of the arcuate scotoma or nerve fiber bundle defect in the visual field must start with the assumption that this is the typical visual field defect of established open angle glaucoma with optic nerve damage. It must also be recognized that the scotoma, as seen in glaucomatous eyes, can assume many forms. These variations in morphology, however, retain certain characteristics which make them recognizable as nerve fiber bundle defects long after they have advanced beyond the scotomatous stage to involve large areas of the peripheral and central visual field. These characteristics have been enumerated in articles¹ and textbooks of perimetry² and need not be discussed here.

It should be pointed out that the pres-