GONIOSCOPIC STUDIES IN CONGESTIVE GLAUCOMA*

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SINCE narrow-angle glaucoma was described by Barkan (1938), conflicting opinions have been expressed as to the correctness of his views. Barkan postulated, and many authors have since agreed with him, that the rise in intra-ocular pressure in the condition usually known as congestive glaucoma, is due to mechanical obstruction to the outflow of aqueous at the filtration angle of the anterior chamber by the apposition of the periphery of the iris to the corneo-scleral trabeculae or to the cornea just anteriorly (Sugar, 1941; Haas and Scheie, 1952; Chandler, 1952). These authors believe that the anatomical configuration of the eye predisposes to this event and do not admit that the pre-existing shallowness of the anterior chamber has a dynamic pathological cause. Moreover, Rosengren (1950) has produced evidence to show that the depth of the anterior chamber in patients with congestive glaucoma does not vary appreciably if measurements are made before, during, or after an acute attack.

Priestley-Smith (1883) showed that the lens increases in size with age, and Törnquist (1953) in a careful study, presented convincing evidence that shallowness of the anterior chamber *per se* may be an inherited characteristic. He also showed that the depth of the anterior chamber in relatives of persons known to have congestive glaucoma tends to be significantly less than in that of the general population.

Although the relationship may not be precise, it is the opinion of the present author, as the result of gonioscopic studies, that shallowness of the anterior chamber is associated with a narrow filtration angle.

There appear to be three schools of thought regarding the mechanism of the rise in intra-ocular pressure in congestive glaucoma. The adherents of the narrow-angle theory are of the opinion that the actual closure of the filtration angle is the result of some physiological event which only produces a pathological result (the rise in intra-ocular pressure) because of the pre-existing anatomical condition of narrowness of the angle. Various suggestions have been made as to the exact mechanism involved; Chandler (1952) and Haas and Scheie (1952) postulated a slight peripheral ballooning of the basal portion of the iris caused by a relatively higher hydrostatic pressure in the posterior chamber over that in the anterior chamber, the so-called physiological iris bombé. Barkan in his original paper suggested a bunching of the base of the iris due to pupillary dilatation, and Sugar quoted a number of factors which

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may influence the state of the angle, such as emotion, darkness, the use of mydriatics, head injury, and acute rhinitis. Posner (1952) suggested that an element of suction of the base of the iris towards the trabeculae occurs when the sinus of the angle is secluded from the rest of the anterior chamber by apposition of the iris to the cornea in the region of Schwalbe's line.

The second school of thought comprises those authors who, while admitting that the occurrence of a raised intra-ocular pressure in this disease is due to blockage of the filtration angle by the iris, believe that the movement of the base of the iris necessary to achieve this has a dynamic pathological cause. Friedenwald (1930) observed that swelling of the ciliary body occurred in acute glaucoma and produced evidence suggesting that it may be associated with the release of a histamine-like substance in the posterior chamber. François (1948) agreed that closure of the angle was the cause of the rise in pressure, but thought it to be due to a pathological event, possibly a neuro-vascular upset. Kleinert (1953) put forward the original view that a vascular dysfunction of the small vessels near Schlemm's canal may cause swelling of the trabeculae which move inwards to become applied to the base of the iris.

The third school of thought includes those authors who believe that in congestive glaucoma the intra-ocular pressure rises before closure of the angle takes place. Duke-Elder (1952) has pointed out that phasic variations in intra-ocular pressure of a pathological magnitude may occur in these cases in the presence of an open angle. Troncoso (1948) followed the evolution of an acute glaucomatous attack and found the angle to be open in the early stages. Weinstein (1953) described a case which showed a rise in tension from 20 to 80 mm. Hg in the dark without gonioscopic evidence of closure of the angle. He repeated the experiment after a retrobulbar injection of a local anaesthetic and although the tension on this occasion did not rise at all, the gonioscopic appearances remained unchanged.

Ross (1953), on the other hand, conducted gonioscopic examinations in association with the dark-room test, and claimed that angle-closure did occur in the eye in which the tension rose. In one eye, however, in spite of an apparent closure of the angle, the pressure remained normal. He found that by shining a light into the other eye a consensual pupillary constriction occurred in the eye under examination, enabling him to see that the angle was in fact open.

