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AUTOMATED PERIMETRY

Every few weeks I receive yet another advertisement for the newest in automated perimeters. The mailman brings an elegantly printed brochure which shows a handsome ivory colored perimeter with an electronic plotter to display the fields. Its "intelligence" resides in a microprocessor which has been programmed according to the specifications of unnamed experts to select successive stimuli and correlate them with the patient's signalled responses. The machine in the brochure appears to be plotting the visual field of an attractive young woman sitting in front of it, who has placed her head in the chin rest and is gazing into the open hemisphere. Nearby, contemplating the scene with overt satisfaction stands a middle aged man in a white coat with whom, if I understand the copywriters correctly, I am to identify myself. For a modest investment of between twenty and ninety thousand dollars, I can take his place.

The brochure explains the sources of his satisfaction. The estimation of the visual field has hitherto been a bottleneck in his work. It made his days long and sometimes disagreeable. It reduced the number of operations he found time to do. It prevented him from spending time with his family. Since he acquired the automated perimeter all that has changed. The drudgery of examining thirty patients a day has dissipated. In a few hours' time, an aide with nothing more than a high school diploma has learned to operate the perimeter. Almost every day scotomata that would previously have been overlooked are picked up. There is the subtle, and sometimes not so subtle implication that only by availing myself of its preprogrammed assistance can I fulfill my professional obligations to my patients. "Better patient care" was the salesman's promise, and the brochure purports to illustrate how the promise can come true. Then too, the practical side of things is not forgotten. The perimeter has in effect created a new class of services rendered, justified a new set of charges, augmented the cash flow, and increased the depreciation allowances permitted on Form 1040. No wonder the perimeter's new owner looks content. A few days later, the salesman stops by my office. "Better patient care," he promises, and a higher net income. The salesman offers me his pen to sign the purchase order. But just as I am about to do so, second thoughts crowd into my mind. At this difficult juncture of trying to decide whether or not automated perimetry is worth the not insubstantial investment, I review what I have learned in all the years of measuring visual fields by hand. I try to pinpoint the clinical decisions that hinge on changes in the field. I try to assess the limitations of manual techniques and to determine, if I can, whether automated perimetry will actually overcome them.

The root problem of measuring the visual field is the discrepancy between the objective characteristics of retinal sensitivity and the patient's subjective experience of what he sees. It is a simple psycho-physiological fact that one can see objects at which one is not looking, that, in other words, one possesses peripheral vision in the technical sense. It is a fact, however, of which the patient is initially unaware. The rapid effortless unconscious motions of the eyes facilitate the illusion that the acuity is the same at all angles and that the visual field is everywhere equally sharp. One is unaware that the eyes are virtually always in motion, that the area of acute vision is constantly being repositioned, and that the visual scene that he perceives is actually a composite of numerous individual and identifiable visual impressions. The naive and natural response to a visual stimulus in the peripheral field, as all of us who have examined the visual fields of our patients know only too well, is to turn the eyes to fixate the object that has attracted ones attention. Thus there is a continuing functional integration of peripheral and central vision, and it is not at all surprising that some of our patients have difficulty distinguishing between the two.

When the examiner plots a patient's visual field for the first time, he is in fact a teacher. His initial task is to demonstrate to the patient that, while fixating on a central target, one can "see" in the periphery. Next the patient must be taught to respond consistently to peripheral stimuli. Finally the patient must learn to recognize scotomata. The identification of a strong peripheral stimulus is easy, and many patients understand immediately what is expected of

them. But the determination of just where a small target disappears into, and the precise point at which it reappears from the depth of a scotoma are judgments at times extremely difficult, and not even the most experienced and intelligent of patients can be certain. It is obvious and yet too readily forgotten that the sensitivity in the peripheral visual field determined in this manner is a function not only of the integrity of the retina and the optic nerve but also of the clarity of the media and of the steadiness of fixation. More than that, it is also a function of attention and discrimination, of the ability to coordinate and to perform simultaneously two separate visual tasks. The identification of the peripheral stimulus is a skill dependent in part on the patient's alertness and intelligence; it is a skill which improves with practice.

