

A NEW OPERATION FOR MALIGNANT GLAUCOMA: A PRELIMINARY REPORT

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MALIGNANT GLAUCOMA has been treated by various surgical procedures, the most successful of which has been removal of the lens.¹ However, as Shaffer² pointed out, if the lens extraction is accomplished without vitreous loss the malignant course generally continues. He postulated that there was extensive posterior vitreous detachment and that aqueous accumulated to the side of or behind the detached vitreous pushing it still further forward. In cases where the anterior chamber remained flat and tension high after lens extraction without vitreous loss, he advocated a deep incision into the vitreous on the theory that such an incision would provide a passageway forward for the aqueous which is presumably trapped behind the detached vitreous. His results were excellent and other ophthalmologists have had similar success with such cases.

In 1962 Chandler and Grant reported uniform success in eight cases in the relief of malignant glaucoma by the use of mydriatic and cycloplegic drugs.³ Since this report several other cases have been treated successfully in this manner. In some of the cases reported by Chandler and Grant it was found that on discontinuation of the cycloplegic drug, the anterior chamber again became shallow or flat and tension elevated, but the situation was again reversed by resuming mydriatic-cycloplegic treatment. In the past year, in four cases of malignant glaucoma the use of mydriatic and cycloplegic drugs failed, and the anterior chamber remained flat and tension elevated. In these cases a new surgical approach was explored.

In the first case, after iridencleisis for chronic angle-closure glaucoma in the left eye, the anterior chamber remained flat and the tension elevated—typical malignant glaucoma. Since the report of Chandler and Grant had not yet been published, the surgeon removed the lens—a generally accepted treatment. Subsequently the anterior chamber again became almost flat, however. The patient was referred to the

author. In view of the heretofore uniformly successful treatment of malignant glaucoma with mydriatic and cycloplegic drugs, a sclerectomy and iridencleisis was done on the right eye with every confidence that if malignant glaucoma developed, it could be readily controlled with mydriatic-cycloplegic treatment. Unfortunately this did not prove to be the case. The anterior chamber remained flat in spite of intensive use of 4% atropine and 10% phenylephrine. Tension was 18. It seemed unlikely that the flat anterior chamber was associated with a choroidal detachment with tension at this level. Nevertheless on the third post-operative day the sclera was opened 4 mm. from the limbus in the lower outer quadrant. No fluid was encountered. Air was injected into the anterior chamber. When the air was absorbed, the anterior chamber was again flat and tension 20. A posterior sclerotomy was done with release of a considerable quantity of vitreous. Air was again injected into the anterior chamber, but when the air was absorbed the anterior chamber was again flat and tension 20. It was obvious that some more radical procedure would have to be carried out on this eye. In view of past experience it seemed that lens extraction would have to be done. However, one felt great reluctance to remove the clear lens from what might eventually be the only eye and subsequent events proved that it was, in effect, an only eye.

Relief of malignant glaucoma by intravenous infusion of mannitol had been reported by Weiss, Shaffer, and Harrington.⁴ However, in both of their cases in which the diagnosis was clearly malignant glaucoma they removed the lens after reforming the anterior chamber and lowering the tension with intravenous mannitol. One could therefore not be sure in these cases whether or not the conditions might have recurred without lens extraction. Verdaguer and Lira⁵ reported one case of malignant glaucoma relieved by intravenous infusion of urea. There had been no recurrence in that case, but the follow-up period was only three months.

Since at that time one could not be certain of permanent relief of malignant glaucoma by means of intravenous hypertonic solutions followed by mydriatic-cycloplegic treatment, it was decided to explore the possibility of obtaining permanent relief of the condition by a new surgical approach. Having in mind Shaffer's concept of a posterior vitreous detachment with aqueous trapped behind the detached vitreous, it was decided to attempt to open the hyaloid membrane without disturbing the lens. The following operation was performed.

