

Elevated Intraocular Pressure in Diabetic Children

Aran Safir, M.D., Elsa P. Paulsen, M.D., and Joel Klayman, M.D., New York

SUMMARY

A case of juvenile glaucoma in a sixteen-year-old diabetic girl led to a survey of intraocular pressures in thirty-eight diabetic children.

Seven (18 per cent) were classified as abnormal; one because of a positive water drinking test, and six because of tension higher than three standard deviations above the mean of a nondiabetic control group.

Four (11 per cent) were classified as suspects because of tension higher than two standard deviations above the control mean.

Diabetic children should have repeated eye examinations including accurate measurements of ocular tension.

The intraocular pressure of diabetic children became of interest to us in 1961 with the referral, from the pediatric to the ophthalmological service, of a sixteen-year-old girl, diabetic for four years and well controlled on a normal diet and 65 units of NPH insulin daily. She complained of sudden, brief episodes of complete loss of vision in the left eye, occurring when she arose quickly from a bending position. These spells of transient blindness had begun three months before and became more frequent. At the time of examination they were occurring one or more times daily. Between episodes she had no ocular symptoms. Vision returned fully within approximately one minute of its loss.

She was found to have ocular tensions of 38 mm. Hg. in the right eye and 53 mm. Hg. in the left. These tensions, in themselves diagnostic of glaucoma, presumably were the cause of the obscurations of vision. It was thought that postural, systemic hypotension caused transient hypoxia and loss of vision in the left eye as intravascular pressure was equalled by intraocular pressure. This remained unproved. An attempt was made, without success, to precipitate such an episode by postural change. Gonioscopic examination of the anterior

Presented at the Twenty-third Annual Meeting of the American Diabetes Association in Atlantic City on June 16, 1963.

From the Department of Ophthalmology and the Department of Pediatrics, Albert Einstein College of Medicine, Yeshiva University, New York, New York.

chamber angle disclosed no anatomical anomaly or visible block to the outflow of aqueous. The angles were open, wide, and free of evidence of disease.

Glaucomatous intraocular pressures in this type of case are usually classified as chronic simple (open angle) glaucoma. This is quite unusual at age sixteen and is then classified as juvenile glaucoma, an unusually early onset of a disease very similar to the form seen in older people.

An investigation was undertaken to determine if this was an isolated case of glaucoma in a girl who also had diabetes or whether there was a correlation, in children, between diabetes and abnormally high intraocular pressure.

MATERIALS AND METHODS

We undertook to examine the juvenile diabetic populations of the Bronx Municipal and Lincoln Hospitals in New York City. The lower age limit was set as that age at which the children were unable to cooperate in the testing procedures. Our youngest subjects were age seven. We have examined forty-one diabetic children.

The control group was composed of children from both the in- and out-patient departments of Bronx Municipal Hospital. This group has included children with minor pediatric complaints, children recovering from surgery but ambulatory and well, and those referred to the eye service and found to have either minor refractive errors or no ocular disturbance at all. Eighteen control subjects have been examined.

Two types of tonometer were used, the indentation tonometer of Schiøtz and the applanation tonometer of Goldmann. The Schiøtz tonometer, though very widely used, is generally acknowledged^{1,2} to have certain important disadvantages. The indentation of the cornea which it makes in order to establish its measurement of ocular tension is brought about at the cost of resting a considerable weight upon the eye. This large, deforming force raises the intraocular pressure by an amount dependent upon the distensibility of the walls of the globe. The tables for conversion of Schiøtz tonometer readings into intraocular pressure in millimeters of mercury are based on calculations assuming an average coefficient of scleral rigidity. Very large

errors occur frequently if Schiøtz tonometer readings are not corrected for this factor.

The recently developed applanation tonometer of Goldmann has the advantage of yielding readings which do not depend significantly upon scleral rigidity.^{2,3} It deforms the globe by a negligible amount. Readings from this instrument are widely accepted as being nearly equivalent to intraocular pressure. All tensions referred to subsequently are Goldmann applanation tonometer readings made with the Haag-Streit slit lamp.

We have also employed the water drinking provocative test. Approximately one third to one half of patients with proven open angle glaucoma will experience a rapid increase in ocular tension after taking a standard water load orally. Nonglaucomatous subjects do not experience such a change. A rise of 8 mm. Hg. or more, or a rise to a clearly abnormal tension is highly significant.^{4,5} We administered water loads of 15 milliliter per kilogram of body weight to twenty-five of the diabetic subjects. Of these, fourteen also had tonography following the water load.

