Prevention of vitreous loss

M. A. GALIN, R. ROBBINS, AND S. OBSTBAUM

From the Department of Ophthalmology of the New York Medical College, U.S.A.

Retrobulbar anaesthesia, digital massage, osmotic therapy, and acetazolamide are frequently employed in various combinations to effect ocular hypotony before cataract extraction.* It is believed by many that hypotony prevents vitreous loss during this operation.†

Profound akinesia to preclude extraocular muscle contraction and resulting shortening of the scleral shell is a clinically accepted mechanism to prevent vitreous loss (Kornblueth, Jampolsky, Tambler, and Marg, 1960). Another clinical and laboratory-proved method is the induction of acute hyperosmolarity.‡

Though digital massage induces immediate vitreous weight reduction in the closed rabbit eye, recent investigations have demonstrated a rebound phenomenon which increases both vitreous weight and intraocular pressure approximately 5 to 10 min. after the completion of massage (Obstbaum, Robbins, Best, and Galin, 1971). This time sequence would, of course, be totally undesirable during a lens extraction.

Experiments concerning the effects of hyperosmolarity and digital massage have been carried out on the closed eye which, though of significant clinical importance, is not comparable to an eye undergoing lens extraction. Consequently, this investigation was undertaken to evaluate the effects of digital massage and 20 per cent. mannitol infusion on vitreous weights in rabbit eyes that had undergone the initial steps of lens extraction.

Materials and methods

New Zealand albino rabbits weighing 3 to 5 kg. were used. General anaesthesia was induced with intravenous sodium pentobarbital, 30 mg./kg. Intraocular pressures were determined by Schiötz tonometry with the 5.5 g. weight, calibrated for the rabbit eye (Best, Pola, Blumenthal, and Galin, 1970). Vitreous body weights were measured by the use of a freezing technique detailed elsewhere (Robbins and Galin, 1969). In summary, the technique involves rapid enucleation of the eye, freezing it for 24 hrs in dry ice at $-78^{\circ}\text{C}.$, isolating the frozen spheroid of vitreous by careful dissection, and then weighing the isolated, intact frozen vitreous body to milligramme accuracy.

Ten animals received no therapy. After each had been anaesthetized for 15 min., intraocular pressures were measured bilaterally. In all cases, the pressures were normal and essentially equal. Both eyes were then enucleated rapidly and placed in the dry ice freezer. Vitreous isolation and weighing were performed 24 hrs later.

Fifteen rabbits were subjected to uniocular limbal incisions of approximately 60° after baselines had been established as in the controls. The posterior lip of the incision was depressed for 10 sec.

Received for publication October 19, 1970

Address for reprints: Dr. M. A. Galin, Department of Ophthalmology, New York Medical College, New York, N.Y., U.S.A. Aided by Grant HE-13660-05 from the USPHS, Grant #P-517 from the American Cancer Society, Grant #63-869 from the American Heart Association, and a Grant from the Susan Greenwall Foundation.

*Atkinson (1943), Kirsch and Steinman (1955), Agarwal, Gupta, and Malik (1959), Friedman, Byron, and Turtz (1962), Hill (1964), Jaffe and Light (1965).

†Gartner (1959), Townes (1965), Jaffe (1968).

‡Kornblueth and Gombos (1962), Seeger and Lewis (1964), Robbins and Galin (1969).

every minute so that the anterior chamber was totally evacuated. After five min. the incision was frozen closed with dry ice (Figure) and both eyes were enucleated. Similar experiments were conducted in other groups of animals leaving the eye open for 7.5 min. and for 10 min.

FIGURE Diagram of closure of incision with dry ice

Digital massage was carried out in a group of fifteen rabbits in which compression was maintained for 30-sec. intervals and released for 2-sec. intervals for a period of 5.5 min. Five min. later a limbal incision of 60° was made, and the eye treated as previously indicated. At the end of 5 min. the eyes were enucleated.

Fifteen animals received rapid infusions of 20 per cent. mannitol, 2 g./kg. Before the infusion one eye was enucleated and 60 min. after the termination of infusion, a 60° limbal incision was made in the remaining eye which was handled as above. After the eye had been open for 5 min. it was enucleated.

Results

Table I lists the vitreous weights in control animals. It is clear that the weights are close enough to permit the utilization of the unmanipulated eye as a control.

Table I Vitreous weights in undisturbed animal

Rabbit No.	Vitreous weight (g.)		Per cent. variation*
	In untreated left eye	In untreated right eye	
1	1.654	1.649	0.30
2	2.072	2.068	0.19
3	1.893	1.896	0.16
4	1.860	1.855	0.27
5	1.778	1.780	0.11
6	1.586	1.582	0.25
7	1.827	1.826	0.05
8	1.985	1.991	0.30
9	1.631	1.640	0.55
10	2.009	2.007	0.10

*Average weight variation = 0.23 per cent.

Table II Vitreous weight change 5 min. after eye has been open for 5 min.

