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PREFACE

Those who are concerned with patients suffering from glaucoma may justifiably become somewhat confused by the abundant literature which has accumulated upon the subject. They are confronted on the one hand with a formidable assortment of involved mathematical calculations (which appear to be based on somewhat insecure foundations) and on the other hand with a rather vaguely defined theory of neuro-vascular malfunction. It is to be hoped that in due time the mechanistic side of the problem will become easier to understand and will be based upon sounder evidence; it is to be hoped, too, that it will be possible to specify more accurately the nature and site of the malfunction of the parts of the eye, and to define which vessels and which nerves are abnormal and in what sense. In the meantime, however, with his patients depending upon him for the preservation of their eyesight, the clinician must labour on.

This book is an attempt to present the views of a practising clinician who, although fully appreciative of the efforts of those devoted workers in library and laboratory, nevertheless tries to put forward in a simple way that which is practical and actual in the diagnosis and management of glaucoma.

This is not, therefore, a book for the research worker or the ardent controversialist, but one for the clinician who is interested to know the approach of a colleague to a difficult subject.

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R. J. H. S.

CONTENTS

CHAPTER ONE

DEFINITION, GENERAL CONSIDERATIONS, AND CLASSIFICATION

Although in theory, as Sugar (1957) has pointed out, it is probably more correct to refer to 'the glaucomas' than to 'glaucoma', it remains the usual clinical practice to use the latter term for that group of eye diseases characterized by undue hardness of the eyeball. It seems justifiable to use the term in the singular, for, although glaucoma has many causes, the several types tend to increase their resemblance to one another as the pathological changes become more advanced. In the end all types may present almost identical symptoms and signs.

When glaucoma has become absolute it is certainly one disease; but it is in the detection, differential diagnosis, and appreciation of the great variation in aetiology and consequent clinical behaviour in the early stages that may be found the key to rational management of the individual case and prevention of progression to the dismal end of blindness and pain. For, at the outset, it is as well to remember that glaucoma is the commonest cause of total and irremediable blindness; cataract can be removed, macular degeneration destroys only central vision and inflammatory diseases usually leave some sight in the affected eye, but in absolute glaucoma no treatment is possible and all sight has gone.

Duke-Elder (1940) described, rather than defined, glaucoma not as a disease entity but as embracing a 'composite congeries of pathological conditions which have the common feature that their clinical manifestations are to a greater or lesser extent dominated by an increase in the intra-ocular pressure and its consequences.' He went on to point out that elevation of the intra-ocular pressure was a symptom which should not be regarded as the disease process itself, and concluded that it was not justifiable to speak of the pathogenesis of glaucoma, unless it were to be understood that the concept embraced the aetiology of many diseases all characterized by a common symptom. On the other hand, it must be admitted that

repeated or persistent raised intra-ocular pressure is the essential abnormality which is directly responsible for almost all, if not all, the immediate or late pathological changes in glaucoma. It seems therefore to be understating the case to dismiss raised intra-ocular pressure as a symptom unless it is transient and non-recurrent.

Glaucoma may, then, be defined as an ophthalmic disease characterized by *persistent or repeated elevation of the intra-ocular pressure which eventually causes certain pathological changes in the affected eye.* There are, however, several difficulties about a definition of glaucoma. An eye may present a raised pressure without apparent ill-effects; it is then a matter of individual choice whether it should be considered glaucomatous or only pre-glaucomatous. An eye may present certain features suggesting that a raised pressure might reasonably be expected to occur in the future, or it may be known that the exhibition of a mydriatic is very likely to give rise to a severe attack; in either event one might consider such an eye to be potentially glaucomatous or, alternatively, as truly glaucomatous but in an early stage. Finally, cases occur from time to time in which there are signs and symptoms indistinguishable from those found in advanced glaucoma but in which the intra-ocular pressure appears to be consistently normal. The tendency has been to apply the term pseudo-glaucoma or 'soft' glaucoma to these cases, but some have regarded them as a special form of optic atrophy due to unknown causes and not to glaucoma.