An ab externo incision 7 mm. long was made 2 mm. from and parallel to the limbus below. From either end of this incision a cut was

made up to the limbus, thus preparing a sort of scleral flap. An iridectomy was done. When the flap was lifted, ciliary processes could be seen. A 17-gauge needle was passed straight backward between two ciliary processes to a depth of 7 to 8 mm. and the point of the needle was moved back and forth. There was escape of a moderate amount of semi-fluid vitreous. The scleral wound was closed with interrupted 6-0 catgut, and air was injected into the anterior chamber. The following day the anterior chamber was definitely formed, though extremely shallow, and twenty-four hours later the anterior chamber was of good depth, approximately the same as before the original operation. As far as the malignant glaucoma is concerned the subsequent course has been uneventful. Tension over a period of eighteen months has been 14 to 15 without treatment. Unfortunately, as has been seen in some cases of prolonged absence of the anterior chamber, an anterior capsular opacity in the lens developed and vision with glass is only 6/15. This lens opacity, as in other similar cases, shows no sign of progression, but of course the patient is considerably handicapped. On the whole this seemed a safer and more satisfactory result than if the lens had been removed.

In the second case, the signs of malignant glaucoma developed in the right eye eight weeks after the original operation for chronic angle-closure glaucoma. Six weeks after operation tension was 17 in the right eye and there was a satisfactory bleb. At this time, scopolamine, which had been used continuously since the operation, was discontinued. Two weeks later (eight weeks after the original operation) the anterior chamber was flat and tension 50. The patient was admitted to the hospital and was given 4% atropine and 10% phenylephrine. The anterior chamber remained flat, and forty-eight hours after admission an operation was done on the right eye in the same manner as described in Case 1. After the needle was introduced, there was at first considerable escape of clear fluid and this was followed by formed vitreous which continued to escape while the scleral wound was being closed with sutures. Air was injected into the anterior chamber. The anterior chamber remained flat or almost so, and forty-eight hours later a second operation was done.

The scleral wound was reopened. A 17-gauge needle was passed straight backwards approximately 17 mm. There was escape of some thin fluid and one drop of formed vitreous. The wound was resutured and air injected into the anterior chamber. For the following three days the anterior chamber was formed but very shallow. On the fourth postoperative day the anterior chamber had regained its original

depth and tension was 12. Since that time tension in the right eye has ranged from 12 to 18. A lens opacity was noted in both eyes shortly after the original operations, always more marked in the left eye. This steadily progressed and on January 17, 1964, vision in the right eye with glass equalled 6/18, in the left, counting fingers at four feet. As can be seen in the detailed report of this case, on two occasions when scopolamine was discontinued in the left eye the anterior chamber became flat and tension rose. On both occasions after resumption of scopolamine the anterior chamber formed and tension returned to normal.

In the third case, after sclerectomy and iridectomy for advanced chronic angle-closure glaucoma in an only eye, the anterior chamber remained flat and tension elevated. On the fourth postoperative day an operation was performed as described in Case 1, except that the needle was passed backward approximately 17 mm. There was escape of considerable formed vitreous. The anterior chamber could not be reformed and the needle was again passed well back into the vitreous cavity. There was escape of considerable fluid, after which the anterior chamber was formed with air and the scleral wound was sutured. The anterior chamber remained flat. Tension on the first postoperative day was 20, on the second 22, and on the third 13. On the third postoperative day another operation was performed. First the sclera was opened 4 mm. from the limbus and a few drops of clear fluid escaped. Then the lower scleral incision was reopened, and a 17-gauge needle was passed well back into the vitreous cavity. There was escape of a considerable quantity of thin fluid. The wound was resutured and air injected into the anterior chamber. Thereafter the anterior chamber was of good depth. The original bleb appeared to be functioning and tension ranged from 10 to 17. The lens subsequently became completely opaque and was removed.

