COMPRESSION OF THE AQUEOUS OUTLETS*

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It is a common experience to find the ocular tension low after cataract extraction when no complications such as iritis, vitreous prolapse, or haemorrhage have occurred. Indeed, it is recognized that a cataract extraction may normalize a moderately raised intra-ocular pressure. This result is usually explained by the abolition of lenticular pressure against the base of the iris and the consecutive widening of the angle, and further by the free communication between the anterior and posterior chambers after the iridectomy and by the neuro-vascular influence of the operation. On the other hand, it has to be considered that the incision is usually made close to the exit channels of the aqueous, and that the resulting scar tissue may involve the trabecula, the canal of Schlemm, and its communications with the aqueous veins in the upper periphery. Though the drainage channels of the lower periphery should be able to cope with the whole aqueous outflow, this compensatory regulation may become insufficient when the resistance to the aqueous outflow is higher than normal. In these cases the question arises whether it would not be better to place the von Graefe section through the anterior part of the limbus rather than through the posterior part.

I have tried to inhibit the aqueous outflow by applying circular pressure at the limbus for 90 seconds. This compression was applied by a metal cone which had an inclination of 30° to the horizontal plane. This closely corresponds to the inclination of the common tangent of cornea and sclera. The cone was 13 mm. wide and was attached as footplate to a plunger fitting into the old Schiötz tonometer. The 15-g. weight was screwed on. To allow control of the vertical position during the compression a spirit level was attached above the scale of the tonometer (Fig. 1, opposite).

The weight of the whole apparatus (including the 15-g. weight) is 38.5 g., but only about half of this weight is used for compression as the pressure is exercised at an angle of 30° and $\sin 30^\circ$ equals 0.5.

For the application of a higher pressure a conical ring of the same dimension was used. This ring has an extension which slides on the shaft of the Bailliart dynamometer, while the footplate of the dynamometer is pressed against another extension of the conical ring (Fig. 2, opposite).

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FIG. 1.—Schiötz tonometer adapted for applying pressure at the limbus.

FIG. 2.—Bailliart dynamometer adapted for applying pressure to the limbus.

I have applied this limbal pressure test to 32 normal eyes, and to operated and unoperated eyes with chronic and congestive glaucoma or cataract. Before and after the compression the tension was tested by means of the weightless tonometer (Weiss), which has a convex footplate. The deviation of the hand at the scale was noted without converting the result into mm. Hg. The average time between removing the limbal pressure and reading the tension was 3 seconds. This should be sufficient for restoring the shape of the eyeball to its former configuration. It should not be sufficient to eliminate aqueous, which might have accumulated during the 90 seconds of compression. The measurements were taken between 10 and 10.30 a.m. The Table (overleaf) gives the results of the circular compression.

Any eye showing tonometric readings of 7 or less was treated with miotics. I had expected that the tension would rise dramatically when the exit channels of the aqueous were compressed. In most of my patients, however, the tension after circular compression was the same or slightly lower than before.

The small increase in tension in two cases may be due to increased blood inflow after the compression ischaemia, but is more probably due to the incomplete recovery of the eye from the pressure. Thus, the root of the iris, which is pushed against the trabecula of the cornea by the pressure, remains for a short time in apposition with the cornea, blocking the angle