These considerations suggest that it might be useful to distinguish between retinal sensitivity on the one hand and the visual field on the other. The visual field has been described as an island of vision rising from a sea of darkness. But it is the spatial representation of retinal sensitivity which so appears as an island with a peak at the fovea, and with a shoreline that corresponds to the boundary of the sensory retina. This interpretation of retinal sensitivity is a model constructed from experimental data whose usefulness requires no re-emphasis. Confusion arises when one forgets that this model does not correspond to the patient's experience. What the patient sees is something quite different. He sees, by and large, what he expects to see. That is why he has difficulty in recognizing, not to speak of defining, a scotoma in the paracentral or peripheral visual field. It is true that in the trained experimental subject the isopters of the visual field and the sensitivity of the retina coincide. But in a large proportion of our patients the sensitivity of the retina, be it constant or otherwise, cannot be clinically calibrated, for it is obscured by unsteady fixation, wandering attention, intervening fatigue, and the intercurrence of both external and internal distractions. The visual field, therefore, that we are trying to plot is from a psychological perspective, an idealization. No wonder we have difficulties in getting consistent results.

The examination of retinal sensitivity is an idealization also from a purely geometrical point of view. It would require, allowing five seconds for each measurement, more than 316 24 hour days of continuous field testing to determine the sensitivity to four different intensities of stimulus of each square millimeter of the visual field at a distance of 330 millimeters. No perimetric technique, however automated it might be, can measure the visual sensitivity of but a small fraction of the retina. Thus to map the visual fields completely is out of the question. No visual field examination will do anything more than to sample the sensitivity of the retina at selected points. Which points are sampled, how frequently, and with how many different stimuli, these are matters of optimizing a cost-benefit ratio. The value of increased precision and completeness must be balanced against increasing expense. An exhaustive examination is precluded, however, not only by financial cost, but by the fatigue which attends prolonged examination and which makes the responses less and less reliable, until, after a certain point, valid initial data become obscured by error.

Automated perimetry is promoted with two distinguishable promises which are customarily lumped together, but which deserve separate consideration. The first of these promises is that when automated perimetry is substituted for manual procedures, there will be a net saving, accruing to the vendor or possibly to the purchaser of the health care in question. If an examiner is very busy with other tasks, so that his time is relatively valuable, then indeed the automated perimeter, if it can be operated reliably by a less skilled technician, may pay its way. However when the examiner, as is sometimes the case, is not fully occupied, his time is less valuable, and then manual examination of the visual field, requiring as it does minimal capital investment, becomes economically preferable. In any event, it would seem wise to defer so large a commitment of funds until a practice is firmly established and the cost-effectivenss of the machine can be confidently predicted.

The second issue is whether or not automated perimetry is inherently more reliable or sensitive than manual techniques. The major problem about field testing with conventional methods is that even in the best of hands they frequently produce inconsistent results. It is a common experience that if a field is repeated several times, a different result may be obtained on each occasion. Thus the real size of the field defect remains in doubt, and even more important, if the examinations in question have been separated by any substantial interval of time, one cannot tell whether the progression of field loss is apparent or real. As a result, one has accustomed oneself, however unsatisfactory it may be, to disregard small changes in the visual field, and to defer taking action until progression of field loss has been established beyond reasonable doubt.

The precise nature of the limitations of field testing is not generally recognized. An excessively mechanical interpretation of the visual function presupposes that the visual field coincides with retinal sensitivity and that given a cooperative and reasonably intelligent patient, a competent examiner should be able in every instance to plot a consistent and reliable field. Thus the difficulty of the task is denied and, ironically, its performance is then delegated to a technician or perhaps to a junior resident. Under these circumstances, the shortcomings of an unreliable field test are blamed on the subordinate, with the implication that the chief, had he not been busy with more important matters, might have done better. Apprised of this state of affairs, the electronic engineer comes forward and offers to help us by building what on first thought might appear to be the ideal examiner, a machine that can provide a reproduceable stimulus without getting tired or bored or impatient.

Can automated perimetry circumvent the limitations of field testing? It offers the great advantage of an absolutely reproduceable stimulus. Yet variation in the stimulus is relatively unimportant among the factors that account for the variability and inaccuracy of the visual field. Of far greater importance is the inconsistency of the patient's response which is often apparent even when, in the course of a single examination, the stimulus is evidently reproduceable. The basic assumption that at any given location in the visual field the patient's response to a stimulus should correspond to the sensitivity of the retina is valid only for a trained experimental subject. The average patient who has glaucoma usually lacks the qualities that make someone a good subject for psychophysical testing. Much of the variation that obscures the significance of clinical field examination almost certainly derives from fluctuations in attention and awareness to which the average patient is prone. When, as is often the case in elderly patients, the optical media are cloudy, the reliability of visual field measurements decreases even more.