In the fourth patient, when first seen by the author, an iridencleisis for chronic angle-closure glaucoma had been done on the right eye three months previously and on the left eye two weeks previously. The postoperative course in the right eye had been uneventful with a normal anterior chamber, a satisfactory bleb and tension ranging from 10 to 15 for approximately three months while under treatment with atropine. Then when atropine was discontinued in the right eye, the anterior chamber became flat and tension rose to 44. When first examined at this time by the author, the right anterior chamber was flat and tension was 63. In the left eye tension was 15, with a good bleb and a good anterior chamber. Atropine 4% and 10% phenylephrine

was prescribed for the right eye and 1% atropine was continued in the left eye. The right anterior chamber formed slightly and tension at first fell to 24 then 20, but after two and one-half weeks the anterior chamber was completely flat and tension 46. An operation was done as described in Case 1, but the needle was passed backward 17 to 18 mm. There was copious escape of formed vitreous. On the first postoperative day the anterior chamber was formed but shallow. The following day, the anterior chamber was flat and remained so. On the fourth postoperative day another operation was performed. The wound was reopened. A 17-gauge needle was passed backward into the vitreous cavity approximately vertically. When the needle had reached a depth of 17 to 18 mm. it was noted that clear fluid was flowing from the top of the needle. This appeared to be a positive indication that fluid under pressure had been trapped posteriorly behind the vitreous. The scleral wound was resutured and air injected into the anterior chamber. On the first postoperative day the anterior chamber was flat, but during the following three days it gradually became of the same depth as in the fellow eye. Thereafter the anterior chamber remained formed and tension normal, but the lens became completely opaque and was noted to be adherent to the peripheral cornea at 6:00 o'clock. Atropine was continued in both eyes. The course in the left eye has remained uneventful. It is proposed to continue atropine indefinitely in this eye, and extract the lens in the right eye.

DETAILED CASE REPORTS

CASE 1, FEMALE, AGE 48

This patient was first examined by her local ophthalmologist July 30, 1962. Tension was R 17, L 33. Vision R 6/6, L 6/12. The angle in the right eye appeared very narrow but open; it was closed in the left eye. Under intensive medical treatment tension in the left eye varied from 30 to 50. On August 31, 1962, an iridencleisis was done on the left eye. The anterior chamber remained flat and tension elevated. In September, 1962, lens extraction was done on the left eye with some vitreous loss. Postoperatively the anterior chamber remained formed but tension rose in the right eye and could only be controlled with intensive miotic treatment plus carbonic anhydrase inhibiting drugs.

When first seen by the author December 11, 1962, vision right with glass equalled 6/5, vision left with glass equalled counting fingers at six feet. In the right eye the media were clear, disc normal, and tension was 17. By gonioscopy the upper half of the angle was closed. In the left eye the anterior chamber was almost flat, cornea somewhat hazy. The disc was pale

and cupped, angle entirely closed. It was felt there was pupillary block. Tension was 20.

DECEMBER 12, 1962, operation on right eye. Gonioscopy during surgery done. Angle closed 10:00 to 2:00 o'clock, open elsewhere. Posterior lip sclerectomy and peripheral iridencleisis done.

DECEMBER 13: right anterior chamber flat. Tension "about normal." Given atropine 4%, phenylephrine 10% each four times a day. Tension L 55.

DECEMBER 14: tension R 18, L 70. Right anterior chamber flat.

DECEMBER 15: operation both eyes. In the left, peripheral iridectomy, cyclodialysis, and incision of the vitreous face was done. In the right eye the sclera was opened in the lower outer quadrant. No fluid was encountered. Air was injected into the anterior chamber. Atropine 4% and phenylephrine 10% each four times a day were continued in the right eye and Phospholine Iodide 0.25% in the left eye.

DECEMBER 16: right anterior chamber formed but very shallow. Anterior chamber deeper in the left eye.

DECEMBER 17: tension R 20, L 17. Right anterior chamber practically flat. Operation was done on the right eye, a posterior sclerotomy with release of a considerable quantity of vitreous and air was injected into the anterior chamber.

DECEMBER 18: tension R 18, L 20. Right anterior chamber flat.

DECEMBER 19: anterior chamber flat. Operation was done on the right eye as described in the text.

DECEMBER 20: anterior chamber formed but shallow.

DECEMBER 21: anterior chamber deeper.

