# OCULAR MASSAGE BEFORE CATARACT SURGERY*

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## INTRODUCTION

THE USE OF OCULAR MASSAGE IMMEDIATELY BEFORE CATARACT SURGERY TO LOWER intraocular pressure and presumably decrease vitreous volume has long been advocated to minimize vitreous loss during surgery.[1] The Honan intraocular pressure reducer has become a popular device for this preoperative softening of the eye.[2-4] Cataract surgeons have found that the anterior chamber deepens and the iris falls back when the eye is opened, presumably making implantation of an intraocular lens easier and safer. It has not been previously determined how long the Honan balloon will maintain the eye in a softened state. An intraocular pressure rebound to near normal levels has been demonstrated in previous studies following digital massage.[5-7] Because of the variability in the amount of time it takes for the surgeon to open the eye after the ocular massage (time for scrub, drape, and preparation of the globe), it is important to know the duration of the effect of the Honan balloon.

We performed serial measurements of intraocular pressure immediately upon removal of the Honan balloon after its application for 30 minutes at a gauge reading of 30. We also carried out studies on phantom and cadaver eyes to determine the variability of digital massage and the safety of constant compression by devices such as the Honan balloon.

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## METHODS

### PHANTOM EYE

We constructed a phantom eye from an 8 cm length of soft rubber tubing that had an outer diameter of 3.0 cm and an inner diameter of 2.5 cm. One end was sealed and the other was connected to a pressure transducer (Model 1280C, Hewlett-Packard, Waltham, MA), which continuously recorded the intraocular pressure on a polygraph (Model 7785, Hewlett-Packard). We filled the entire system with water and instructed 24 residents and attending staff who regularly perform cataract surgery at the University of Illinois Eye and Ear Infirmary to massage the middle one-third of the tube. We instructed them to carry out "typical preoperative digital massage" on the phantom eye as it rested on a table. We did not allow the physicians to see the polygraph, and we recorded the peak pressure achieved in one of five or more cycles.

### CADAVER EYE

We monitored the intraocular pressure of a cadaver eye, obtained from the Illinois Eye Bank, by a pressure transducer (Model 1280C, Hewlett-Packard) connected to a 23-gauge needle inserted into the eye through the pars plana. Initially, we set the intraocular pressure at 20 mm Hg by adjusting the height of an infusion bottle connected to the ocular cannula. We then closed the valve of the infusion bottle and recorded the intraocular pressure continuously throughout the application of the Honan balloon. We slowly inflated the Honan balloon, which was applied to the cornea, while the eye lay flat on the table, until the balloon's gauge read 30. After the new, stable intraocular pressure was achieved we released the Honan balloon pressure. We then reset the intraocular pressure to 20 mm Hg with the infusion bottle and repeated the procedure for a Honan balloon reading of 25. We obtained similar measurements for readings of 20, 15, 10, 5, and 2.5. The entire cycle was repeated for a total of three intraocular pressure measurements at each Honan balloon gauge reading.

### SUBJECTS

Men and women over the age of 50 years who were waiting for cataract surgery but had no other history of eye disease were selected at random from the general eye clinic or the ophthalmology inpatient ward of the University of Illinois Eye and Ear Infirmary. We gave each subject a complete eye examination and our exclusion criteria consisted of shallow anterior chamber angles, glaucoma, uveitis, vascular occlusions, ischemic or inflammatory optic nerve diseases, or a history of eye trauma. We accepted monocular aphakes into the study and measured their phakic eyes.

We dilated the pupil of one eye of ten subjects with one drop of 10% phenylephrine hydrochloride applied once every 5 minutes for 15 minutes. The subjects remained quietly seated in the slit-lamp chair while the experiment was in progress. We initially measured three control intraocular pressures with a Goldmann applanation tonometer and three control anterior chamber depths with a Haag-Streit pachometer. We then placed the Honan balloon over the closed eyelid for 30 minutes and inflated it to a gauge reading of 30, which we constantly monitored and adjusted as needed. Within 10 seconds after removing the Honan balloon, we measured the intraocular pressure and anterior chamber depth. We repeated these measurements every 5 minutes thereafter for 35 minutes or until the intraocular pressure became stable.