Rabbit No.	Vitreous weight (g.)		Per cent. weight loss in 5 min.*
	Control eye	Opened eye	
1	1.848	1.738	5.95
2	1.532	1.440	6.01
3	1.460	1.388	4.93
4	1.947	1.756	9.80
5	1.810	1.692	6.52
6	1.718	1.629	5.18
7	1.686	1.583	6.13
8	1.617	1.499	7.29
9	1.724	1.596	7.44
10	1.873	1.794	4.22
11	1.928	1.785	7.41
12	2.226	2.044	8.19
13	1.708	1.602	6.20
14	1.605	1.491	7.12
15	1.822	1.702	6.59

*Average weight loss in opened eye = 6.60 per cent.

Tables II to IV list the vitreous weights of non-manipulated, limbally incised globes. It is apparent that a significant loss of vitreous weight is caused simply by opening the eye.

Table III Vitreous weight change 7.5 min. after eye has been open for 5 min.

Rabbit No.	Vitreous weight (g.)		Per cent. weight loss in 7.5 min.*
	Control eye	Opened eye	
1	1.837	1.719	6.41
2	1.549	1.440	7.03
3	1.587	1.487	6.29
4	1.624	1.518	6.53
5	1.925	1.772	7.96
6	1.748	1.622	7.20
7	1.656	1.555	6.10
8	1.483	1.385	6.62
9	1.598	1.478	7.50
10	1.870	1.739	7.01
11	1.819	1.683	7.47
12	1.728	1.624	6.01
13	1.608	1.524	5.22
14	1.451	1.349	7.03
15	1.964	1.782	9.27

*Average weight loss in opened eye = 6.91 per cent.

Table IV Vitreous weight change 10 min. after eye has been open for 5 min.

Rabbit No.	Vitreous weight (g.)		Per cent. weight loss in 10 min.*
	Control eye	Opened eye	
1	1.866	1.773	4.98
2	1.811	1.680	7.24
3	1.439	1.300	9.65
4	1.647	1.542	6.36
5	1.572	1.422	9.55
6	1.948	1.807	7.23
7	1.708	1.611	5.67
8	1.781	1.656	7.02
9	1.645	1.522	7.45
10	1.916	1.817	5.15
11	1.763	1.632	7.44
12	1.464	1.359	7.19
13	1.627	1.469	9.69
14	1.794	1.654	7.82
15	1.878	1.746	7.02

*Average weight loss in opened eye = 7.30 per cent.

This reduction was not much altered by increasing the length of time that the eye was open before the globe was enucleated. As is shown in Table V, the vitreous weight change was essentially unaltered by previous digital massage for 5 min., even though intraocular pressure was substantially lowered at the time of surgery.

Table V Vitreous weight change 5 min. after eye has been opened, having been massaged for 5 min.

Rabbit no.	Vitreous weight (g.)		Intraocular pressure in treated eye (Scale units Schiötz tonometer, 5.5 g.)			Per cent. weight loss in treated eye
	Control eye	Massaged 5.5 min. and opened 5 min.	Before massage	After 5.5 min. massage	5 min. after massage	
1	1.403	1.309	3.0	16.0	8.0	6.71
2	1.484	1.378	4.5	20.0	8.0	7.15
3	2.049	1.912	4.0	19.0	10.0	6.68
4	1.465	1.347	3.0	17.0	9.0	8.05
5	1.553	1.442	3.5	14.0	7.0	7.16
6	1.630	1.527	2.5	13.5	7.5	6.32
7	1.618	1.524	4.0	18.0	10.5	5.82
8	2.009	1.848	3.0	15.0	9.0	8.01
9	1.902	1.773	4.5	16.0	9.0	6.79
10	1.811	1.691	3.0	14.0	8.5	6.64
11	1.914	1.813	3.5	15.5	7.5	5.28
12	1.907	1.767	2.5	12.0	6.5	7.35
13	1.923	1.762	4.0	13.0	8.0	8.36
14	2.183	2.001	3.0	14.0	7.5	8.34
15	1.696	1.572	3.5	13.0	6.0	7.32

*Average weight loss in treated eye = 7.07 per cent.

Table VI indicates that osmotic therapy produces a net reduction in vitreous weight significantly greater than that induced by atmospheric equilibration alone or by digital massage.

Table VI *Vitreous weight change 5 min. after eye has been opened, having been infused with mannitol 60 min. before being opened.*

Rabbit no.	Vitreous weight (g.)		Intraocular pressure changes in treated eye (Scale units Schiötz tonometer, 5.5 g.)		Per cent. weight loss in treated eye
	Control eye	In eye treated with mannitol 60 min. and opened 5 min.	Before mannitol	60 min. after mannitol infusion	
1	2.228	2.001	3.0	11.0	10.18
2	2.037	1.833	4.0	13.0	10.00
3	1.618	1.472	3.5	9.5	9.01
4	1.821	1.668	4.0	10.5	8.40
5	1.498	1.366	2.5	11.0	8.80
6	1.885	1.707	3.0	10.5	9.44
7	1.421	1.314	4.5	12.0	7.54
8	1.264	1.142	3.0	11.0	9.65
9	1.226	1.121	2.5	9.0	8.56
10	1.527	1.387	4.0	13.0	9.15
11	1.376	1.280	3.5	9.0	6.96
12	1.358	1.236	3.5	12.0	8.98
13	2.170	1.986	4.0	10.0	8.48
14	1.781	1.601	4.5	12.5	10.12
15	1.845	1.664	3.5	14.0	9.82

*Average weight loss in treated eye = 9.01 per cent.