Nothing that has been published suggests that automated perimetry solves the problem of the inattentive or unreliable patient or the problem of plotting a meaningful field in the presence of media opacities. Indeed it seems possible, and this is perhaps the greatest hazard of automated perimetric techniques, that a technician who has no other duty than to operate the machine, who is indifferent to the patient's state of mind and who knows nothing about his cataract or vitreous opacity, may misinterpret an apparent loss of field as being glaucomatous in origin, when in fact it is anxiety or inattention, lens opacity or vitreous infiltrate that is responsible. For the elderly, forgetful and confused patient, with perhaps poor central fixation or cloudy media, with short memory and defective hearing, automated perimetry will probably be even less reliable than manual techniques. Indeed, its uncritical use will give highly misleading results that would have been immediately apparent to a human examiner attempting to enlist the patients cooperation in the classical tangent screen examination. It is a common observation that the only truly satisfactory field examinations are those that are obtained on patients who by virtue of their intelligence and insight and by virtue also of their concern about their problem have acquired many of the characteristics of trained experimental subjects. Indeed clinical field testing is successful largely to the extent that the examiner is able to teach the patient to remain alert and objective in reporting what he sees. Thus field testing is a process of communication. One of the examiner's most important tasks is to evaluate the patient's understanding of the field testing procedure and interpret the patient's replies accordingly. Clearly any elaborate instrumentation is likely to interfere with this process. One of the reasons why tangent screen examination is so satisfactory is that close and reliable communication between patient and examiner may be so readily established. One of the disadvantages of automated perimetry is that it interposes a complex electromechanical device between patient and examiner which cannot but block the processes of communication that are so important in the interpretation and evaluation of the visual field examination.

Whatever scientific value the geometric model of the visual field may have, it is the purpose of field testing in clinical practice not to demonstrate retinal physiology but to obtain specific information essential to determining the treatment that the patient is to receive. We consider, therefore, the actual function which the information derived from the field examination fulfills in our diagnosis and treatment of the glaucoma patient. (It may be noted parenthetically that similar analyses are apposite in the evaluation of potential or actual field defects in diseases of the retina and of the nervous system, and that, mutatis mutandis, the conclusions to which we come about the glaucoma fields may well have relevance in those other areas also.)

As a screening technique for glaucoma, perimetry is unsatisfactory, because disease thus uncovered will be far advanced and would better have been detected

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by tonometry and ophthalmoscopy in an earlier stage. We do not wait for field loss to occur before initiating treatment for glaucoma. That decision is made on the basis of the pressure and the appearance of the disc. Information about the visual field is required primarily for one purpose: to ascertain whether, given the prevailing intraocular pressure, one may continue to treat the patient with medication or whether filtering surgery is required. This question arises in two distinguishable contexts. We encounter it in the situation where the disc is badly cupped and the tension remains significantly elevated on maximum tolerated medical therapy and after laser trabeculoplasty. Consider a patient with an excavated disc and a pressure that can not be brought below, for example, 34 mm Hg. If such a patient were found to have a nerve fiber bundle field defect, one would recommend prompt filtering surgery, since under those circumstances the likelihood of field loss progressing to blindness would be very great. If, on the other hand, no field loss were demonstrable, it would be essential, no matter which technique of examination had been utilized, to repeat the field examination at relatively frequent intervals because of the rapidity with which large amounts of field loss can occur under these conditions. The second situation where the results of field examination are decisive in determining the course of glaucoma treatment is where, given preexisting field loss, the tension has been brought to statistically normal levels but where a filtering procedure offers the possibility of lowering the pressure yet further. In this situation one would advise surgery only if there were evidence of progression of field loss, and it would be of the utmost importance to obtain precise and reproduceable fields. In both situations we now content ourselves with identifying gross and unmistakable alterations, and we have adapted our clinical decision making to the imperfections of our field testing techniques. More reliable methods of estimating visual field loss would enable us to proceed with greater confidence to the surgical treatment of glaucoma. Nonetheless, it is important not to forget that inaccuracy in the field examination is seldom the limiting factor in glaucoma therapy: When field examination is performed sufficiently frequently, its inaccuracy is almost never the cause of therapeutic failure.

How much help, if any, automated perimetry will provide us in monitoring the progression of glaucoma cannot be predicted on the basis of available data. The literature with which the manufacturers supply us is devoid of any meaningful calibration of their machines. We need to know how accurate the automated perimeters are, how reproduceable their results. We need to know what proportion of the population that has glaucoma lends itself to satisfactory examination with the automated perimeter. It is the absence of this information which makes one hesitate to place ones order. If automated perimeters are reliable and accurate, data to support their reliability and accuracy should be forthcoming. Until then, we would do better to stay with manual techniques.

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