We determined the reproducibility of the intraocular pressure measurements obtained by the Goldmann applanation tonometer by carrying out seven consecutive measurements during 55 minutes (t = 0, 30, 35, 40, 45, 50, and 55 minutes) in one eye of one of us (JDZ). The reproducibility of the anterior chamber depth measurements was evaluated by making ten consecutive measurements during 50 minutes (5 minutes apart) in one eye of one subject. The same physician (MAS) performed all of these readings.

## RESULTS

### PHANTOM EYE

Techniques for digital massage of the phantom eye varied considerably. Most of the physicians utilized an "on-off" cycle with 2 to 20 seconds "on" and 2 to 20 seconds "off," with somewhat more time "on" than "off." Four of 24 stated they used a "constant on" technique which was applied until the eye "felt soft" or until the intraocular pressure was less than 10 mm Hg as determined by Schiøtz tonometry. The peak pressures achieved ranged from 15 to 400 mm Hg (Fig 1). Half of those tested achieved pressures over 100 mm Hg at some time.

### CADAVER EYE

A linear relationship (Fig 2) existed between the Honan balloon gauge reading and the actual intraocular pressures over the range tested, except at the lowest gauge reading where some initial deformation probably distorted the result. A reading as little as 2.5 on the Honan balloon gauge

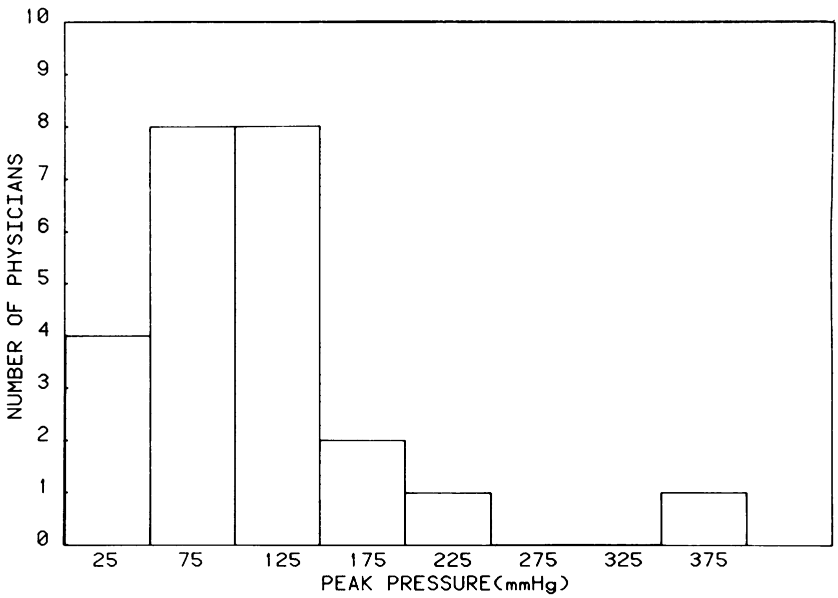


FIGURE 1
Histogram of peak pressures obtained by 24 physicians on phantom eye. Intraocular pressures indicate mid-point of range, which is ± 25 mm Hg. Peak pressures ranged from 15 to 400 mm Hg.

translated to an intraocular pressure of over 45 mm Hg, while a reading of 30 corresponded to an intraocular pressure of over 180 mm Hg (Fig 2).

## SUBJECTS

We found a standard error (SE) of ± 0.2 mm Hg in seven consecutive measurements of applanation tension in the same eye.

The average control intraocular pressure before applying the Honan balloon to the ten subjects used in the study was 17.0 ± 1.4 mm Hg (mean ± SE). We placed the Honan balloon on each subject's eye and inflated it to a gauge reading of 30 for 30 minutes. Immediately (10 seconds) after removing the balloon the intraocular pressure averaged 7.3 ± 1.7 mm Hg. A recovery curve for a typical subject is shown in Fig 3. The average of the intraocular pressure difference from each subject's control pressure is shown in Fig 4 following removal of the Honan balloon.