All authors seem to be agreed that in the fully established state of acute congestive glaucoma, angle-closure is probably present; the disagreement hinges on the mechanism of the minor rises in intra-ocular pressure which may precede, sometimes recurring regularly for years, the true acute attack.

Miller (1953) has shown that a difference exists in the timing and steepness of the rise in tension and the suddenness of the fall between periods of raised pressure in congestive glaucoma and phasic variations in the intra-ocular pressure in normal eyes and in eyes with glaucoma simplex. He raises the question whether there is a different mechanism at work in the two types of phasic variation.

Aim of Present Investigation

The following investigation was undertaken to see if any information of value could be obtained by the gonioscopic examination of cases of congestive glaucoma, relating the gonioscopic appearances to the level of the intra-ocular pressure.

The patients were all attending the Glaucoma Clinic at the Institute of Ophthalmology, London, and all were believed to be true cases of congestive glaucoma. The diagnosis was based on the presence of a narrow angle, sharp episodic rises in intra-ocular pressure, frequently a history of haloes, and a positive response to the dark-room test. Cupping of the optic disc and field changes were not regarded as excluding the diagnosis.

Method of Examination

The patients were deprived of their usual miotic for 24 or in some cases 48 hours before the examination. Readings were taken with the Schiötz, or in some cases with the electronic, tonometer, and gonioscopy was carried out with the Goldmann contact lens and the Zeiss or Haag-Streit slit lamp immediately afterwards. This procedure was repeated at intervals during the day.

The illumination of the room in which gonioscopy was performed was arranged to be approximately the same as that in the room in which the patient had been waiting during the period of rising tension. This was a relatively simple matter, as the illumination was either the ordinary daylight existing at that particular time in the waiting room, or in some cases complete darkness into which the patient had been placed to induce a rise in tension. The contact glass was then inserted and the patient arranged comfortably at the slit lamp, which was then switched on for the angle to be examined in the usual way. The inferior part of the angle was almost invariably found to be open whatever the height of the tension, although it was extremely narrow in some cases.

When this preliminary examination had been made, the widest part of the angle was brought clearly into focus and the light was switched off. The patient was asked to keep still at this stage and as far as possible the whole system was held motionless for several seconds.

Then the light was switched on again. This was found to be awkward with the Zeiss instrument as the switch is not of the simple "on-off" variety but incorporates a rheostat, and the phenomenon about to be described was found to be more easily seen on the Haag-Streit instrument. With the sudden return of the light a definite change was seen to occur in the angle, not particularly impressive in some cases, but in others so marked as to justify the term dramatic. The change in its most extreme form can be described as the appearance of the rapid opening of a completely closed angle. In the less extreme cases the change consisted in a visible increase in the distance between the surface of the iris and the corneoscleral trabeculae.

Case Reports

Only the cases in which an appreciable rise in tension occurred are included in the Table opposite.* It should, however, be mentioned that in the several eyes (not reported) in which no rise in tension occurred, closure of the angle was not found.

Comments

Where the filtration angle is already narrow it is difficult to detect changes in width unless one actually sees the change occurring. A few attempts were made to measure the angle-width with a graticule in the eyepiece of the slit-lamp, after the method of Gradle and Sugar (1940), but the technique was not found helpful in this type of case.

*In some cases included in the report, the tension was taken independently by Dr. A. DeRoethth, Jr., and the readings were not made known to the author until the completion of the day's work.

