TWO PROVOCATIVE TESTS FOR GLAUCOMA*

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To assess the value of the provocative tests of glaucoma we investigated the water-drinking and jugular compression tests in about 140 eyes. Three groups of cases were investigated:

(i) Normal eyes	...	...	...	50
(ii) Eyes with established glaucoma:				
(a) chronic simple glaucoma	...	...	...	33
(b) acute congestive glaucoma	...	...	...	13
(c) chronic congestive glaucoma	...	...	...	11
(iii) Pre-glaucomatous eyes (<i>i.e.</i> unaffected eyes of patients already affected)	...	...	...	33

Technique

Jugular Compression Test (also known as the cervical compression test).—1 per cent. anethaine drops were used to produce surface anaesthesia. The ocular tension was then taken with a Schiötz tonometer, and again after 30 min. to ascertain any change. The sphygmomanometer cuff was tied round the neck, keeping the cushion in front in order to compress both jugular veins equally. A stop-watch was used to record the time. The cuff was inflated to a pressure of 40–45 mm. Hg for 1 min. and the ocular tension was taken again. A rise of more than 6 mm. Hg Schiötz or a ceiling of more than 30 mm. Hg was considered to be pathological. The tension was recorded every 10 min. for 30 min.

Water-Drinking Test.—The patients were given no miotics for at least 24 hours previously, and no breakfast before the test. They were then asked to drink from 600 to 1,000 ml. water within 4 min. Tensions were taken by the Schiötz tonometer 30 min. before the test, at the commencement of the test, and then every 15 min. for 2 hrs. During the test, the petechial index and fluorescein test were also done. The haemoglobin per cent. was estimated by Sahli's technique using Adam's haemoglobinometer. The plasma proteins were estimated by the microchemical Nesslerization method of King (1946) at the beginning of the test and 45 min. after it had begun. The blood pressure was taken before, and at 1 and 2 hrs. after the commencement of the test. A rise in tension of more than 6 mm. Hg Schiötz or a ceiling of more than 30 mm. Hg was considered to be pathological.

Discussion

In the fifty normal eyes there was a rise in tension of 2 to 6 mm. Hg Schiötz with the water-drinking test, except in one case which showed a rise of 10 mm. this patient was classified as pre-glaucomatous and is under observation.

The jugular compression test of Schoenberg (1929) was employed in the various groups of cases of primary glaucoma. Schoenberg found three types of curves:

* Received for publication December 11, 1952

- (i) a rise of ocular tension during jugular compression and a fall to the initial level after release,
- (ii) a rise of ocular tension during jugular compression and a fall to below the initial level after release,
- (iii) no change.

Similar changes in intra-ocular pressure were found in the present series of cases. Schoenberg attributed the rise of tension in the eyes on compressing the jugular veins to a mechanical factor, *i.e.* a damming-up of the venous exit from the eyeball and a consequent accumulation of blood in the uvea. The variations of intra-ocular pressure are more dependent on venous than on arterial pressure, so that local variations in the venous return from the eyeball, whether due to local or to general causes, may readily give rise to a glaucomatous attack.

The drop in intra-ocular pressure to below the initial level after the release of pressure on the neck which is recorded in some cases by Schoenberg is inexplicable. Some changes may occur in the vascular unit of the eyeball (*i.e.* the venule, capillary, and arteriole unit), and a regulatory reflex may act in defence against an acute impediment of venous circulation; it may be that this reflex fails to function in glaucomatous eyes (Table I).

TABLE I
RESULTS OF JUGULAR COMPRESSION TEST IN GLAUCOMATOUS EYES

Type of Glaucoma	Total Eyes	Positive Results	
		No.	Percentage
Chronic simple	33	14	42.4
Acute congestive	11	10	90.9
Chronic congestive	13	9	69.3

It is thus advisable that those with pre-glaucomatous eyes should not wear tight collars or engage in occupations which cause mechanical pressure over the jugular veins, *e.g.* glass-blowing, blowing musical instruments, lifting and carrying heavy objects, acrobatic performances, scrubbing floors, etc. Glaucoma is potentially a bilateral disease, one eye being affected earlier than the other, so that an unaffected eye must be regarded as predisposed to glaucoma. These are true examples of pre-glaucoma, and may be utilized for the evaluation of the various results (Table II).