The average anterior chamber depth was 2.69 ± 0.13 mm before administering the Honan balloon. The mean anterior chamber depth

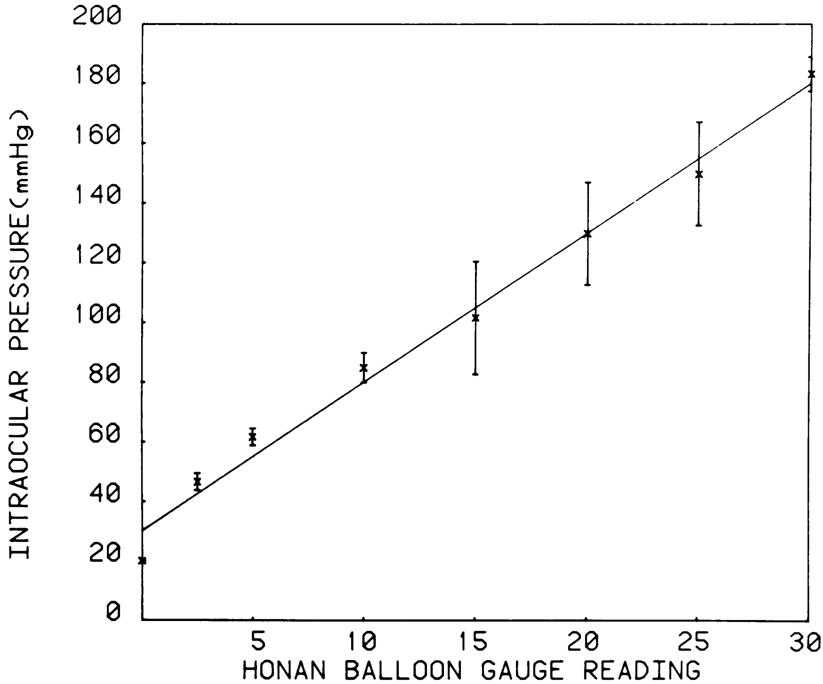


FIGURE 2
Intraocular pressure in a cadaver eye with Honan intraocular pressure reducer applied to it. Limits are ± SE. Response of a living eye would undoubtedly be significantly lower because orbit would presumably absorb some of force applied by Honan balloon.

measurement decreased to 2.58 ± 0.15 mm immediately after removing the Honan balloon. The average 0 time difference from control was 0.12 ± 0.05 which was barely statisticaly significant ($P < 0.05$). Significant deepening compared to pretreatment values could not be demonstrated at later times.

## DISCUSSION

The surprising variability and relatively high peak pressures found in our "phantom eye" study (Fig 1) suggested that compression applied in a controlled fashion may be an attractive alternative to digital massage. In 1967, Vorosmarthy[8] described the "Oculopressor," which had a bellows that was placed over the lids and a bulb with a pressure gauge to control the force applied to the eye. In 1978, Honan introduced a compressible

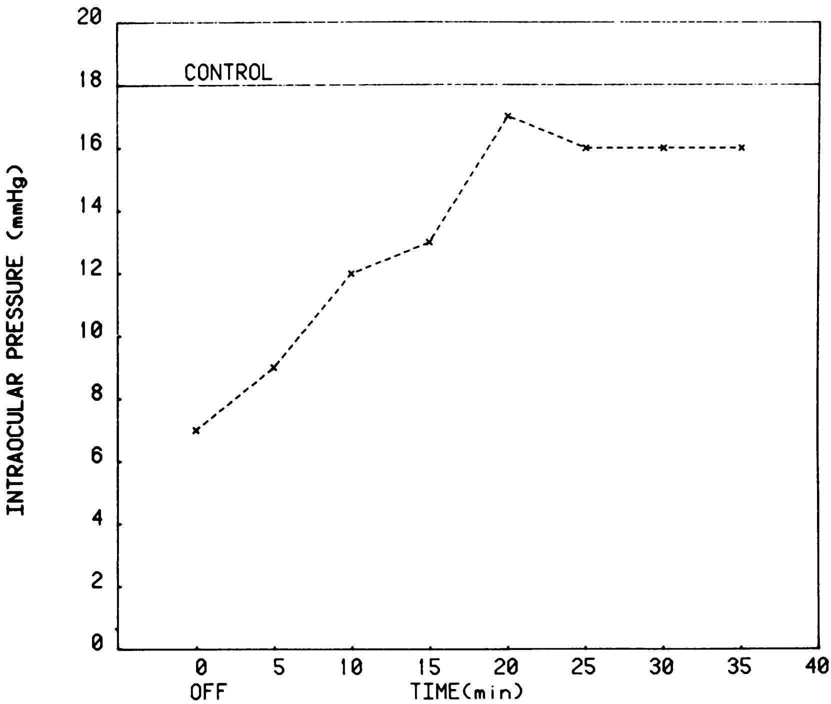


FIGURE 3
Intraocular pressure following removal of Honan balloon in a representative subject. Honan balloon had been applied for 30 minutes at a gauge reading of 30.