TABLE

Case No.	Age	Sex	Date	Eye	Miotic	Time	Tension (mm. Hg Schiötz)	Gonioscopy
1	74	F	Feb. 25, 1953	L	Pilocarpine 1 per cent.	10.00 a.m.	52	Angle very narrow, pigmented anterior trabeculae visible below No corneal oedema
						11.15 a.m.	31	View now obtainable right into cleft below, anterior trabeculae visible all round
2	54	M	Nov. 27, 1953	L	Eserine 1 per cent.	2.15 p.m.	48	Angle closed all round except chink below in which no details of wall can be seen No aqueous veins visible in episclera
						3.15 p.m.	45	
						3.30 p.m.	45	
						3.50 p.m.	28	Angle conspicuously more open. Chink all round, and some pigment spots seen below on posterior trabeculae not visible before Aqueous veins very prominent
3	47	F	Jan. 28, 1953	R	Eserine $\frac{1}{2}$ per cent.	2.05 p.m.	35	Angle not quite closed Small chink open at 5 and 12
						3.00 p.m.	25	Angle definitely more open
4	43	F	Jan. 26, 1953	R	Eserine $\frac{1}{2}$ per cent.	11.45 a.m.	45	Angle can be made to open and shut by turning light on and off
						12.00 noon		
						12.45 p.m.	25	Angle open all time and not made to shut by turning off light
5	56	M	Mar. 25, 1953	L		10.20 a.m.	45	Angle very narrow and appears shut except from 5 to 8. Narrow cleft and anterior trabeculae seen below. "On-and-off" shows iris coming close to Schwalbe at 7—not possible to be sure if touches
						11.30 a.m.	40	
						2.00 p.m.	31	Angle looks same but with more definite cleft all round. Opening and shutting sign++
						4.15 p.m.	35	
						4.35 p.m.	31	No clear change
6	63	F	May 20, 1953	R		10.00 a.m.	40	Narrow angle open 5 to 8, much black, finely divided trabecular pigment, chink just open 8 to 10, remainder closed. Opening and shutting sign nil.
						12.00 noon	38	No change
						2.00 p.m.	30	No change
						4.00 p.m.	30	No change
				L		10.00 a.m.	20	Narrow angle, appears closed from 10 to 2 only. Marked "on-off" sign but no obvious shutting

TABLE (Contd.)

Case No.	Age	Sex	Date	Eye	Miotic	Time	Tension (mm. Hg Schiötz)	Gonioscopy
7	69	M	May, 20 1953 Tension by A. de Roeth	R	Eserine	10.30 a.m.	36	Angle open but narrow, very marked "on-off" sign
						12.15 a.m.	38	Same
						3.30 p.m.	33	Not gonioscoped
						3.55 p.m.		
						4.15 p.m.	31	Not gonioscoped
				L	Eserine	10.30 a.m.	46	Angle open but narrow, much bigger "on-off" excursion below than above
						12.15 a.m.	55	Anterior trabeculae visible below, very narrow chink above—not shut—no real change
						3.30 p.m.	63	No change
						3.55 p.m.		
						4.15 p.m.	41	No doubt that angle is more open, pupil miotic
8	61	M	May 27, 1953	R		2.30 p.m.	22	Very narrow angle, anterior trabeculae visible below—few chinks show pigmented line along Schlemm's canal
				L		2.30 p.m.	39	Little more anterior trabeculae visible below than in R, but behind angle so narrow as to be virtually shut, pigment line at line of closure
						4.30 p.m.	50	No change
9	48	F	June 3, 1953 Tension by A. de Roeth	R		11.15 a.m.	20	Angle shut, P iridectomy not basal. Trepine well anterior? patent
				L		11.20 a.m.	46	Upper half of angle shut, lower half shows anterior trabeculae and chink into cleft at 5
						4.15 p.m.	30	Has had eserine—no change in angle
10	61	M	April 28, 1953 Tension by A. de Roeth	R	Eserine	4.00 p.m.	63	Very narrow angle, slightest chink visible below, iris face bowed and no convolutions
						4.15 p.m.		
						5.00 p.m.	22	Angle undoubtedly more open and whole width of trabeculae visible below. Elsewhere 60 per cent. of circumference showed peripheral anterior synechiae (P.A.S.), some extending across whole trabecular width, some partial
				L		4.00 p.m.	30	Angle very narrow, but at 4 base of iris is wavy and ciliary body can easily be seen for a short segment
11	63	F	June 5, 1953	R	Eserine ½ per cent.	2.30 p.m.	48	Angle open in lower 10 per cent. only, apparently 90 per cent. P.A.S. elsewhere
						3.30 p.m.	25	Remarkable difference, angle now only medium-narrow and open all round, showing that above observation of P.A.S. incorrect, angle was merely closed by simple apposition of iris.

TABLE (Contd.)