TABLE II
RESULTS OF JUGULAR COMPRESSION TEST IN PRE-GLAUCOMATOUS EYES

Pre-disposed Eyes (First eye affected by)	Total Eyes	Positive Results	
		No.	Percentage
Chronic simple glaucoma	14	3	23.5
Acute congestive glaucoma	9	6	66.6
Chronic congestive glaucoma	10	2	20.0

The jugular compression test has not been singly investigated before in pre-glaucomatous eyes, or if done alone has been brushed aside as unreliable. Our experience, however, has been contrary, as Table II shows, and we recommend this test as simple and not time-consuming. It also throws some light on the aetiology of glaucoma; from it we may infer that glaucoma may be due to some upset in the venule-capillary-arteriole system of the eye which causes increased pressure in the venous system; this supports the view of the congestive factor in the aetiology of glaucoma.

The water-drinking test, performed in various types of primary glaucoma, gave a rise of ocular tension from 6 to 20 mm. Hg Schiötz, irrespective of the condition of the angle of the anterior chamber. Repeated tests with smaller quantities of water gave negative results, but positive results were obtained by the administration of 250 ml. water. In our opinion smaller quantities than this should be regarded as useless, in spite of two case reports by Schmidt (1931), who obtained positive results by the administration of 50 ml. water. The results of the water-drinking test in various types of primary glaucoma are given in Tables III, IV, and V. Table V (opposite) shows that our results are in conformity with those of other workers.

TABLE III
RESULTS OF WATER-DRINKING TEST IN GLAUCOMATOUS EYES

Type of Glaucoma	Total Eyes	Positive Results	
		No.	Percentage
Chronic simple	33	30	90.9
Acute congestive	11	11	100.0
Chronic congestive	13	13	100.0

TABLE IV
RESULTS OF WATER-DRINKING TEST IN PRE-GLAUCOMATOUS EYES

Pre-glaucomatous Eyes (First eye affected by)	Total Eyes	Positive Results	
		No.	Percentage
Chronic simple glaucoma	14	7	50.0
Acute congestive glaucoma	9	6	66.6
Chronic congestive glaucoma	10	4	40.0

The haemoglobin percentage and plasma proteins were also estimated at the beginning of the test and after 45 min. The results indicate that there is definite haemodilution after 45 min. The plasma was more diluted by the ingested water in the glaucomatous than in the normal cases. It may therefore be said that there is excessive absorption or less excretion of water by glaucomatous patients. There was no evidence of vasomotor phases in determining the rise of tension. Why this variation in haemodilution between normal and glaucomatous eyes should occur with the administration

TABLE V
RESULTS OF WATER-DRINKING TEST OBTAINED BY VARIOUS
WORKERS AS COMPARED WITH OUR RESULTS

Author	Date	Total Eyes Tested	Positive Results		Type of Glaucoma
			No.	Percentage	
Wegner	1930a, b, c	—	—	66.0	Chronic simple
Schmidt	1931	34	33	97.0	Chronic simple
Ohm	1936	8	4	50.0	Chronic simple
Tichomirow	1940 1941	— —	— —	} 90.0	Chronic simple
Bloomfield and Kellerman	1947	22	18		Pre-glaucomatous
Sugar	1948	143 Not known	9 Not known	5.0 Not known	Normal Glaucoma
Kronfeld	1949	269	179	66.0	Chronic simple
Leydhecker	1950a	—	—	77.0	Chronic simple
		—	—	74.0	Congestive
Weinstein (with modified Water-Drinking Test)	1950	—	—	90.0	Unoperated
		—	—	60.0	Operated
		—	—	30.0	Pre-glaucomatous
Present Investigations		33	30	90.0	Chronic simple
		11	11	100.0	Acute congestive
		13	13	100.0	Chronic congestive
		33	17	51.5	Pre-glaucomatous

of the same quantity of water is difficult to understand. These observations add to the complexity of the problem.

The rise of tension in the water-drinking test is caused to a certain extent by changes in the osmotic pressure of the blood. Since the degree of haemo-dilution is the same in normal and in pre-glaucomatous eyes, the change in tension is due either to a reduced inflow of water when the blood serum becomes relatively hypotonic, or to the fact that an increased volume of aqueous can flow out more easily. According to the results of Kinsey, Grant, and Cogan (1942), the former mechanism is improbable. Even if the decisive factor determining positive and negative tests is localized in the eye itself, this does not mean that systemic reactions are unimportant. The degree and rate of the development of hypotonicity in the blood vary considerably in different people, and at different times in the same person. These differences are presumably caused by varying rates of absorption and exchange of fluids between blood and tissue, which in their turn depend on the amount of fluid taken by the patient on the days before the test and on his individual regulation of the water exchange. Whether this regulation is

hormonal or due to an autonomous function of the capillary endothelium is uncertain.

Considering the problem of the mechanism whereby this test acts, the positive results shown may be due either to increased permeability of the capillaries or to an increase in blood pressure.