balloon held in place over the eye with a headband; the applied force was adjustable with a rubber bulb attached to a pressure gauge calibrated in millimeters of mercury. The balloon has typically been applied in regimens such as "30 mm Hg for 30 minutes,"[2] although other regimens such as "30 mm Hg for 5 minutes"[4] have also achieved preoperative hypotony.

It states in the product information folder that an inflation pressure of 30, indicated by an arrow on the gauge, should be employed. In addition, the gauge is color coded to suggest that pressures above 30 to 40 should not be used. A safety valve has been developed to limit to about 60 mm Hg the peak air pressure that can be applied to the Honan balloon. Our cadaver eye reached an intraocular pressure of 183 mm Hg with the Honan balloon pressure gauge set at 30 (Fig 2). This intraocular pressure probably represents the peak pressure possible in the absence of an orbit containing soft tissue that would presumably be more forgiving to forces

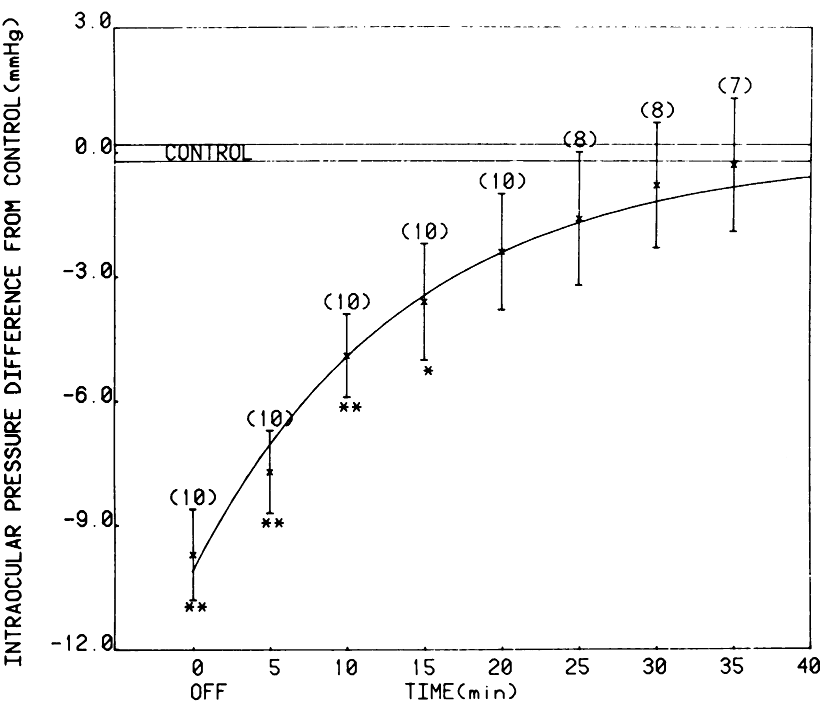


FIGURE 4

Intraocular pressures expressed as average difference ± SE between the control values before application of Honan intraocular pressure reducer and values following its removal in ten subjects. Honan balloon had been applied for 30 minutes at a gauge reading of 30. Line is an unweighted, nonlinear regression fit of data for exponential recovery to control value. Half-time for recovery is 9.6 minutes. $*P < 0.03$, $**P < 0.001$. There was no statistically significant decrease in intraocular pressure after 15 minutes ($P > 0.1$).

applied to it. Recently McDonnell and co-workers[9] measured intraocular pressures using a cannula and transducer in the eyes of patients shortly after death and again after enucleation. These investigators found that the intraocular pressures were highest in the enucleated eyes and in both cases, the eye pressures were higher than the balloon pressures. We may wonder how close the experimental intraocular pressure is approximated when applying the device to a tight (eg, thyroid) orbit. The Honan balloon has reportedly been used in thousands of cases without apparent complications,[2-4] although prolonged compression of the eye by external devices has recently been implicated in infarction of the outer retina.[10]

The Honan balloon consistently and dramatically reduced intraocular pressures in all human eyes studied, but after its removal the intraocular pressure rapidly recovered (Fig 4). In less than 20 minutes there was no statistically significant effect. As was true in some of the cases reported by Obstbaum and Podos[6] who employed digital massage, the intraocular pressure often eventually overshot the control pressure. Nonetheless, in clinical cases the "softened state" is still appreciated by the surgeon well after 20 minutes, suggesting that the benefits derived from the Honan balloon do not result from a sustained reduction in intraocular pressure.