The exact place of such conditions in a classification of glaucoma remains obscure, but if they are to be included the definition of glaucoma has to be extended to embrace them as follows: *An ophthalmic disease characterized by persistent or repeated elevation of the intra-ocular pressure which eventually causes certain pathological changes in the affected eye; or by a state in which it is known that under certain physiological conditions a pathological rise in intra-ocular pressure can be induced; or by a state in which the eye, in the absence of demonstrably raised intra-ocular pressure, shows signs indistinguishable from those usually resulting from raised intra-ocular pressure and for which no other reason can be found.*

For convenience of description, therefore, the clinical approach to glaucoma is the approach to one disease, with the usual discipline of attention to incidence, aetiology, the relevant anatomy and physiology, pathology, symptoms and signs, clinical course and complications, differential diagnosis, treatment and prognosis.

However, before proceeding to a description along these lines mention must be made of the problem of classification.

According to Duke-Elder (1940) it is useful to admit a classification into two groups: '*Secondary glaucoma*, wherein the symptom of raised pressure is due to some obvious ocular lesion which is known, and *primary glaucoma*, wherein the raised pressure is due to some inobvious cause at present unknown.' He points out that since in the end it must be that all cases of glaucoma are secondary to one condition or another, this classification is rather unsatisfactory in that it is not really scientific but has boundaries drawn by the state of human knowledge rather than by natural phenomena. Furthermore, amongst many clinicians the term secondary glaucoma has unfortunately tended to take on one particular connotation, that of raised intra-ocular pressure in the presence of active uveitis, with the very unfortunate consequence that a standard form of treatment (mydriasis) has tended to be advised indiscriminately in such cases. It is tempting, therefore, to drop the terms primary and secondary altogether and to classify the disease with strict regard for its aetiology where known. The result, however, would be a formidable list without the easy division into groups that a satisfactory classification should produce. Thus, a compromise must be sought in which due regard for aetiology is observed and yet one in which, as Sugar (1957) puts it, 'the time-honoured terms primary and secondary' are retained.

As Sugar points out in discussing the problem of classification, the only type of glaucoma in which the aetiology remains completely unknown is chronic simple glaucoma, and all the other types could, therefore, justifiably be classified as secondary. Sugar adds: 'It is only a step further to avoid the terms primary and secondary entirely and simply to classify each type of glaucoma according to its causal relationships.' He takes the eminently reasonable view that the primary glaucomas are those which do not follow, or are not associated aetiologically with, other ocular disease, even though the cause, which may depend on an anatomical predisposition (for example a narrow filtration angle) or a physiological factor (such as dilation of the pupil), is well known.

This of course still leaves the situation with regard to classification far from perfect since one is including in the primary group cases with an anatomico-physiological basis—cases, it might be thought, with a congenital anatomical deformity—together with cases (the

chronic simple group) in which the aetiology remains unknown but which may eventually prove to be of a truly pathological nature. It is most probable, in fact, that more than one aetiological factor exists in this latter type, since there is considerable variation in clinical behaviour from case to case.

In spite of the difficulties and imperfections already mentioned it is proposed to retain, for the present at least, the traditional division into primary and secondary glaucoma but to classify the disease with strict regard to aetiology where this is known. It is proposed to drop entirely the term 'congestive', as this has become so strongly identified with a particular phase of closed-angle glaucoma that to use it in connection with any other type can give rise to misunderstanding regarding aetiology. In any case the term is too vague to be of scientific value, serving only to give a single descriptive connotation to multiple signs and symptoms such as redness, pain, corneal oedema, haloes, and marked blurring of vision (which may be present only in part) in the particular case which is being classified.

For those not familiar with the subject the following classification will not be easy to understand, as much of it depends upon pathological and aetiological features to be described later. It is thought best, however, to state the classification at the beginning so that the ensuing subject matter may be read in the light, however dim and flickering it may be, that the classification throws upon the problem of glaucoma. It is intended as a frame, set at the start and into which it is hoped to fit the jumbled, frustrating and often mystifying pieces of personal clinical experience.

