CORNEO-SCLERAL TONOGRAPHY* †

BY

T. H. HODGSON AND R. K. MACDONALD

From the Department of Ophthalmology, University of Toronto, Canada

THAT pressure exerted on the eyeball caused a lowering of ocular tension has been known for many years (Pagenstecher, 1878; Schiötz, 1908; Thomassen, 1946). However, it was not until the introduction of the electronic tonometer and the subsequent work of Grant (1950, 1951) that the knowledge thus gained could be translated into an easily measured form which has gained wide clinical acceptance.

In all this work bulbar pressure has been exerted either on the cornea or on the sclera, and the results variously interpreted. Blaxter (1953) reported on a large number of cases in which simultaneous pressure lasting 4 minutes was applied to the cornea by a Schiötz X tonometer and to the sclera by a Bailliart dynamometer. Our present investigation has combined both corneal and scleral compression, using the Mueller electronic tonometer in a method which is easily standardized and causes a minimum of discomfort to the patient, and which, we believe, yields valuable information, particularly with regard to border-line cases.

Method

The patient is placed in the supine position. Care is taken to ensure that there is no constriction by neck bands. A marker on the ceiling directly overhead and a marker on the wall to the right and to the left are pointed out to the patient. The two side markers are so located that when, for example, the left eye is fixing on the spot to the right, enough bulbar conjunctiva is exposed temporal to the cornea to accommodate the foot-plate of the tonometer with 2 mm. of conjunctiva still separating the tonometer from the limbus (Fig. 1).

FIG. 1.—Bulbar conjunctiva exposed to receive tonometer.

A drop of 0.5 per cent. pantocaine is instilled into each eye. The patient is first instructed to fix on the overhead marker and the electronic tonometer is applied to the cornea, the lids being separated by the operator. All readings are

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recorded on a Sanborn recorder. After a 15-second interval, if the left eye is being tested, the patient is instructed to transfer fixation to the spot on the wall to the right.

The tonometer is now re-applied over the temporal conjunctiva leaving 2 mm. of free conjunctiva between the foot-plate and the limbus (Fig. 2). This position is held for exactly 3.75 minutes. At the end of this period the tonometer is re-applied to the cornea with the eye in the original position (looking at the ceiling) for a final 15-second recording.

FIG. 2.—Electronic tonometer in position.

All timing is done accurately by stop watch and plotted on a graph by the assistant. The watch is always stopped during transfer of fixation and re-started on re-application of the tonometer. This transfer period may take from 1 to 3 seconds, during which time the patient may blink to moisten the cornea. The greatest care must be exercised at all times to avoid tension on the lids.

In cases of irregular readings, corneal tonography may be continued slightly longer before and after scleral compression. A mean curve drawn over the plotted points can then be extrapolated forward and backward respectively to the edge of the scleral compression period.

The mean reading at the end of the corneal tonography, just before scleral compression, is taken as the initial reading, and the reading after scleral compression, at the end of the final 15-second period of corneal tonography, is taken as the final reading. Thus a period of compression of exactly 4 minutes, the final 15 seconds of which was corneal, has been measured.

In our series corneal tonography was done on all cases for comparative purposes.

Results

The results of corneal tonography and the results of corneo-scleral tonography as outlined in our method both demonstrated a lowering effect on the intra-ocular pressure. In Figs 3 and 4 (opposite) the initial reading is plotted against the final reading. With both methods tonography showed a generally greater lowering effect in normal eyes than in glaucomatous eyes.

CORNEO-SCLERAL TONOGRAPHY

303

FIG. 3.—Distribution of results of corneal tonography, showing border-line between normal and glaucomatous eyes.

FIG. 4.—Distribution of results of corneo-scleral tonography, showing border-line between normal and glaucomatous eyes.

In our series, the results of corneal tonography demonstrated a certain degree of overlapping between normal and glaucomatous eyes, though a line could be drawn which for the most part separated normal cases from cases of glaucoma. On the other hand, with corneo-scleral tonography, the general lowering effect was less than that observed with corneal tonography, and there was much less overlapping of results between normal and glaucomatous eyes; the dividing line between the two groups is, however, almost parallel to that found with corneal tonography.

