

Psychophysical testing in glaucoma

Glaucoma can be diagnosed as a group of conditions that share a characteristic topographic change at the optic nerve head (glaucomatous cupping) and pattern of visual loss (glaucomatous visual field defect). Usually the intraocular pressure (IOP) lies above the normal range. For a common complaint, the existence of which has been known for centuries, we ophthalmologists are not good at identifying its early stages or recognising progression of the established disease. We are quite good at measuring IOP but, with progression still occurring despite IOP levels within the normal range, quantification of optic disc and visual field changes are essential to good glaucoma management. The recognition of optic disc^{1,2} and retinal nerve fibre change^{2,3} predating observed visual loss has led to enormous efforts being made to characterise these features. Although we can record and describe them²⁻⁷ we are not good at measuring them.^{4,8} It is to be hoped that the current research with scanning laser ophthalmoscopes can resolve this problem, both for the optic disc and the peripapillary nerve fibres. In the absence of objective measurement data on optic disc change, the ability of visual psychophysics and electrophysiology to quantify visual change has an increasing importance.

Tests which examine specific aspects of retinal sensitivity – for example, in the discrimination of spatial or temporal stimuli, coloured stimuli, or stimuli of varying contrast, have frequently been advocated in the study of glaucoma.⁹⁻¹¹ Recent studies on experimental models of ocular hypertension, such as those described by Ofri *et al* in this issue of the journal and in more detail elsewhere¹² have provided good electrophysiological evidence for abnormal retinal sensitivity before the onset of clinical and/or pathological signs. It is the purpose of this editorial to assess the current position.

Quantification of visual performance took a major leap forward with the harnessing of computer driven software to the bowl perimeter. Current programs provide raw data which can be subjected to intense analysis. The cost of this development has been the capital expenditure, reduced patient throughput, and patient alienation. Inadequate training has led to the ophthalmic equivalent of 'garbage in, garbage out,' with medical dependence on 'the printout,' negating clinical skills and burying true visual field change. With training and test repetition the quality of data improves, allowing reliance to be placed on the results of data analysis. The earliest sign of disease remains focal depression of ≥ 5 dB at two or more contiguous locations repeated on retesting once or preferably on two occasions. As optic disc change is usually visible before then the role of this type of visual testing in distinguishing between 'converters' and 'suspect to glaucoma' will diminish as other more sensitive tests become established. Even for chronic glaucoma the time take per test, the test repetition needed to show change, the numbers of patients per clinic, and current financial restraints all conspire to restrict the use of computer assisted perimetry. It is most usefully employed in the diagnosis of established disease and the management of the younger high risk cataract free patient.

Raw data can be analysed in different ways. 'Global indices' can only provide an overview of loss, and cannot identify local disease progression. The glaucoma hemifield test and the glaucoma screening study, by comparing mirror image locations in the upper and lower hemifield, have a use in screening.¹³ Statpac 2 accurately demonstrates the difference between static and deteriorating locations.¹⁴ Peridata utilises cumulative frequency charts to identify focal and local loss

without specifying location. Pointwise regression analysis assumes this mode of change, and identifies both location and statistical significance^{15,16} as well as rate of change.¹⁷ Increasing reliance will be placed on these last two forms of analysis in the future for the management of chronic glaucoma.

The problems in identification of early 'disease' noted above have stimulated the drive to alternative approaches. 'Blue on yellow' perimetry uses a bowl perimeter, altering the current white on white to a yellow background with a size 5 blue target. Two recently published long term prospective studies have shown that defects are identified earlier.^{18,19} Isolation of one cone system seems to confer greater sensitivity to the detection process.²⁰ Universal adoption of this approach will depend upon the development of an easily applied system to identify the extent of reduced blue transmission by the patient's own optical media. There is some evidence that this question has been addressed, allowing earlier adoption of this 'coloured' approach to screening.²¹

Glaucoma screening tests which avoid the bowl perimeter can be seen to be more user friendly. The oculokinetic perimeter (OKP)²² offers rapid screening for established glaucoma for home or primary care use. Comparative tests which suggest that the original hole size creates targets equivalent to 15 dB, with a 95% confidence interval spanning 28 dB, suggest that some modification is needed.^{23,24} As was recently shown in this journal, these are under way.²⁵

High pass resolution perimetry²⁶ uses a television monitor to create circular targets in the central field of varying size. Each target consists of a light centre with a dark annular margin. The circles expand concentrically around the test location, where sensitivity at that location is inversely proportional to the size when seen. The test is rapid and user friendly; it has been shown to be of use in neuro-ophthalmology,²⁷ but has not been universally shown to be more sensitive than conventional perimetry.²⁸

Sensitivity to both flicker²⁹ and temporal³⁰ modulation of stimuli is reduced in glaucoma. Temporal modulation in the mid (8 Hz) and high (16 Hz) frequencies has corresponded well with blue on yellow defects and the subsequent development of white on white defects.¹⁸ However both stimulus condition and procedure need to be standardised before this approach can enter clinical practice.

Fine matrix mapping uses the scanning laser ophthalmoscope to identify very localised defects in retinal function. The advantages of direct visualisation of the test area need to be weighed against the time taken for the test and the limited size of the test area.³¹

Motion detection testing presents a moving target (a spot^{32,33} or bar³⁴) on a television monitor. The test identifies magnocellular function by noting the extent of the image displacement required for perception. Reduced perception has been shown to predate focal loss of white on white sensitivity by up to 3 years. Incorporated into a laptop computer it can be easily used as a screener in the Third World.³⁵ A multilocation test could become a useful visual screener in primary care centres.

The tests described are all influenced by non-visual aspects of the patient's response. The pattern electroretinograph is an electrophysiological test, measuring only the response from the inner retina, specifically the ganglion cells.³⁶ It has been shown to be reproducible, quantifiable, and predictive.^{37,38} The need for support staff and data interpretation means that it can only be used in the hospital setting. However, it may well become established for the early identification of glaucomatous disease.

To date the computer assisted bowl perimeter using 'white on white' targets is the standard for quantifying visual loss in glaucomatous disease and for monitoring change. The '5 dB limit' means that it will only identify gross change. To pick up early visual loss a psychophysical or electrophysiological alternative is required. One or more of the tests outlined above may well come to fit that role.

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