DECEMBER 24: good anterior chamber both eyes.

Since that time the patient has been followed by her local ophthalmologist and tension right and left remain about 14. By May, 1963, the cornea in the left eye showed edema from contact with the temporal iris. On June 6, 1963, a posterior sclerotomy was done on the left eye with release of a considerable quantity of vitreous. Air was injected into the anterior chamber but it went behind the iris and contact between iris and cornea temporarily remained unchanged.

When last seen by the author July 19, 1963, vision right with glass equalled 6/15. There was a filtering scar. Tension was 15. There was a central anterior capsular lens opacity. The periphery of the lens was clear. In the left eye tension was 17. The anterior chamber was formed but very shallow in the nasal half, flat in the temporal half, and the cornea showed edema in this area.

CASE 2, FEMALE, AGE 65

This patient was first examined by the author April 15, 1963. She had been under treatment for glaucoma for six years. There was said to have been progressive loss of field and unsatisfactory control of tension. Examination was as follows: vision in the right eye with glass equalled 6/6, in the

left 6/5. Both eyes were five and one-half diopters hyperopic. There was pathologic cupping of both discs, more marked in the right. The field of the left eye was full except for a small upper nasal step. In the right eye there was loss of most of the upper field. Tension was R 28, L 32. In the right eye the angle was open 2:00 to 6:00 o'clock, closed elsewhere. In the left eye the angle was open 8:00 to 10:30 o'clock, closed elsewhere. On May 2, 1963, an operation was done on the right eye. After determining by gonioscopy during surgery that all the closure previously noted was synechial closure, a posterior lip sclerectomy and peripheral iridectomy was done. On May 4 a similar procedure was done on the left eye. The anterior chamber remained formed in the right eye but flat in the left eye. On May 8 a posterior sclerotomy and air injection was done on the left eye. No fluid was found on opening the sclera. However the anterior chamber remained formed and the patient was discharged on May 11, 1963, on a solution containing scopolamine and phenylephrine.

At the first postoperative visit the anterior chamber was formed in both eyes and there was evidence of filtration. On June 13, 1963, one month after discharge, drops were discontinued. Two weeks later, on June 27, 1963, the anterior chamber was flat in the right eye, tension 50. In the left eye the anterior chamber was formed but shallow, tension 35. The patient was readmitted to the hospital and given 4% atropine and 10% phenylephrine several times a day. The anterior chamber in the right eye remained flat and tension firm. On June 29, 1963, an operation was done on the right eye as described in the text. The anterior chamber remained flat and forty-eight hours later, on July 1, 1963, the operation was repeated. The following day the anterior chamber was formed but quite shallow, but twenty-four hours later the anterior chamber was at its original depth. In the left eye the anterior chamber remained of the same depth and tension on discharge July 8, 1963, was R 8, L 23. Scopolamine and local steroid drops were prescribed. Since that time the anterior chamber in the right eye has remained the same and tension has ranged from 16 to 26, usually below 20.

On July 29, 1963, tension was 32 in the left eye and the anterior chamber was more shallow. Scopolamine .25% and phenylephrine 10% were given four times a day. Two days later, on August 1, 1963, tension in the left eye was 23 and the anterior chamber was of the same depth as in the right eye. For the next three months tension in the left eye ranged from 16 to 23. On November 4, 1963, all treatment for the left eye was discontinued. Four days later, on November 8, 1963, tension in the left eye was 46, the anterior chamber was almost flat. Scopolamine .25% and phenylephrine 10% were given every three hours. Four days later, on November 12, 1963, tension in the left eye was 21 and the anterior chamber was again reformed. Scopolamine has been used once a day since that time and tension has ranged from 16 to 20. The lens opacity gradually increased in both eyes, and on January 17, 1964, corrected vision was R 6/18, L counting fingers at four feet. On March 10, 1964, lens extraction was done on the left eye.