TABLE

Case No.	Sex	Age	Diagnosis	Surgical Intervention		Anterior Chamber		Tension (degrees of tonometer scale)					
				Eye	Operation	R	L	Before Compression		After Compression (T=tonometer; Bx=dynamometer and pressure)			
								R	L	Measure- ment	R	L	
1	M	64	Chronic glaucoma	R	Iris inclusion	Narrow	Narrow	6½	7	T	6	7	
2	F	74	Congestive glaucoma	—	—	Medium	Medium	8	9	T	9	10	
3	F	68	Congestive glaucoma	R	Iridectomy	Narrow	Narrow	7½	7½	T	8	8	
4	F	72	Chronic glaucoma	R	Iris inclusion	Medium	Medium	10	7	T	11	8	
5	F	72	Chronic glaucoma	R	Iris inclusion	Narrow	Narrow	8½	7½	T	9	8	
6	M	79	Chronic glaucoma	L	Trephining	Medium	Medium	8	11½	T	10	11½	
7	F	70	Right cataract	R	Cataract extraction	Deep	Medium	8	7½	B90	8½	8	
8	M	70	Chronic glaucoma	—	—	Medium	Medium	7½	8	B90	7½	8½	
9	F	70	Chronic glaucoma	—	—	Medium	Medium	6	5½	B100	5½	5	
10	F	75	Bilateral cataract	R, L	Cataract extraction	Deep	Deep	8	9	T	11	9	
11	M	75	Chronic glaucoma	R	Excision	—	Narrow	—	6	T	—	7	
12	F	59	Congestive	R	Iridectomy	Medium	Medium	9	9	T	9½	9½	
13	F	78	Cataract	R	Cataract extraction	Medium	Medium	9½	9½	T	9½	9½	
14	F	71	Chronic glaucoma	—	—	Medium	Medium	5	7	B100	5	7½	
15	F	60	Congestive	L	Iris inclusion	Narrow	Narrow	6	12	B100	6	12	
16	F	79	Chronic glaucoma	—	—	Medium	Medium	8	7	B80	8	8½	
17	F	77	Chronic glaucoma	—	—	Medium	Medium	8	8	B90	8	8	
18	M	57	Cataract	R	Cataract extraction	Medium	Medium	7½	8	T	7½	8½	
19	M	78	Congestive	R	Iridectomy	Narrow	Medium	9	10	T	10	10½	
20	F	74	Chronic glaucoma	R, L	Trephining	Medium	Medium	9	9	T	9½	9½	
21	F	72	Chronic glaucoma	L	Iris inclusion	Medium	Medium	10	11	T	11	11	
22	M	75	Chronic glaucoma	R	Iris inclusion	Medium	Medium	8	4	T	8	4	
23	F	64	Cataract	L	Cataract extraction	Medium	Medium	8½	8½	T	9	9	
24	F	72	Chronic glaucoma	L	Iris inclusion	Medium	Medium	8	10	B90	10	10	
25	F	54	Chronic glaucoma	—	—	Medium	Medium	6	7	B90	7	8	
26	F	50	Presbyopia	—	—	Narrow	Narrow	8	8	B80	9	9	
27	F	80	Chronic glaucoma	—	—	Narrow	Narrow	8	8	B80	8	8	
28	F	77	Chronic glaucoma	—	—	Medium	Medium	7½	8½	B70	8	9	
29	F	58	Presbyopia	—	—	Medium	Medium	10	10	B70	10½	10½	
30	F	71	Chronic glaucoma	L	Iris inclusion	Narrow	Narrow	6	10	B70	7½	10½	
31	M	83	Chronic glaucoma	—	—	Narrow	Narrow	5	5	B70	5½	5½	
32	M	71	Chronic glaucoma	—	—	Deep	Deep	8½	8½	B75	8	8	

like a gonosynechia. After two minutes the tension in both these cases had returned to the level of the first reading. The tension was high during the compression. This could be demonstrated by using a conical ring with a handle; this was pressed against the limbus while the tonometer was placed on the cornea through the ring. The hand of the tonometer was pushed back nearly to zero, but the tension went down when the pressure was released.

How can the absence of a rise in tension after circular compression of the aqueous drainage channels be explained? As there are no other outlets of significance it must be assumed that the production of aqueous is inhibited by the increased pressure. For this reason tonometry cannot claim to be an exact method for measuring the aqueous outflow. The reduced tension in tonometry depends not only on the amount of aqueous outflow, but also on the inhibition of aqueous production by the increased pressure. This inhibition of the function of the ciliary body was evident in my cases even with the moderate degree of compression exercised by the weight of the tonometric instrument. It is probable that some automatic regulation exists between intra-ocular pressure and production of aqueous. Thus, a

moderate rise in pressure is often not progressive, and the tension will not become excessive if the aqueous production is correspondingly diminished. Using high compression with the dynamometer equalling the systolic pressure in the ophthalmic artery, the circulation within the eye comes to a standstill and no aqueous can be produced by the ciliary body. This is also the case in a severe attack of acute glaucoma, the low tension after the attack being obviously due to pressure inhibition and damage of the ciliary body. It may be asked whether a mathematical relation between aqueous production and intra-ocular pressure exists. The few tonometric measurements which I have made with different weights do not bear out this possibility. There are too many variables: differences in corneal-scleral elasticity, individual reaction of the ciliary body and its vessels to pressure, and especially the reaction of the autonomous nerves. Wide variations in the autonomic reaction of individuals is seen in the effect of increased ocular tension on the heart and stomach: in some persons nausea and a slowing of the pulse rate are very marked, while in others these parasympathetic responses are negligible.

Summary

The technique of compressing the aqueous outlets at the limbus is described. The tensional results of the compression show that an increase in the intra-ocular pressure inhibits the production of aqueous. Tonography which does not take this inhibition into account cannot give exact information regarding the aqueous outflow. It is suggested that the production of aqueous is automatically regulated by the intra-ocular pressure. The production decreases when the pressure rises and *vice versa*, thus maintaining the equilibrium between production and outflow. In chronic glaucoma decreased production compensates to a certain extent for the increased resistance of the aqueous outlets, and a new equilibrium between aqueous production and outflow at a higher pressure level is established.