It is well known that an increase in blood pressure is reflected by an increase in intra-ocular pressure. On this hypothesis it may be argued that the water-drinking test acts purely by an increase in blood pressure due to an increase in blood volume. In chronic glaucoma this is incompatible with our observation that there was no appreciable change in blood pressure before the test, at the first hour, and at 2 hours after the commencement of the test. In acute congestive glaucoma, however, this too may be regarded as contributory factor; we found positive results in all cases giving a variation of from 3 to 8 mm. Hg in systolic pressure, and in three cases which gave a variation of from 5 to 8 mm. Hg in diastolic pressure at the end of 2 hours.

The only remaining factor is haemodilution, leading to a change towards hypotonicity in the osmotic pressure of the serum; this hypotonicity causes an increased flow of aqueous into the eye. In normal eyes this increased inflow is dealt with by increasing the drainage through the normal channels, which leads to a negative result, but in glaucoma this regulating mechanism is upset, and the added strain leads to an increase in intra-ocular pressure. In about 50.5 per cent. of the so-called pre-glaucomatous eyes, the results were positive. We suggest therefore that these eyes, though non-glaucomatous from the clinical standpoint, are in fact glaucomatous from the pathological standpoint, and we recommend the regular use of miotics as a preventive measure.

All glaucomatous patients should be warned not to drink tea or coffee in bed before breakfast, as two large cups of tea or coffee contain approximately 500 ml. fluid and caffains which are enough to precipitate an acute attack of glaucoma. Sugar (1948) suggested a combination of the water-drinking test with other tests; in our opinion this offers no advantage, as when two fundamentally different provocative tests are mixed it may not be possible to assess which mechanism is defective in an individual eye.

The results of the jugular compression and water-drinking tests (Table II, III, IV, and V), show that the water-drinking test is more sensitive and gives better results. For the diagnosis of the pre-glaucomatous condition the water-drinking test is recommended; the result may be confirmed afterwards by the jugular compression test.

Our present knowledge of the aetiology of glaucoma is incomplete and full of uncertainties. It may be suggested that the tests should not be combined at one time; on the contrary, if one test is negative we may exclude the factor guiding the mechanism of action of that test from the aetiology and try another test with a different mechanism.

Conclusions

(1) Increased capillary permeability plays a significant part in the aetiology of glaucoma, especially the acute congestive type.

(2) The jugular compression test gives 55 per cent. positive results in glaucomatous eyes, and 33 per cent. results in pre-glaucomatous eyes, which indicates that the negative results should be ignored and the positive results taken into consideration; the negative results do not necessarily mean that the eyes tested are not pre-glaucomatous. The test acts by the mechanical obstruction of the venous blood in the jugular veins.

(3) The water-drinking test gives a high proportion of positive results: 94.7 per cent. in glaucomatous eyes and 51.5 per cent. in pre-glaucomatous eyes. It probably acts by haemodilution, as there is an accompanying dilution in the plasma proteins and a decrease in haemoglobin percentage.

(4) There is no appreciable change in blood pressure during the water-drinking test, except in cases of acute congestive glaucoma.

We are grateful to Dr. R. S. Varma, Professor of Ophthalmology for his guidance throughout this work and to Dr. H. N. Bhatt, Principal of the Medical College, Agra, for permission to carry out the project in this department.

REFERENCES

- BLOOMFIELD, S., and KELLERMANN, L. (1947). *Amer. J. Ophthal.*, **30**, 869.
 KING, E. J. (1946). "Micro-analysis in Medical Biochemistry", p. 34. Churchill, London.
 KINSEY, V. E., GRANT, M., and COGAN, D. G. (1942). *Arch. Ophthal., Chicago*, **27**, 242.
 KRONFELD, P. C. (1949). *Trans. Amer. Acad. Ophthal. Oto-laryngol.*, **53**, 175.
 LEYDHECKER, W. (1950). *British Journal of Ophthalmology*, **34**, 457.
 OHM, G. (1936). *v. Graefes Arch. Ophthal.*, **135**, 537.
 SCHOENBERG, M. J. (1929). *Arch. Ophthal., Chicago*, **1**, 681.
 SCHMIDT, K. (1931). *Arch. Augenheilk.*, **104**, 102.
 SUGAR, H. S. (1948). *Ibid.*, **31**, 1193.
 TICHOMIROW, P. E. (1940). *Vest. Oftal.*, **16**, 127.
 ——— (1941). *Ibid.*, **18**, 57.
 WEGNER, J. (1930a). *Zbl. ges. Ophthal.*, **24**, 1.
 ——— (1930b). *Ber. dtsch. ophthal. Ges. Heidelberg*, **48**, 127.
 ——— (1930c). *Arch. Augenheilk.*, **103**, 303.
 WEINSTEIN, P. (1950). *Amer. J. Ophthal.*, **33**, 1442.