CASE 3, FEMALE, AGE 75

First examination in the clinic of the Massachusetts Eye and Ear Infirmary was made July 17, 1963. Vision in the right eye was 6/18. The anterior chamber was shallow; there was nuclear sclerosis and marked cupping of the disc; tension was 43. By gonioscopy approximately one-half of the angle was open. Tonography showed a facility of outflow of 0.05. In the left eye there was no light perception, mature cataract, rubeosis of the iris; tension was 58.

JULY 18, 1963: operation right eye, sclerectomy and iridectomy.

JULY 19: anterior chamber flat. Scopolamine four times a day prescribed.

JULY 20: anterior chamber flat, tension 33. Given 4% atropine and 10% phenylephrine each four times a day and acetazolamide 250 mg. four times a day.

JULY 21: anterior chamber flat, tension 22.

JULY 22: anterior chamber flat. Operation done as described in text.

JULY 23: anterior chamber flat, tension 20.

JULY 24: anterior chamber flat, tension 22.

JULY 25: anterior chamber flat, tension 13. Operation done as described in the text.

JULY 26: good anterior chamber.

The anterior chamber remained well formed and the patient was discharged on August 1, 1963. During the next few weeks tension ranged from 14 to 19. The lens became more and more opaque.

OCTOBER 31: mature cataract, tension 19, unintentional extracapsular cataract extraction. The anterior chamber remained formed but there was considerable striate keratitis. Patient discharged November 7, 1963.

NOVEMBER 20: still considerable striate keratitis. White reflex from fundus. (?) sterile endophthalmitis from lens matter. Scopolamine four times a day and prednisone 10 mg. four times a day prescribed.

DECEMBER 4: patient fractured left hip. This was nailed.

DECEMBER 10: cornea still somewhat hazy. Good anterior chamber. Much vitreous opacity.

DECEMBER 26, 1963: vision equalled hand movements. Cornea slightly hazy.

JANUARY 8, 1964: right eye white and quiet. Tension normal. Red reflex.

MARCH 4, 1964: vision equalled fingers at one foot. Vitreous more clear. Glimpses of fundus made out here and there. Tension normal.

CASE 4, FEMALE, AGE 57

Glaucoma diagnosed May 24, 1963. Initial tension R 27, L 50. Cupping of both discs, more on the left. Angles said to be very narrow. Miotic treatment reduced tension to R 24, L 25.

JUNE 3, 1963: iridencleisis right eye. Postoperative course uneventful. There was a filtering scar and tension ranged from 12 to 14. Atropine drops used daily.

AUGUST 26: iridencleisis left eye. Atropine discontinued right eye.

AUGUST 30: painful right eye. Anterior chamber flat, tension 44. Atropine, and local and systemic steroids prescribed.

SEPTEMBER 10: first seen by author. Vision right with glass equalled counting fingers at six feet, vision left with glass equalled 6/9. Tension R 63, L 15. Right eye showed a bleb above, anterior chamber flat, cornea hazy. Left eye showed normal anterior chamber, good filtering scar. Four per cent atropine and 10% phenylephrine four times a day prescribed for the right eye and 1% atropine continued in left eye. During the next two and one-half weeks the patient was seen frequently by her local ophthalmologist. The anterior chamber formed slightly at first and tension fell to 24.

SEPTEMBER 27: tension R 46, L 13. Right anterior chamber flat, many posterior synechias.

SEPTEMBER 28: operation as described above.

SEPTEMBER 29: right anterior chamber formed but very shallow.

SEPTEMBER 30: right anterior chamber formed but very shallow.

OCTOBER 1: anterior chamber flat.

OCTOBER 2: anterior chamber flat. The operation was repeated.

During the next two days the anterior chamber was formed but very shallow. It gradually increased in depth and was of normal depth by October 5, 1963. The patient was discharged from the hospital on October 8, 1963.

OCTOBER 17: anterior chamber of normal depth. Tension 13. Considerable lens opacity.

OCTOBER 29: tension R 10. Anterior chamber of normal depth. By goni-scopy a little less than half the angle was open. The equator of the lens was adherent to the peripheral cornea below. The lens was opaque.