CLASSIFICATION OF GLAUCOMA

Primary Glaucoma

A. CHRONIC SIMPLE GLAUCOMA

B. CLOSED-ANGLE GLAUCOMA: acute; sub-acute; insidious; chronic; inverse

C. INFANTILE GLAUCOMA

Secondary Glaucoma

A. HYPERSECRETION OF AQUEOUS HUMOUR

B. OBSTRUCTION TO OUTFLOW OF AQUEOUS HUMOUR BY
   1. **Trabecular blockage**

(*a*) *By the iris*
- (i) Pupillary blockage due to: occlusio or seclusio pupillae; anteriorly dislocated lens; air; vitreous humour
- (ii) Peripheral anterior synechiae (goniosynechiae): post-inflammatory; post-traumatic; post-operative
- (iii) Pushing forward of the iris: swollen lens; bulky neoplasm
- (iv) Essential atrophy of the iris and congenital 'aniridia'

(*b*) *By trabecular clogging with*
- (i) Blood
- (ii) Inflammatory or malignant cells
- (iii) Lens debris
- (iv) Pseudo-exfoliation of the lens capsule
- (v) Vitreous humour (aphakia and dislocated lens)
- (vi) Pigment
- (vii) Siderosis bulbi

(*c*) *By trabecular organization due to*
- (i) Rubeosis
- (ii) Post-inflammatory membranes
- (iii) Epithelialization of the anterior chamber

2. **Blockage of Schlemm's canal**
3. **Blockage or congestion of veins in the sclera, episclera or further posteriorly**

C. EXACT MECHANISM UNKNOWN

1. **Toxic**
   Corticosteroids
   Sanguinarine poisoning (in epidemic dropsy)
2. **Certain congenital abnormalities**
   Sturge-Weber syndrome; neurofibromatosis
3. **Miscellaneous conditions**
   - (i) Glaucomato-cyclitic crises (Posner-Schlossmann syndrome)
   - (ii) Posteriorly dislocated lens
   - (iii) Retinitis pigmentosa
   - (iv) In non-purulent keratitis (herpetic keratitis)
   - (v) Iridoschisis
   - (vi) Marchesani syndrome

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CHAPTER TWO

THE INCIDENCE OF GLAUCOMA

Glaucoma may occur in all races and at all ages and is common as a complicating factor or terminal state in many serious eye diseases. Thus it may follow injuries, inflammations, and neoplasms, and its incidence in these disorders will depend upon the incidence of the disorders themselves. Where, however, glaucoma has a cause unconnected with other ophthalmic diseases, for example the anatomical peculiarity found in primary closed-angle glaucoma or the deposits found in 'pseudo-capsular' glaucoma, or has no known cause, as in chronic simple glaucoma, the incidence follows a fairly regular pattern.

ABSOLUTE INCIDENCE

Since glaucoma is not a registrable disease its absolute incidence in the population of Great Britain is not accurately known. Mass surveys by a number of authors (Carpenter, Brew, and Seidel 1950; Vaughan *et al.* 1957, in the United States; Reed and Bendor Samuel 1957, in Canada; Richter and Sautier 1956, in Germany; as well as others) suggest that the incidence is in the region of 2 per cent. of the population over the age of 40 years. Studies of the incidence in all new patients attending the ophthalmic outpatient clinics of the Western Ophthalmic Hospital and St. Mary's Hospital in London also suggested an incidence of 2 per cent. This level appears to remain remarkably steady; the design of the glaucoma clinic serving the two London outpatient clinics was based on an expected incidence of 2 per cent., and that figure has been almost exactly maintained for the last five years.

Sorsby (1956), in an analysis of the causes of blindness in England and Wales for the years 1951–4, found that glaucoma was the third commonest cause of new blind registrations; it accounted for just under 15 per cent. of all causes of blindness in the age group 50 years and over and was exceeded only by cataract and macular degeneration.

RELATIVE INCIDENCE OF THE VARIOUS TYPES OF GLAUCOMA

There is a surprising scarcity of data in the literature to indicate the relative incidence of the various types. Several studies have been published concerning the proportion of *chronic simple* to *closed-angle* cases and there appears to be a consensus of opinion that the chronic simple cases outnumber those of closed-angle glaucoma. Gradle (1931), Carvill (1932), and Lehrfeld and Reber (1937) found a considerable preponderance of chronic simple cases in their series; but it must be borne in mind that their mode of classification depended more upon the clinical 'congestive or non-congestive' behaviour of their cases and was not based upon an aetiological approach. Sugar (1951), studying cases seen after Barkan's (1938) classical description of narrow-angle glaucoma, also found a preponderance of chronic simple cases. Figures emanating from glaucoma clinics may not give a true picture of the relative incidence of the various types in a population. Depending upon the method of reference, the cases seen in these clinics may be subject to selection, the acute cases, for example, finding their way directly into an emergency bed not having been seen by the glaucoma clinic.