Case No.	Age	Sex	Date	Eye	Miotic	Time	Tension (mm. Hg Schiötz)	Gonioscopy
12	69	M	July 14, 1953	R	Eserine	3.00 p.m.	45	The angle appears completely closed and iris face much bowed
						3.20 p.m.	25	Angle much more open, Schlemm's canal line now visible in lower half and anterior trabeculae above
13	59	F	Aug. 5, 1953	R	Dark	10.10 a.m.	28	Angle narrow but open, medium broad 6.30 to 8.30, marked variation "on-off"
						11.25 a.m.	31	Not gonioscoped
						12.15 p.m.	73	Angle closed except area 6.30 to 8.30—this area however definitely shuts with light off.
					Eserine			
						2.00 p.m.	25	Angle open all round, will not shut even in dark
				L	Eserine ½ per cent.	10.10 a.m.	63	Angle shut except 4.30 to 6.30, where medium-narrow, shuts on switching light off.
						10.40 a.m.		
					Dark	11.25 a.m.	35	Angle narrow but open, all round except for P.A.S. at 6 and nasally. Some trabecular P.A.S. where angle widens at 4 to 5.30, may be more in depths of narrow parts, no "on-off" variation
						12.15 a.m.	43	Angle seems unchanged but definite variation in width on change of light amounting probably almost to closure at "off", pupil also reacts
					Eserine ½ per cent.	12.30 a.m.		
						2.00 p.m.	25	Angle same but not made to vary or shut with light intensity

The only constant finding in this series was the fact that, viewed with the slit-lamp light switched on in the ordinary way, complete angle-closure was never seen with certainty.

Cases 1 and 2 showed an appearance suggestive of closure but I could not be certain about it. On the other hand, the instillation of eserine which was followed by a fall in tension did appear markedly to open the angle. (This action of eserine or pilocarpine was seen in all the cases in which it was used).

An interesting feature of the series was the occurrence of the sign previously mentioned of marked movement of the base of the iris on turning the light of the slit-lamp on and off. It would appear that this "on-off" sign has some value, for it can be used to show up angle-closure when ordinary continuous illumination suggests that the angle is open. In Case 4, for example, when the tension was 45 mm. Hg the angle could be made to open and shut by turning the light on and off. After eserine, however, and when the tension had subsided to 25, the "on-off" sign was no longer detectable and the angle appeared constantly to remain open.

Case 13, in which the excursion of the base of the iris was very obvious, also shows a close correlation between the presence of this sign and the level of the tension.

At the present stage no evidence is available as to the mechanism underlying the marked movement of the base of the iris with variations in light intensity. The obvious explanation would appear to be that the variation in the size of the pupil causes peripheral bunching during dilatation and thinning during miosis, but in the opinion of the author this does not explain the great variability from case to case. Some eyes in which pupillary movements are quite appreciable, give no very obvious movement of the base of the iris. On the other hand, Case 13 showed considerable movement of the base of the iris even when the pupillary reactions were considerably dampened down by eserine.

Conclusions

The evidence suggests that an opinion as to the openness of a narrow angle is of limited value unless the "on-off" technique is employed, since without this practically all the angles appear open because of the light of the slit lamp. Consequently, the significance of reports claiming the existence of open angles during periods of raised tension in cases of congestive glaucoma, is doubtful. It would be of interest if Weinstein's case, in which the tension rose to 80 mm. Hg on dark-room testing, could be re-gonioscoped by the "on-off" technique.

Summary

Theories relating to the mechanism of the rise in intra-ocular pressure in congestive glaucoma are discussed.

Thirteen cases thought to be of the congestive type of glaucoma were examined by tonometry and gonioscopy, and observations made in phases of both raised and normal tension. Elevation of tension was spontaneous in some cases (although congestion was not observed) and was induced in others by darkness. A return to normal tension was spontaneous in some eyes but had to be induced by miotics in others.

A new gonioscopic sign is described; marked variation in the width of the angle occurs in some eyes on turning the slit-lamp light on and off.

Complete closure of the angle in congestive glaucoma with raised tension, but in the non-congestive phase, is rarely seen if the eye is examined by the usual gonioscopic technique. The "on-off" technique gives an appearance which suggests that in some cases, the angle is in fact completely closed when the slit-lamp light is off (no studies of the angle in a fully established acute congestive attack are included in this series).

The excursion of the base of the iris elicited by the technique described is much more obvious in some eyes than others.

It is possible that previous reports of the presence of open angles with raised intra-ocular pressure in certain cases of congestive glaucoma should be treated with reserve, since the use of this new technique might have led to the conclusion that a given angle, which appeared by ordinary examination to be open, was in fact shut.

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