RESULTS

The eighteen control subjects ranged in age from eight to nineteen years. The mean resting applanation tension of the thirty-six eyes was 15.25 mm. Hg. with a standard deviation of 2.72. This compares closely to the data of Goldmann⁶ for 400 normal eyes in unselected age groups. He found a mean of 15.45 and a standard deviation of 2.52. Levene,⁷ in 122 patients under twenty years of age, found a mean of 14.7 and a standard deviation of 2.9. *Castrén and Pohjola*⁸ found somewhat lower values. In ninety-four eyes of normal ten-year-olds they recorded a mean tension of 14.4 with a standard deviation of 2.52, and in 103 eyes of normal fifteen-year-olds, a mean of 14.1 with a standard deviation of 2.50. *Ytteborg*,⁹ in twenty-five eyes, ages twelve to nineteen, found a mean of 12.0 mm. Hg.

The forty-one diabetic children ranged in age from seven through seventeen. Of these forty-one, three were unable to cooperate sufficiently. From the remaining

thirty-eight subjects we draw our conclusions.

Seven diabetic subjects (18 per cent) were classified as abnormal (table 1). One of these, Case G, had only a markedly positive water drinking test. His tensions, which before water were nineteen (right eye) and sixteen (left eye), rose to twenty-five and thirty following the water load. The other six abnormal diabetic subjects all had resting tensions more than three standard deviations above the control mean (24 mm. Hg. or over). Two of these (Cases B and E) had positive water drinking tests in addition, and two cases (A and B) had visual field abnormalities.

Case A, the girl whose disease led to this survey, proved difficult to manage clinically. She responded well initially to medical treatment of open angle glaucoma, but eventually broke through these efforts at control of the disease. Pilocarpine and other miotics, Acetazolamide (Diamox) and related drugs, and topical epinephrine-like compounds, alone and in many combinations all proved insufficient to maintain the tension at normal levels. She finally developed a characteristic, glaucomatous field defect in her left eye (figure 1). This field was measured at a time when both eyes had normal tension and normal acuity. Surgery was done to establish artificial outflow channels. Uncontrollable, high tension developed in the right eye and this too was operated on. At present her tensions are normal and she is taking no ocular medications.

Case B has been seen many times and has had tensions of twenty-seven, twenty-eight, or twenty-nine repeatedly. He has had two positive water drinking tests. On two of his clinic visits his tensions were normal. Figure 2 shows his visual field, measured recently. Though not diagnostic, the enlargement of the blind spot in the right eye is very suggestive and, in a patient with tensions as high as his, is very likely due to glaucoma.

Case C had normal tensions on two occasions and abnormal on only one. She had a negative water drinking test.

Case D had normal tensions on four occasions and abnormal on only one. He too had a negative water drinking test.

Case E has had a normal resting tension on only one occasion (the day she had a positive water drinking test). On four other visits she had abnormal tensions.

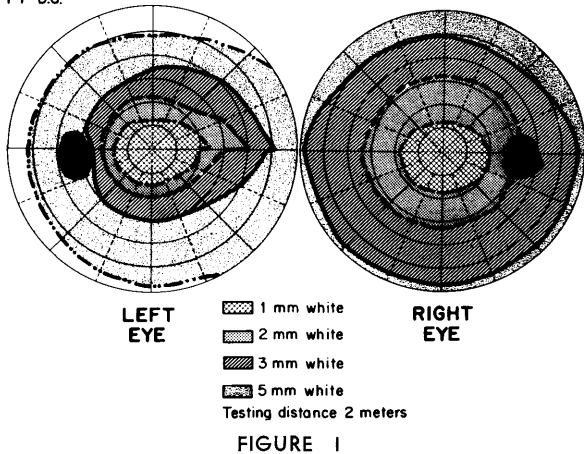
Case F has had normal tension once and abnormal once.

Four other diabetic subjects (11 per cent) have had tensions of twenty-one or over, but less than twenty-four. This is

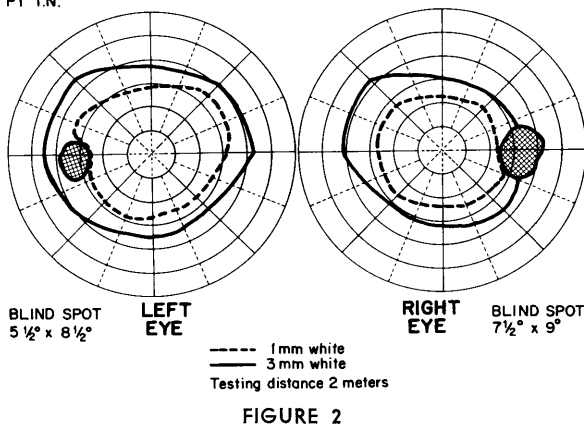
TABLE 1
Diabetics classified abnormal—applanation tonometer readings

Case	Age (years)	Duration of diabetes (years)	Highest resting tension mm. Hg.		Positive water load results			
			Right eye	Left eye	Tension before water Right eye	Left eye	Tension after water Right eye	Left eye
A	16	4	38	53				
B	12	5	27	28	20	20	34	36
C	15	7	24	24				
D	12	8	24	24				
E	13	10	25	28	21	21	32	35
F	17	10	28	20				
G	11	2	19	16	19	16	25	30

CASE A 4/7/63
PT D.G.