From the cases shown in the preceding graphs (Figs 3 and 4), the results of all cases of closed-angle glaucoma were extracted and recorded (Figs 5 and 6, opposite).

The corneo-scleral technique placed all these cases in the glaucoma group; the results of corneal tonography were less conclusive. Typical tracings taken from a case of closed-angle glaucoma are shown in Fig. 7.

FIG. 7.—Tonographic tracings in a proven case of closed-angle glaucoma:
(a) Corneal method; (b) Corneo-scleral method.

Similarly, a group of cases showing moderate to severe loss of visual field were extracted, and the results of corneal and corneo-scleral tonography are shown in Figs 8 and 9 (overleaf). Here again corneo-scleral tonography placed all, even the low tension cases, in the glaucoma group, but corneal tonography placed some of these cases well within normal limits.

Two cases of pseudoglaucoma, not shown in the graphs, fell within the normal group with both methods of testing.

FIG. 5.—Distribution of results of corneal tonography in closed-angle glaucoma.

FIG. 6.—Distribution of results of corneo-scleral tonography in closed-angle glaucoma.

FIG. 8.—Distribution of results of corneal tonography in cases of moderate to severe loss of visual field.

FIG. 9.—Distribution of results of corneo-scleral tonography in cases of moderate to severe loss of visual field.

Discussion

The slight discrepancy in the location of the dividing line between normal and glaucomatous cases which is seen in this series as compared with that of Grant (1950, 1951), is probably as much as would be found in any two centres doing carefully controlled tonography. Obviously, each laboratory must develop its own criterion of border-line cases, having in mind the slight inevitable differences of technique and apparatus.

That the 1 to 3 second interval allowed for transfer of fixation in corneo-scleral tonography made no difference to the test can be demonstrated with corneal tonography. Here, if the tonometer is lifted and replaced, no significant difference will be found in the tension before and after such a short interval. It is again pointed out, however, that the assistant stopped the watch for the duration of the interval, short though it was.

That scleral compression generally resulted in a lighter lowering effect than corneal compression is felt to be partly the result of encroachment of the iris root on the angle structures with subsequent impairment of outflow. This encroachment of iris root may result from forward displacement of the vitreous body or from secondary engorgement of ciliary vessels. Whichever is the case, a certain degree of compression of angle structures and subsequent embarrassment to aqueous filtration is likely to take place. Interference with the more superficial collector channels, whether carrying aqueous humour or blood, by direct pressure of the tonometer foot-plate must also be considered. On a purely physical basis, this area compressed by the tonometer could not influence more than one-tenth of the available channels. Because corneo-scleral tonography does not bring normal eyes with narrow angles within the glaucomatous group, the forward displacement of vitreous alone could not be the sole cause of the impaired outflow.

The results in closed-angle glaucoma are thought to indicate not the severity of the disease but rather the susceptibility to angle embarrassment.

Why cases of moderate to severe loss of visual field, even those from among the low tension glaucoma cases, should fall within the glaucomatous group after scleral compression, rather than after corneal compression is a more intriguing observation. Ease of compressibility of somewhat tenuous venous and aqueous escape channels is a possible explanation.

As a corollary we tested two cases of glaucoma which had shown a constant high tension for several years, not responding too well to treatment but not developing field loss or symptoms. Both of these cases came well within the glaucomatous group when tested by corneal compression, but came very close to the border-line when tested by scleral compression. Thus it seems that, apart from closed-angle cases, the results of scleral compression give some idea of the severity of the disease.

Summary

(1) Corneo-scleral tonography using the electronic tonometer is a practical and fairly accurate test in the diagnosis of glaucoma.

(2) Cases of closed-angle glaucoma, even in interval stages, fall within the glaucomatous group.

(3) Cases of moderate to severe loss of visual field, even in true low pressure glaucoma, fall within the glaucomatous group.

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