A study designed to allow for this factor was carried out at the Western Ophthalmic Hospital (Smith 1958). The absolute incidence of the various types in patients presenting at the hospital was compared with the incidence of cases referred to the glaucoma clinic in the normal course of events, and the statistics relating to the two groups of patients are shown in Tables I and II. Group A consists of 506 patients referred to the clinic during a three-year period in the

TABLE I. *Group A Cases*

All Cases	No.	Primary Glaucoma	
		No.	%
Closed-angle:			
Acute	95	209	56·7
Proved	32		
Probable	66	134	36·3
Not proved	16	25	7·0
Total closed-angles		368	100·0
Chronic simple	134		
Type unknown	25		
Total primary glaucomas			
Secondary glaucoma	38		
Glaucoma suspected	17		
Not glaucoma	83		
Total cases	506		

normal manner, that is to say at the discretion of the various surgeons concerned. It will be seen from Table I that, of those patients eventually diagnosed as suffering from primary glaucoma, 56·7 per cent. were of the closed-angle type, 36·3 per cent. only were of the chronic simple type, and 7 per cent. were of 'type unknown'. (The latter consisted of patients operated upon before being seen in the clinic who were found to have extensive occlusion of the filtration angle by goniosynechiae and in whom there was no clear history of the original type of glaucoma.)

Group B consists of 102 patients who were specially assembled to show the true incidence in the hospital. During one year all cases, including all acute admissions, of three of the surgeons' outpatient clinics at the hospital were seen by a member of the glaucoma clinic staff and a strict type-diagnosis was made. It will be seen from Table II that this procedure revealed quite surprising figures. No less than 73 per cent. of the cases were of the closed-angle type, 24 per cent. of the chronic simple, and 3 per cent. of type unknown. It is probable that the high incidence in this series of the closed-angle type is due to the care which was taken to include all the acute cases. Furthermore, as will be seen later, there is little doubt that a fairly substantial number of closed-angle cases are permanently cured by surgery, thus giving a lower reattendance rate in routine out-patient clinics than the less fortunate chronic simple cases. This would tend to add to the widely-held impression that the latter is the commoner variety; probably it is commoner in terms of total attendances but certainly not in those of initial incidence.

TABLE II. *Group B Cases*

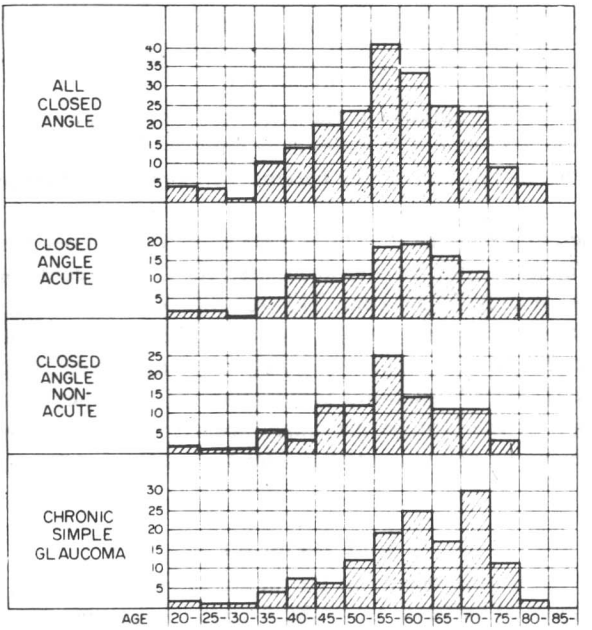
All Cases	No.	Primary Glaucoma	
		No.	%
Closed-angle:			
Acute	20	48	73·0
Proved	11		
Probable	10	16	24·0
Not proved	7	2	3·0
Total closed-angles		66	100·0
Chronic simple	16		
Type unknown	2		
Total primary glaucomas			
Secondary glaucoma	6		
Glaucoma suspected	9		
Not glaucoma	21		
Total cases	102		

The incidence of that type of glaucoma associated with pseudo-exfoliation of the lens capsule (to be described later) was only 2 per cent. in the Western Ophthalmic series and the figures from the Institute of Ophthalmology, London, tend to support this. Holst (1947), however, found a very much higher incidence in Norway, where it was as much as 82 per cent. At present there is no known reason for this striking difference; it is certainly not the result of differing methods of observation, since Thomassen (1949) confirmed the low incidence in England, where he found only 2 per cent. of cases compared with 79 per cent. in Oslo.

