Some of the technical difficulties could be overcome in the group of patients under 40 years old whose pressures were in the upper 20s and 30s but who had a normal disc. Dr. Spaeth had investigated about 500 cases and felt he had reasonable technical results in about one out of three of the patients with established glaucoma in the older age groups. He also felt that there should be at least a 2-second difference between the arm-to-retina circulation time and the arm-to-choroid circulation time for the phenomenon of reversal to be significant. However, Mr. S. S. Hayreh had seen filling of the choroidal circulation after the retinal circulation at longer intervals than this in perfectly normal eyes, and said that, so far, the method was unproven and required further investigation.

(2) PROGRESSION OF GLAUCOMA IN STEROID-INDUCED GLAUCOMA

Steroid-induced glaucoma is usually permanent but may regress, particularly in the early stages. Regression has been seen over several months and has been observed after a period of 10 years, but it is most unsafe to assume that the glaucoma has disappeared without very careful diurnal measurements, which must include a measurement of the pressure in the early morning with the patient *in bed*. The pressure may fall 5 mm.Hg within a few minutes of rising. Accurate diurnal curves are important in all patients with chronic glaucoma, both treated and untreated, but this is particularly true of cases of steroid glaucoma, in which the diurnal curve may remain abnormal for a prolonged period after the medication has been stopped.

(3) STEROID-INDUCED GLAUCOMA

An increasing number of children seem to have been treated with steroid drops, particularly for vernal conjunctivitis, and a large number of these have developed steroid glaucoma. Mr. Rice had two patients who were blind from steroid glaucoma which was irreversible. For the treatment of vernal conjunctivitis he now uses Intal which has no steroid-like effect and does not affect the intraocular pressure.

Diagnostic evaluation and therapeutic decision in the glaucomas

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The glaucomas are multi-parameter medical problems that can cause confusion if the physician fails to organize his approach and his thinking. Once he becomes confused or insecure, the tendency is to look for precise measurement, a "magic number" that will eliminate his insecurity. Unfortunately, there are no magic numbers in the evaluation and therapy of the glaucomas. To determine whether a patient requires more or less intense therapy solely on the basis of a Po/C value, or to rest one's diagnosis of chronic open-angle glaucoma on the patient's response to water-drinking, suggests at best a superficial understanding of glaucoma as a disease. It further suggests a failure to understand that the disease, glaucoma, is not simply the inverse of random population statistics.

Three general guidelines are useful when evaluating a glaucoma patient.

There are no magic numbers

Although the search for one in an endeavour to ease the burden on the physician's judgment will undoubtedly continue, the clinician should be cautioned that the evaluation and therapy of the glaucomas remains primarily an exercise in judgment.

Never jump to conclusions

In the midst of a busy practice, one is tempted to make judgments quickly, perhaps before all facets of the problem can be considered. Some glaucomas are so complex that premature decisions can be confusing to the physician as well as to the patient.

Avoid meaningless phrases

How often do we hear phrases such as "acute glaucoma" or "aphakic glaucoma"? Perhaps at times we are even tempted to use these ourselves. If we allow ourselves to use such meaningless diagnostic terms and, worse yet, to record them on charts, it is easy to see how problems in evaluation and communication occur.

The glaucomas lend themselves to a meticulous, methodical examination. When this has been completed, an accurate diagnosis can almost always be reached and a reasonable therapeutic approach designed. The initial examination should be completed in one day if at all possible, and should certainly not be allowed to drag out over several weeks. The "little bit now, little bit later" approach is like reading a Russian novel one chapter a week. By the time the third or fourth chapter is attacked, the reader has forgotten all the characters and is obliged either to begin again or to eliminate those characters which are not of immediate concern to him. Although at first glance a full initial glaucoma examination at one session may seem impractical in a busy office, it requires less time than the "little bit now, little bit later" approach and is certainly more reassuring to the patient. The following can be accomplished efficiently during a single consultation:

1. History
2. Vision
3. Optic disc evaluation
4. Slit-lamp examination and measurement of intraocular pressure
5. Visual fields
6. Tonography
7. Gonioscopy
8. Dilatation and peripheral retinal evaluation (if safe)