We found that there was an exponential recovery (half-time = 9.6 minutes) of the intraocular pressure to control values after the Honan balloon was removed (Fig 4). It is interesting to note that the half-time of the intraocular pressure recovery was approximately 10 minutes, which is similar to findings in other reports.[5-7]

The corneal-scleral wall varies in shape and distensibility among individual eyes. Friedenwald,[11] assuming a spherical globe, proposed that an eye's distensibility could be empirically defined by the straight line obtained in a plot of the log pressures versus volume. Assuming that the eye remains spherical, a decrease in volume of as little as 30 ul would be sufficient to decrease the intraocular pressure from approximately 20 to 5 mm Hg. This value is similar to that predicted by Robbins and co-workers[12] who extrapolated to human eyes vitreous weight reductions in rabbits after digital massage. The low value may explain why neither Francois et al[13] nor we could demonstrate significant, prolonged deepening of the anterior chamber after massage. Possibly a small volume of liquid vitreous either leaves the eye or enters the anterior chamber and is subsequently expelled when the eye is opened, thus decreasing the volume of the vitreous cavity.

The exact mechanism by which massage and compression protect against vitreous loss remains unclear. A decrease in the volume of the orbit following ocular massage was suggested by Schimek and colleagues[14] who showed that ocular compression not only eliminated the exophthalmos induced by retrobulbar injection but actually resulted in a brief mild enophthalmos. Massage may also improve akinesia of the extraocular muscles, thus preventing their contraction and effecting a decrease in the volume of the globe. It may also be that massage and compression lead to consolidation of the vitreous followed by outflow of the expressed fluid when the eye is incised. Further research and experimental measurements, in particular anterior chamber depths immediately before and immediately after incision, are needed to clarify the exact mechanism(s) by which massage and compression decrease the possibility of vitreous loss during cataract surgery.

**SUMMARY**

We used the Honan intraocular pressure reducer, a balloon that applies a constant force, to the eyes in ten subjects with senile cataracts. An initially significant decrease in intraocular pressure after removal disappeared exponentially with a half-time of 9.6 minutes, indicating that the benefits derived from the Honan balloon do not result from a sustained reduction in intraocular pressure. Measurements made on a phantom eye showed both marked variability and unexpectedly high intraocular pressure during typical preoperative digital massage by a group of ophthalmic surgeons. Measurements made on a cadaver eye after application of the Honan balloon showed that very high intraocular pressures may be achieved under some conditions.

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## *DISCUSSION*

DR SAMUEL D. MCPHERSON, JR. The authors have added more facts to our knowledge of the effects of ocular compression in reducing the incidence of complications during cataract extraction. The high intraocularpressures reported following enucleation of the eye are not surprising when one considers that the eye was completely isolated from the cushioning effect of orbital tissue. Also the failure to demonstrate deepening of the anterior chamber is not surprising since there was never an indication that aqueous would not be forced from the eye by such constant pressure. The reduction in intraocular pressure by 7.3 mm Hg in normal eyes is roughly similar to that which Quist, Stapleton, and I had found in an earlier study. In 48 eyes we found an average reduction of intraocular pressure of 6.5 mm Hg after 5 minutes application of the balloon at 30 mm Hg. Similar results were found by McDonnell and associates in a more recent study.

In regard to the dangers of the balloon in the glaucomatous eye, it was our finding that in eight eyes with glaucoma with an initial pressure of 24 mm Hg, a similar application of the balloon produced a greater fall of intraocular pressure with an average of 10 mm Hg. There were no deleterious effects from the use of the device in either normal or glaucomatous eyes, and within the guidelines of 20 to 30 mm Hg this appears to be a safe procedure.

The apparent increase in intraocular pressure in excess of that of the intra-arterial pressure is more difficult to understand. It does appear that until some feasible method of measuring orbital compressibility is devised that we will have difficulty in explaining the entire process.