AGE INCIDENCE

Advancing age seems to predispose the eye to both closed-angle and chronic simple glaucoma, and pseudo-capsular glaucoma is

TABLE III. *Age Incidence in Primary Glaucoma (Western Ophthalmic Series)*



almost entirely confined to patients over the age of 60 years. Closed-angle glaucoma appears to have a slightly earlier age of onset than chronic simple—55 years compared with 58 years.

However, it is doubtful if these figures are of much significance since the exact age of onset is often impossible to estimate accurately. For instance, there is a difference in age incidence between acute closed-angle cases and cases of similar aetiology but with a non-acute type of onset, the former having an average age of onset of 53 years and the latter an average age of onset of 57, but this is probably due to the rapid diagnosis of the acute type and is therefore fictitious. It is quite possible that chronic simple glaucoma may exist in a sub-clinical form in a large proportion of patients for many years before its eventual detection. As mentioned earlier, as many as 2 per cent. of persons over the age of 40 years may show tonometric evidence of a tendency to glaucoma.

Both closed-angle and chronic simple glaucoma may present very early in life, cases of both varieties having been seen, although rarely, in the third decade. Thereafter the incidence gradually increases with age. Table III illustrates the age incidence in the Western Ophthalmic patients.

SEX INCIDENCE

There is general agreement that chronic simple glaucoma occurs slightly more commonly in males than females. The Western figures support this, 54 per cent. of the patients being males and 46 per cent. females.

In closed-angle glaucoma the female cases outnumber the male. In the Western series females accounted for 77 per cent. of cases and males for only 23 per cent. This sex difference was accentuated if acute cases only were studied, the ratio then being 80 per cent. females to 20 per cent. males. In fairly close agreement with these figures are those of Posner and Schlossmann (1948); they found that 72 per cent. of the 'congestive' cases occurred in women, whereas in chronic simple glaucoma the incidence was the same in the two sexes.

RACE INCIDENCE

Primary glaucoma occurs in all races; but since statistics of the total numbers of sufferers from the disease in any one country are not available, it is impossible to tell with certainty whether some races have a higher rate of attack than others. Carvill (1932), who published figures relating the incidence of primary glaucoma in Boston to the racial origins of the patients, found no special predisposition

in any particular race. However, the numbers reviewed were too small for reliable conclusions to be drawn.

The proportion of glaucoma patients to other ophthalmic patients has been the subject of many published reports, but since the total number of patients in one country cannot validly be compared with that in another, no firm conclusions as to any special racial predisposition, or lack of one, can be inferred. In most countries of the world the numbers of glaucoma sufferers can be estimated, very approximately, at between 1 and 2 per cent. of all ophthalmic patients, although Mann (1954) found an incidence of only 0·41 per cent. in the Kimberley division of Western Australia. Holmes (1961), too, found an extraordinarily low incidence of glaucoma in the Polynesian peoples. In Iceland, on the other hand, the incidence is much in excess of normal.

At present, therefore, it may be said that the influence of race as opposed to that of environment may play some part in determining the rate of attack in primary glaucoma, but the point has not been proved.

One type of glaucoma notable for a marked geographical incidence, and particularly common in Bengal, is that associated with epidemic dropsy. It seems likely that this is due to the toxic effect of sanguinarine, an alkaloid derived from the *Argemone Mexicana* plant, which occurs as a contaminant of mustard oil used in the preparation of food in certain districts (Hakim 1954).

Pseudo-capsular glaucoma (*see* p. 64) also shows a marked geographical incidence, but again the relative influences of heredity and environment remain obscure.

HEREDITY AND GLAUCOMA

The majority of patients with primary glaucoma have no known relatives with the disease; in the remainder a hereditary influence is undoubtedly present (Posner and Schlossmann 1947). When considering heredity it is important to remember the distinctive types of primary glaucoma that exist. Inherited glaucoma will always be of the same type, either chronic simple or closed-angle, as the case may be.

The evidence for inheritance of glaucoma consists, first, in the large number of pedigrees which have been published (McCulloch and MacRae 1950; François *et al.* 1950; Courtney and Hill 1931; Holland 1924; and Zorab 1932), and, secondly, in the classic work of