CASE B 5/18/63
PT T.N.



more than two standard deviations above the mean of the normal controls. We regard these four cases as suspects.

If the Schiøtz tonometer alone had been used, two of the seven positives and one of the four suspects would have been classified as normal.

Statistical analysis of the data reveals that there is no correlation between ocular tension and age, or ocular tension and age at onset of diabetes. There is a slight ($r = +0.43$) correlation between tension and duration of diabetes.

None of the children with abnormal tension had any visible evidence of ocular diabetes. One boy who has had diabetes for thirteen of his seventeen years has one small retinal lesion, presumably a microaneurysm. His tension was twenty-two in each eye and he is one of the four suspects. One boy, age twelve, diabetic for four years, has classical diabetic cataract. His tensions were eighteen and twenty.

DISCUSSION

It has been shown¹⁰ that glaucoma is more common in diabetic than in nondiabetic adults. To our knowledge, elevation of intraocular pressure has not previously been noted in diabetic children. Because glaucoma, with the exception of the congenital type, is considered

rare in children, and uncommon even in young adults, ocular tension is not often measured in young people. Indeed, many authorities advise that tension be measured routinely only in patients above the age of forty.

It is our opinion that a thorough ocular examination, including measurement of tension, is an essential part of the care of the diabetic child. The Goldmann applanation tonometer should be used. Repeated examinations are necessary since even children whose tensions are often abnormal are likely to have normal tensions some of the time.

SUMMARIO IN INTERLINGUA

Elevation del Pression Intraocular in Juveniles con Diabete

Un caso de glaucoma juvenil in un puera diabetic de dece-sex annos de etate inspirava un investigation del pression intraocular in trenta-octo altere diabeticos juvenil.

Septe esseva classificate como anormal (18 pro cento). In un de istes le test de imbibition de aqua esseva positive; in sex alteres le tension esseva plus que tres deviationes standard supra le nivello medie de un non-diabetic gruppo de controllo.

Quatro esseva classificate como suspecte (11 pro cento). In istes le tension esseva plus que duo deviationes standard supra le nivello medie de controllo.

In juveniles diabetic, repetite examines del oculos deberea esser effectuate, e istos deberea includer un accurate mesuration del tension ocular.

ACKNOWLEDGMENT

This project was supported, in part, by funds from The Upjohn Company, Kalamazoo, Michigan.

REFERENCES

- ¹ Sugar, H. Saul: *The Glaucomas*. New York, Hoeber-Harper Co., 1957, p. 71.
- ² Duke-Elder, S.: *System of Ophthalmology*. St. Louis, C. V. Mosby Co., 1962, vol. VII.
- ³ Becker, B., and Shaffer, R. N.: *Diagnosis and Therapy of the Glaucomas*. St. Louis, C. V. Mosby, 1961, p. 63.
- ⁴ Kronfeld, P. C.: *Glaucoma—A Symposium*. Springfield, Ill., Charles C Thomas Co., 1955, p. 234.
- ⁵ Leydhecker, W.: The water drinking test. *Brit. J. Ophth.* 34:457-79, Aug. 1950.
- ⁶ Goldmann, H.: *Glaucoma*, Transactions of the Second Conference. New York, Josiah Macy, Jr. Foundation, 1956, p. 192.
- ⁷ Levene, R. Z.: Tonometry and tonography in a group health population. *A.M.A. Arch. Ophth.* 66:68-73, July 1961.
- ⁸ Castrén, J., and Pohjola, S.: Scleral rigidity at puberty. *Acta Ophth.* 39:1015-19, 1961.
- ⁹ Ytteborg, J.: Further investigations of factors influencing size of rigidity coefficient. *Acta Ophth.* 38:643-57, 1960.
- ¹⁰ Armstrong, J. R., Daily, R. K., Dobson, H. L., and Girard, L. J.: The incidence of glaucoma in diabetes mellitus. *Amer. J. Ophth.* 50:55-63, 1960.