The one factor which has not been fully examined is the measurement of the tension of the band and the velcro strip when the balloon is applied to the eye. This could be easily measured, and when combined with the measurment of the pressure within the balloon, the data might be more significant. It is apparent that when the balloon is placed on the eye and the band is not closed that one can still obtain a pressure of 30 mm Hg within the balloon and have no pressure whatsoever on the globe.

The authors are to be congratulated on a stimulating study of this universally interesting problem.

DR JAMES GILLS. The use of long-term, soft, gentle compression applied prior to cataract surgery, has decreased complications. Jerry Tenant points out that his vitreous detachment rate was reduced from 7% to 0.7% after using ocular massage in the form of a "super pinky." It can be dangerous if it isn't done properly. The proper straps must be used, and correct pressure should be applied for the safety of the patient.

Research work by Schimek and Galen, some 25 years ago, showed that long-term ocular massage reduces the orbital volume, and makes it more likely to have a long-term recovery phase. This is true, providing adequate time is given for cataract surgery, particularly with lens implantation.

When doing extracapsular surgery, a soft eye enables one to use a scissors anterior capsulotomy. If the posterior capsule is ruptured, when doing a loop delivery during the cortical aspiration, the soft eye allows one to simply clean out the remainder of the cortex, because vitreous will frequently not protrude through the ruptured posterior capsule.

There is danger in using any type of pressure upon the eye. Ocular massage may result in pressures from 150 to 200 mm of mercury. Other types of rubber bands may exert up to 100 mm of mercury. The soft, elastic bands are preferable.

Dr Alfred Sommer. Measurement of pressure elevation induced in an isolated globe is not directly comparable to results obtained in real-life clinical situations, when most of the balloon is in direct contact with the boney orbit. This difference may explain the lower intraocular pressure readings generated in cadaver and nonhuman primate studies.

Dr Jules Baum. For some years, I have been reducing intraocular pressure preoperatively employing a technique which decreases the pressure more rapidly than the standard procedure. I place my pinky on the globe just inside the lateral canthus and behind the equator. Having a small finger, I can do so. I push the globe nasally against ethmoid bone with strong force. The pressure comes down much faster that way and I know the intraocular pressure is above systolic pressure. I push for 20 to 30 seconds, intermittently. I think that you are cutting of the blood supply; in fact, I'm sure of it. The question is why good vision is retained. There was a German article, which I cannot locate, published about 20 years ago in which eyes to be enucleated were subjected to pressures above systolic for a long period of time and good vision was retained. It could be that the pressure—and this is just conjecture—sends the retina into hibernation in some metabolic way. We do know that we can maintain the pressure above systolic for a relatively long period of time and still retain good vision.

Dr Robert E. Kennedy. These are a couple of insignificant but basic comments about time and volume.

Several years ago while working in Algiers, Afghanistan, Pakistan and on the HOPE Ship in South America, on many occasions we did not have water for scrubbing and had to use alcohol to rinse our hands. The alcohol was collected in an emesis basin and was then ignited to sterilize our instruments. Because the situation was so awkward we would inject three cataracts at a time, prep and do three in a row, and then proceed to the next three. The basic advantage was the time lapse between the injections which seemed to have some benefit on the intraocular pressure.

Upon my return home I would inject first, scrub, prep the patient, then I check pressures with a Schiøtz tonometer after allowing that period of time. Some of my colleagues would go into the operating room, prep the patient, give the injection, massage for 3 minutes by the clock and check their Schiøtz tonometer readings.

Upon comparing the readings we found the earlier injection rather than the 3-minute wait would sometimes lower the pressure as much as 3 to 8 points more.

While this is not a very scientific approach, I question whether time itself can be a factor.

Also, I used 2 ml retrobulbar injections and I am very much aware that some of my colleagues use as much as 5 ml. I wonder in the present study if there is any correlation with a volume which might increase orbital pressures and influence some of the readings.

Dr Robert Shaffer. It is a surprise that everybody is thinking only of the amount of fluid that is pushed out of the eye or the amount of compression of the orbital contents. We have forgotten the work of Bill McEwen, PhD at the University of California in rheology. There are two rheologic factors in the sclera—one is the fast component and the other a very slow one. The fast component is the one that you see when you take an intraocular pressure and the sclera immediately pops right back up where it was before. The slow component is the one occurring with compression of the globe and that slow component produces an enlargement of the eyeball. When the lens is removed you end up with a concave vitreous. It is the scleral creep and not these other factors that is the main factor, I believe.