Discussion

It is commonly believed that steps to produce hypotony are of benefit in the performance of intraocular surgery by reducing the incidence of vitreous loss (Gartner, 1959; Townes, 1965; Jaffe, 1968). It has never been shown, however, that hypotony is of value *per se*. This study would infer that hypotony *per se* is not of benefit in reducing the potential for vitreous loss, but is only a concomitant of techniques that are effective in reducing vitreous mass.

Once the eye is open, intraocular pressure is equilibrated with atmospheric pressure. In this state, any positive pressure against the globe will prolapse the vitreous body forwards. Vitreous prolapse may be (Gartner, 1959) similarly effected by collapse of the scleral shell, contraction of extraocular muscles, or internal expansion of the choroidal or subchoroidal spaces. If less vitreous is present, a margin of volume displacement becomes available to offset small vectors directed towards expelling the vitreous. It is certainly not the intraocular pressure (or hypotony) *per se* that is involved.

These studies indicate that vitreous water loss is caused simply by opening the eye. Most investigators are familiar with the observation that the entire rabbit lens and vitreous

body is readily removed and will "drip water" if supported in air. This has also been demonstrated in eye-bank eyes (Irvine, 1953). Presumably, the closed space pressure gradient in the undisturbed eye is one factor in maintaining vitreous mass which is lost when the eye is opened. These data further show that previous digital massage does not induce a reduction in vitreous mass during the usual duration of time associated with removing the lens. In fact, in the rabbit, massage may induce vitreous weight rebound. This has been observed in the closed eye and, though the net vitreous weight change was not found to be increased after massage when it was studied in the open eye, the technique of this investigation does not preclude this phenomenon (Obstbaum and others, 1971).

The hyperosmolar state does appear to reduce vitreous mass even when the eye has been opened. Presumably, the osmotic gradient is operative during the usual time necessary for a lens extraction.

These data strongly support the idea of the clinical value of hyperosmolar therapy, but they cast doubt on the value of preoperative massage in decreasing vitreous loss. If this latter technique is of value, its effect is probably due to the dissemination of anaesthesia and the consequent improvement in akinesia (Atkinson, 1943; Gartner, 1959, 1961).

It is a fair observation that vitreous will not run uphill. Something pushes it out. Hyperosmolar therapy provides a theoretical margin of safety while digital massage does not (Robbins, and Galin, 1969). Of course, this margin of safety is theoretical, since the choroidal volume has not been measured in the open eye and may significantly reduce or totally offset any reduction in vitreous mass.

All in all, these studies tend to support the concept that, of all the available means to preclude vitreous loss, excellent akinesia seems most significant.

Summary

Limbal incisions were made in rabbit eyes to mirror the initial steps of lens extraction. The vitreous body loses water when the eye is open and decreases in weight. Previous digital massage does not increase this vitreous weight change but hyperosmolar therapy does.

References

- AGARWAL, L. P., GUPTA, R. B. L., and MALIK, S. R. K. (1959) *Brit. J. Ophthalm.*, **43**, 302
 ATKINSON, W. S. (1943) *Arch. Ophthalm. (Chicago)*, **30**, 777
 BEST, M., POLA, R., BLUMENTHAL, M., and GALIN, M. A. (1970) *Ibid.*, **84**, 200
 FRIEDMAN, B., BYRON, H., and TURTZ, A. (1962) *Ibid.*, **67**, 421
 GARTNER, S. (1959) *A.M.A. Arch. Ophthalm.*, **61**, 50
 ——— (1961) *Arch. Ophthalm. (Chicago)*, **66**, 76
 HILL, K. (1964) *Amer. J. Ophthalm.*, **58**, 79
 IRVINE, S. R. (1953) *Ibid.*, **36**, 599
 JAFFE, N. S. (1968) *Sth. med. J. (Bgham, Ala.)*, **61**, 859
 ——— and LIGHT, D. S. (1965) *Arch. Ophthalm. (Chicago)*, **73**, 516
 KIRSCH, R. E., and STEINMAN, W. (1955) *A.M.A. Arch. Ophthalm.*, **54**, 697
 KORNBLUETH, W., and GOMBOS, G. (1962) *Amer. J. Ophthalm.*, **54**, 753
 ———, JAMPOLSKY, A., TAMLER, E., and MARG, E. (1960) *Ibid.*, **49**, 1381
 OBSTBAUM, S. A., ROBBINS, R., BEST, M., and GALIN, M. A. (1971) *Ibid.*, **71**, 1059
 ROBBINS, R., and GALIN, M. A. (1969) *Arch. Ophthalm. (Chicago)*, **82**, 694
 SEEGER, F. L., and LEWIS, P. M. (1964) *Ibid.*, **72**, 219
 TOWNES, C. D. (1965) *J. int. Coll. Surg.*, **44**, 298