The order of testing is important. The physician will have two interviews with the patient. During his first interview, the first four parts are completed and at the slit-lamp examination, the physician determines whether or not the pupils may safely be dilated. This judgment can be quickly made in most instances by the Van Herick slit-lamp method (van Herick, Shaffer, and Schwartz, 1969). The physician then releases the patient to have the pupils dilated with a weak alpha-stimulating sympathomimetic agent such as 2·5 per cent. phenylephrine. Visual fields and tonography are then completed by the technicians and the patient returns for the second interview with the physician. Gonioscopy is now carried out and, if the angle is open, a rapid-acting parasympatholytic agent, such as tropicamide 1·0 per cent., is instilled into both eyes. The physician now evaluates the accumulated data, determines the necessary course of action, and discusses his conclusions with the patient. After this, indirect ophthalmoscopy of the peripheral retina can be carried out and the patient released.

The validity of tonography after the instillation of an alpha-stimulating sympathomimetic agent may be questioned. If one views tonography as a quantitative, highly

reproducible procedure that will ultimately be utilized in evaluating the therapeutic response of the patient, then this question is valid. A more reasonable view, in my opinion, is that tonography is a quantitative test helping one to determine the mechanism of the disease so that the small variations which may be introduced by the sympathomimetic agent (especially an alpha stimulator) are of little consequence in the average case. In contrast to this, visual fields must be quantitative if they are to be of value. Thus it is desirable that the pupils be dilated to at least 3 or 4 mm. and that the cornea be clear at the time of their determination.

Once this initial examination is accomplished, very few cases will remain confusing to the physician. Should such confusion exist, it may be necessary to repeat certain tests such as tonography at a later date, to consider diurnal variation, provocative testing, ophthalmodynamometry, blood studies, bilateral comparative gonioscopy, etc. These additional considerations are rarely necessary if the first examination has been properly performed and the physician has avoided premature conclusions and has forced himself to classify the disease while avoiding the meaningless diagnostic phrases referred to above.

A few comments are in order regarding each aspect of the initial examination. It is beyond the scope of this paper to do more than offer a few practical tips at each stage.

History

Since many glaucomas are known to be genetically determined, a careful family history is of obvious importance in establishing the diagnosis and perhaps of even greater importance in determining how vigorous the therapy should be.

It must be asked whether the patient has systemic hypertension and, if he is under therapy for hypertension, what specific medications are being used. Patients with systemic hypertension seem to tolerate intraocular pressures somewhat better than average and it is clear that glaucoma patients with systemic hypertension whose blood pressure is substantially lowered may experience a serious deterioration of the visual fields (Harrington, 1971). With this in mind the ophthalmologist must make his glaucoma patient aware of the hazards of reducing systemic blood pressure. The patient should understand that it is his responsibility to bring his general physician and his ophthalmologist into consultation should treatment for hypertension be suggested. Physicians are often unaware of the deleterious effect of antihypertensive medications in cases of chronic glaucoma, and the patient must therefore be properly informed so that he may be responsible for protecting himself against this possible hazard.

I suspect that patients are using eye drops prescribed for them by someone else or given to them by a pharmacist more frequently than we realize, and these eye drops not uncommonly contain cortisone. In spite of the considerable publicity that cortisone-induced glaucoma has received, we continue to see such cases. Very often the use of these cortisone-containing eye drops is most difficult to establish, either because the patient is embarrassed to be using eye medications not prescribed by an ophthalmologist or because they have been used so long that they have achieved the status of an "eye wash", and tend to be dismissed as unimportant.

Vision

The central visual acuity is not reduced in early chronic glaucoma. This statement seems obvious and yet from time to time I see a glaucomatous patient in consultation in whom vision is reduced to 20/40 or so, and whose physician has erroneously attributed this reduction in visual acuity to the glaucoma and has missed some other ocular disease or

pituitary tumour. It is also important that the patient's visual acuity be corrected to its best possible level if proper quantitative visual fields are to be obtained. A refractive error of as little as 0·5 D sph. on the Goldmann instrument can significantly alter the glaucoma visual field (Armaly, 1967b).