Dr Marvin Sears. I enjoyed Doctor Ernest's paper and the discussions. I just have one trivial remark to make that may be central to the discussion. Several people, as Doctor McPherson and Doctor Gills pointed out in their comments, quite a long while ago, maybe more than 20 years ago, indicated very clearly that the reason why the eye loses its volume after massage is because the vitreous loses its water. If you push for a short period of time what you are doing is pushing blood out or you may push a little aqeuous out, but you're not pushing very much aqueous out otherwise you'd see the anterior chamber depth change as Doctor McPherson has pointed out. You could push a couple of microliters of blood out. That would drop the pressure down but soon after you took your finger or your pressure lowering device off the eye the blood would come right back into the eye. On the other hand, after slow, gentle, prolonged pressure, as some of you have emphasized, you'd find out that the vitreous may have reduced its weight by as much as 30%. So the reason for the concavity of the cornea after surgery had to do with the fact that the vitreous has lost its water. Now if you are going to take a couple of hours to do the cataract extraction the vitreous will rehydrate itself but if you do it in 10 to 45 minutes the vitreous still retains its dehydrated state.

Dr J. Terry Ernest. I would like to thank Doctor McPherson for his discussion. I agree with him that how tight the strap is made will affect the balloon's pressure on the eye. We did not measure this factor and I don't know how to control it.

Doctor Gills suggests that mildly elevated pressure on the eye for a relatively long time may be better than short-term intermittent high pressures. My concern about the former technique which utilizes the Honan balloon is that there is a potential for excessive pressure elevations. There is a safety valve available but the balloon is usually used on essentially unattended patients. I prefer the intermittent technique even though balloon pressures are very high because the application period is relatively short and the patient is on the operating table and constantly observed.

In response to Doctor Sommer, I would point out that a Honan balloon gauge reading of 30 resulted in a pressure much greater than 30 in the cadaver eye. The pressure varied with the initial pressure in the cadaver eye but when you set 30 on the gauge all you can be certain of is that the pressure is going to be a good deal higher in the eye.

Doctor Kennedy, we did not correlate the volume of the retrobulbar injection with the effect of the balloon, but this is certainly an important factor. I was taught to put 1½ ml in the muscle cone but residents now in our training program put 3 to 4 ml back at the apex. These are important differences but I couldn't measure them because of the relatively small number of patients in our study.

Doctor Sears points out that there is some data supporting the notion that ocular compression induces water loss from the vitreous. I believe the work was done sometime ago by Miles Galin and his group. They weighed the vitreous before and after compression in rabbits and showed that the weight of the vitreous was a little less after the application of the pressure. We thought, however, that if such was the case then we ought to have seen a deepening of the anterior chamber, because the iris-lens diaphragm ought to fall back. Our results were actually in the opposite direction, so I don't know if the vitreous dehydrates or not. I don't know if you can push water out of the vitreous even if you press on the eye for a long period of time. I'm uneasy about that early work and we think it should be repeated using radioactive tracers.

Doctor Shaffer, I'd like to talk to you about the two phases of scleral creep later.

Doctor Baum, you state that you are not concerned about raising the intraocular pressure with ocular compression. I have, for some 20 years now, studied animals models of disease. I can tell you that it is extremely difficult to induce pathology by ocular compression in young, healthy animals. You can almost completely occlude the chorio-capillaris with little effect on the retina. But these are young, healthy animals, and in the aging human I'm very concerned about the possibility of retinal infarction. In fact, we have had a recent report implicating preoperative compression in retinal ischemia that I believe Doctor Gass put into the literature. So I would conclude by saying that I think we should be very careful with preoperative ocular compression. It varies with the initial intraocular pressure so that eyes with glaucoma may be at greater risk than normotensive eyes. I'm especially concerned about the patients who have hypertensive cardiovascular disease. I think cataract extractions should not be done without blood pressure monitoring. The patients may be receiving antihypertensive medications and when they are recumbent and medicines are continued for fear of too high a blood pressure, their blood pressures may actually decrease. This, coupled with ocular compression, could result in retinal ischemia.