Electronic applanation tonometry in corneal edema and keratoplasty

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The effect of corneal edema and the effect of penetrating keratoplasty upon the accuracy of electronic application tonometry were studied in rabbits. Pressure readings made directly from cannulas in the anterior chamber correlated well with those made by electronic application tonometry both in severe corneal edema and 24 hours after penetrating keratoplasty. The advantages of electronic application tonometry in patients with corneal disease are discussed.

Key words: Tonometry, corneal edema, electronic application tonometer, MacKay Marg tonometer, penetrating keratoplasty, corneal curvature, corneal thickness, artificial change of intraocular pressure, anterior chamber cannulation, rabbits.

Many patients have corneal diseases which make it difficult to measure intraocular tension by either the Goldmann application or the Schiötz tonometers. Application with the Goldmann instrument requires an area of cornea greater than 3 mm. in diameter with a smooth, regular curvature; moreover the presence of corneal sutures, which pool fluorescein, hinders application tonometry. The footplate of the Schiötz tonometer is designed for corneas with a standard curvature. Attempts to use this instrument on corneas whose curvature has been markedly altered can only be misleading. The desire to find a method of accurately measuring intraocular tensions in patients after keratoplasty led us to an evaluation of the MacKay-Marg electronic application tonometer.1,3 The fact that this instrument has an applanating surface of only 1.5 mm. and does not require fluorescein provides obvious advantages. Trials in our clinic have shown that readings taken upon normal human anesthetized corneas with the MacKay-Marg instrument correlate well with Goldmann application readings.4 The present study was undertaken to determine whether corneal edema or the corneal distortion and flattening produced by keratoplasty affect the accuracy of the readings.

Materials and methods

Experiment 1. Effect of corneal edema upon intraocular pressure measurements. New Zealand white rabbits weighing 2.5 to 3.5 kilograms were sedated with chlorpromazine. One cornea of each rabbit was anesthetized with topical 0.5 per cent...
Fig. 1. Correlation of pressure measurements made by direct cannulation of the anterior chamber with those made by applanation with the MacKay-Marg tonometer on normal and edematous corneas. Normal eyes are represented in the upper graph and eyes with edematous corneas in the lower. The slope is 0.96 for the normal eyes and 0.93 for those with edematous corneas. The slopes were calculated with the restriction that the lines must go through the origin by the formula: slope = \( \frac{\sum X \sum Y}{\sum X^2} \). Such a restriction makes it more difficult to obtain a high degree of correlation. The correlation coefficient was 0.97 for the normal eyes and 0.98 for those with edematous corneas and thus the high degree of correlation obtained would seem to indicate that the restriction is valid. The slope was also calculated without this restriction and the intercept thus obtained was no significantly different from zero.
proparacaine hydrochloride, and five to ten applications were made to this cornea with the Frigtomic 2 mm. cryoprobe at -60° C.5

Twenty-four hours later the treated corneas had become markedly edematous. The corneal thickness was measured in both the treated and untreated eye of each rabbit with a Haag-Streit pachometer as modified by Mishima and Hedbys.6 Chlorpromazine and intravenous pentobarbital sodium were then given as needed to anesthetize the rabbits and allow them to be mounted in a stereotaxic headholder. Two 23 gauge needles were inserted into the anterior chamber of each eye by means of a modified Sears gun. One needle was attached by vinyl tubing to a Sanborn electronic pressure transducer. The second needle was attached through similar tubing to a Harvard infusion pump. The intraocular pressure was varied by altering the rate of inflow and was measured directly from the anterior chamber by the Sanborn transducer. The intraocular pressure was regulated to cause the pressure to maintain a steady state while readings were taken. Applanation readings were taken from the corneal surface with the MacKay-Marg tonometer,* recorded, and then compared with those readings taken simultaneously from the anterior chamber.

Experiment 2. Effect of penetrating keratoplasty upon intraocular pressure measurements. New Zealand white rabbits weighing 4.0 to 5.0 kilograms were anesthetized with a combination of intramuscular chlorpromazine and intravenous pentobarbital sodium. Five to ten topical applications of proparacaine hydrochloride, and five to ten applications were made to this cornea with the Frigtomic 2 mm. cryoprobe at -60° C.5

After keratoplasties were performed upon enucleated, grafted eyes. Twenty-four hours after keratoplasty, readable tracings remain obtainable thereafter. Furthermore, on the first clinic visit after suture removal, when accurate Goldmann applanation can be performed, the Goldmann measurements correlate well with those obtained by the MacKay-Marg instrument in human grafted eyes.8

Results

1. Effect of corneal edema upon the intraocular pressure as measured by applanation with the MacKay-Marg tonometer. The corneal thickness of the treated eyes was between 2.0 and 3.5 times that of the control eye in every rabbit, illustrating the severity of the corneal edema produced by the freezing treatment. Fig. 1 plots the results of intraocular tension measurements by direct cannulation against those by applanation with the MacKay-Marg tonometer. In both the treated and control groups, there was very good correlation between direct intraocular measurements and those taken by applanation of the corneal surface. The slope was 0.96 for the controls and 0.93 for the treated eyes. This was based upon 140 measurements taken from 10 eyes of 5 rabbits with a range from 9 to 59 mm. of mercury.

2. Effect of penetrating keratoplasty upon the intraocular pressure as measured by applanation with the MacKay-Marg tonometer. Measurements taken from direct cannulation of the anterior chamber correlate well with those taken by applanation of the corneal surface with the MacKay-Marg applanation tonometer (Fig. 2). The slope was 0.94 for the control group and 0.91 for the treated group. This was based upon 110 measurements taken from 10 eyes of 5 rabbits with a range of 6 to 52 mm. of mercury. (When 2 measurements coincided only a single point appears on the graph.)

Discussion

These studies in rabbits indicate that neither severe stromal edema nor the corneal distortion produced by penetrating keratoplasty was a factor in the differences obtained in the intraocular pressures recorded with the MacKay-Marg tonometer.
keratoplasty alters the accuracy of the MacKay-Marg tonometer to a clinically significant degree. The difference between the treated and the control curve was never more than 2.5 mm. of mercury over a pressure range from 6 to 50 mm. of mercury.

Many types of corneal disease make accurate intraocular tension measurement by Goldmann applanation impossible. These include corneal edema with bullous keratopathy, congenital glaucoma (where pressure is measured under general anesthesia) irregular central corneal scars, and...
recent keratoplasty. The small footplate of the MacKay-Marg tonometer and the fact that it can be placed upon any portion of the cornea, so as to avoid scars or large bullae, make it reliable in many cases where the Goldmann or Schiotz instruments cannot be used. If the results reported here in rabbits are valid in human subjects, then the MacKay-Marg tonometer should be a valuable addition to the armamentarium of any ophthalmologist dealing with a large number of patients with corneal disease. This seems a reasonable assumption since readings on normal eyes have been shown valid in both man and rabbits by several authors. 3, 4

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REFERENCES