Optic disc evaluation

When evaluating the optic disc ophthalmoscopically, three specific observations must be recorded: cup diameter, cup asymmetry, and the optic nerve rim.

The diameter of the cup is important in assessing how much pressure the optic nerve will tolerate, whereas the rim of the optic nerve gives a clue as to whether or not visual field change should be anticipated and where the defect may be located. While it is sometimes impossible to determine whether a large cup (greater than 0·3 cup : disc ratio) is due to glaucoma or to a familial trait, it is best to assume that such a cup will withstand intraocular pressure less well than smaller cups regardless of its origin (Armaly, 1970b). Cups with a vertical diameter greater than the horizontal are more likely to be glaucomatous (Anderson and Kirsch, personal communication).

Asymmetry of optic cupping is an exceedingly important finding, especially if it is marked, *i.e.* greater than 0·2 difference in cup-disc diameter between the right and left eyes. This amount of asymmetry occurs in less than 1 per cent. of the population (Richardson, 1968; Snydacker, 1964), compared to 50 per cent. of the bilateral chronic glaucoma patients (Armaly, 1970b). Neither the optic cup size nor the frequency of asymmetry is affected by age.

The rim of the optic nerve should be observed for uniformity, colour, and haemorrhages. A localized narrowing of the rim, especially if the colour (capillarity) is reduced, is a strong suggestion that visual field loss may be anticipated in the related area of the visual field. Haemorrhages on the optic nerve rim may mark an acute decompensation of the vascular system in a chronic glaucoma patient and are often associated with corresponding visual field change (Begg, Drance, and Sweeney, 1971). Their presence is transient so that observation is fortuitous. When they are found, they are of extreme importance.

Intraocular pressure

It is established that intraocular pressure as measured by the Goldmann applanation tonometer is more accurate than that measured by Schiötz tonometry, primarily because of the errors that may arise with the latter in eyes with decreased scleral rigidity. The primary reason that applanation tonometry is less affected by decreased scleral rigidity than Schiötz tonometry is the small amount of displaced volume which occurs during Goldmann applanation tonometry (0·5 µl.) compared to Schiötz tonometry (12·5 µl.). *Not all applanation tonometers displace the same volume as the Goldmann instrument.* Although the applanation method has some inherent advantages over the indentation method, the difference in displaced volume is the most important single factor to be considered when attempting to design an instrument which is free from error related to decreased scleral rigidity. The critical question to ask when any new tonometer is suggested is "what volume does it displace when it is applied to the cornea?", not "is it an applanation unit or an indentation unit?"

Both Schiötz and the Goldmann instruments tend to read low when applied to oedematous corneae and there is a suggestion that the Mackay-Marg may be a more accurate instrument under these conditions (Wind and Irvine, 1969).

Much excellent work has been done to determine the distribution of intraocular pressure in the randomly distributed population. It is critical that the clinician recognizes that

these population statistics by themselves cannot be used to predict the likelihood that any given pressure is glaucomatous. Although it can be demonstrated that *in the randomly distributed population* the chances of having an intraocular pressure greater than 24 mm.Hg are only one in 666, this *cannot be taken to imply* that the odds are 666 to 1 that an individual with a pressure higher than 24 has glaucoma. In order to make such a prediction, it is necessary to know the distribution of intraocular pressures (untreated) in the chronic open-angle glaucoma population and the size of this population relative to the non-glaucoma population. It seems likely that, when such statistics are available, the chance that any given patient with a pressure in the mid- to high 20s will have glaucoma is about 50 per cent. The application of random population statistics relating to tonography and Po/C is also invalid in arriving *directly* at conclusions regarding the glaucoma population. *If magic numbers are ever derived (and this is very doubtful) they will be derived from comparing the randomly distributed population with the glaucoma population and not by attempting to convert the random population statistics into a form which is representative of the glaucoma population.*

Visual fields

An honest appraisal of one's own capabilities in measuring the visual fields is mandatory. Excellent glaucoma fields are difficult to achieve even if one has first-class equipment such as the Goldmann perimeter. The technician (or physician) is the critical factor in obtaining good glaucoma visual fields. Given a superb technician, visual fields can be the key to excellent glaucoma management whether the tangent screen or the Goldmann perimeter is used.

The earliest changes in the visual fields in patients with glaucoma are small circumscribed paracentral scotomata (Aulhorn and Harms, 1967; Armaly, 1969b; Drance, 1969; Fisher, Carpenter, and Wheeler, 1970), which can best be demonstrated with small test objects such as the Goldmann I_2 or the tangent screen 1/1000. It is necessary to present these test objects in a random off-on scatter sequence within Bjerrum's region and central to it. This can be accomplished on the Goldmann instrument with the silent (be sure to keep it silent) on-off switch, and on the tangent screen wand by placing the test object on the side of the wand rather than on its end, and then rotating the wand so as to cause the test object to disappear and reappear. The more standard kinetic methods which are so useful in outlining large geographical changes are ineffective in demonstrating *early* glaucoma scotomata. The "lumiwand" can be useful in demonstrating these scotomata, providing some illumination is directed at the patient's face so that fixation can be observed. Nasal depression with an associated step is also a useful early sign, although it is rarely the presenting sign (Aulhorn and Harms, 1967; Lynn, 1969). Usually the circumscribed scotomata occur at the same time or before the nasal depression. Concentric contraction of the visual field is much more common in the glaucoma population than in the general population (Armaly, 1967b), but is generally not a helpful early sign of glaucomatous damage because of its non-specific nature. Blind spot baring is not a useful sign of early glaucoma since it can be demonstrated in most normal subjects if threshold value stimuli are used (Drance, 1969).

Tonography

This is not a necessary component of every glaucoma evaluation, but its usefulness in understanding the mechanism of certain cases cannot be doubted and, if available, it should form part of each evaluation. In my view, tonography serves two useful purposes

for the clinician. It helps to define the mechanism of the glaucoma and to determine whether or not medical therapy is likely to succeed. So many errors of interpretation are associated with tonography that it should probably be considered a qualitative and not a quantitative test.

If chronic open-angle glaucoma is a disease characterized by morphological changes in the optic nerve and by visual field alterations and not by a number (unless the patient's intraocular pressure is so high that one can confidently predict damage before it occurs), tonography is unnecessary in diagnosis, but it may be used in a somewhat different context. I find the concept of *zone tonography* to be clinically useful (Table).

Table *Zone tonography*

Outflow		*Glaucoma*
High zone	>0·18	Absent — normal Present — hypersecretion error
Mid-zone	0·12—0·18	Absent — hyposecretion Present — medical control likely
Low zone	0·06—0·12	Absent — hyposecretion Present — medical control unlikely
Paradoxical zone	<0·06	Pressure response to miotics unpredictable

Gonioscopy

This is obligatory in every glaucoma evaluation. It is the principal means of determining the mechanism of the disease. Shaffer's angle grading (Kolker and Hetherington, 1970a) has been very useful in establishing a communication system which can be easily noted on the patient's record. Excellent gonioscopy can be accomplished with either the indirect (Goldmann) or the direct (Koeppe) method. Contrary to popular opinion, the Koeppe method is faster once the technique has been perfected. The Koeppe lens without a dimple is preferred, since direct ophthalmoscopy can be performed directly through the lens gaining an effective 25 per cent. magnification of the pupil size and allowing ophthalmoscopy through miotic pupils more easily than when the ophthalmoscope is used without the lens. In the few cases in which it is necessary to hold the lens in place, this can be accomplished with the rubber portion of an eye dropper or similar object, making the dimple unnecessary.

Dilatation and evaluation of the peripheral retina

Providing the patient does not have potential angle-closure glaucoma, the pupil should be dilated and the peripheral retina examined with the indirect ophthalmoscope. Peripheral degenerative disease, particularly lattice degeneration, should be searched for so that the clinician can better interpret the symptoms of floaters and flashes which so often occur in patients using miotics. It is also desirable to temper one's judgment regarding the use of miotics, particularly the anticholinesterase agents, in individuals with lattice degeneration.

Once a methodical examination of the glaucoma patient has been accomplished, it is important to document the accumulated data in a manner which is easy to record and

simple to review. We have devised a rubber-stamp proforma (Fig. 1) which has proved useful in organizing the data acccording to mechanism (gonioscopy and tonography), functional status (discs and visual fields), and control (medication and adequacy of pressure response).

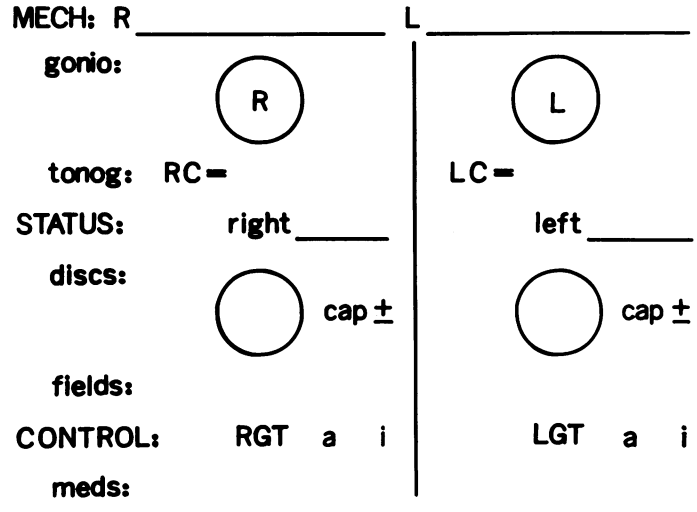

FIG. 1 *Proforma for recording results of examination*

MECH – mechanism
cap – capillarity
GT – Goldmann tension
a – adequate control
i – inadequate control

A classification of the functional status of the chronic glaucoma patient is summarized in Fig. 2.

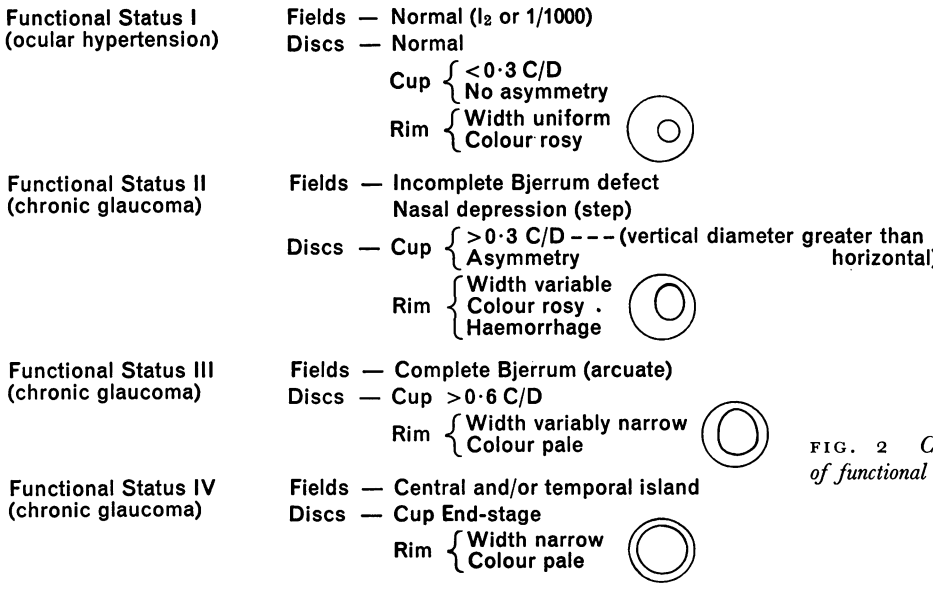

FIG. 2 *Classification of functional status*

Decision making in the glaucomas is greatly simplified if the physician has a clear understanding of the disease mechanism, the functional status of the patient, and whether or not he is controlling the intraocular pressure satisfactorily in relation to the functional status. I have found the foregoing to be a useful pattern of evaluation. By using such a methodical approach, most glaucoma problems can be satisfactorily assessed and the information quickly recorded in a way that can be easily retrieved or communicated.