Since that time the anterior chamber has remained the same and tension has been 15 or less. Lens extraction is planned.

DISCUSSION

Malignant glaucoma is a relatively rare but potentially very serious complication of operation for angle-closure glaucoma. In recent years the generally accepted treatment has been removal of the lens. When this was accomplished without vitreous loss the malignant course often continued but was generally relieved by deep incision into the vitreous cavity. More recently, treatment by mydriatic and cycloplegic drugs has proven effective in most cases in which it has been tried, but may have to be continued indefinitely to prevent recurrence. In the four cases herein reported this treatment failed in one eye of each. The new operation applied to these four eyes was based on the assumption that aqueous passed backward instead of forward and accumulated lateral to or behind the vitreous body, thus tending to push it further

forward and block all exits of fluid from the eye. That this assumption is correct is suggested by the dramatic result in Case 1 and especially by the findings at the second procedure in Case 4. At this operation when the point of the needle was well back in the vitreous cavity fluid was forced upwards $2\frac{1}{2}$ cm., the length of the needle, so that several drops overflowed the top of the needle. This could only mean that the tip of the needle had entered a pocket of fluid under pressure. The immediate success of the procedure in Case 1, even though the needle penetrated only approximately 7 mm. into the vitreous cavity, suggests that in this case the posterior hyaloid was far forward at least in this area and was penetrated by the first passage of the needle. In each of the other three cases there was considerable escape of formed vitreous as soon as the needle was introduced. This suggests that the initial penetration of the needle had been into the vitreous body but not through the posterior hyaloid and did not reach the fluid trapped behind the vitreous body, hence the operation failed. When the operation was repeated, presumably the posterior hyaloid had moved forward and was opened at the second attempt. In Case 3 even the second attempt seemed doomed to failure until the needle was introduced a second time. This time, not formed vitreous but thin watery fluid escaped, indicating that the needle had finally passed through the posterior hyaloid into a pocket of fluid trapped behind, as was so dramatically demonstrated at the second attempt in Case 4.

It is the writer's belief that in no case was the lens injured by the needle. The non-progressive anterior capsular opacity in Case 1 was of the same type as has several times been observed in cases of prolonged absence of the anterior chamber. In Case 2 the lens opacity in the left eye developed before and progressed more rapidly than in the right eye with its two further operations. In Case 3 the patient was old, already had lens opacity before the original procedure and it is not surprising that the prolonged absence of the anterior chamber and three surgical procedures resulted in a marked increase in the lens opacity. In Case 4 the prolonged absence of the anterior chamber and the two attempts to relieve the malignant glaucoma resulted in adhesion of the lens to the peripheral cornea, presumably resulting in damage to the lens capsule.

The experience with these four cases lends support to the theory that in malignant glaucoma aqueous is trapped behind the vitreous body and that if a way is provided for this fluid to come forward, the anterior chamber will form again and the condition is relieved. However, the question must be raised as to whether the method of approach

employed in these cases is the best. Might it not have been better to have removed the lens as the first procedure once malignant glaucoma developed since the lens in the last three cases at least will eventually have to be removed anyway? Certainly many eyes are saved by removing the lens in such cases, but in others as in the left eye of Case 1 the cornea eventually becomes edematous due to adhesion of hyaloid or iris and all useful vision is lost. Lens extraction in malignant glaucoma is not to be regarded as always a simple and safe procedure. Even if it is accomplished without complication, the malignant glaucoma may continue, requiring later incision deep into the vitreous, again with the possibility of vitreous contact and persistent corneal edema.

Opening the posterior hyaloid from an anterior approach appears to be a logical procedure, but it is a question whether the technique described is the best for accomplishing this purpose. In cases of posterior vitreous detachment, readily demonstrable in many cases, especially in aphakia, posterior superior vitreous detachment is most common. In some aphakic eyes the posterior hyaloid is seen to be uniformly far forward even to a level comparable to that of the posterior surface of the lens when the lens is *in situ*. Possibly such a marked posterior vitreous detachment was present in Case 1 which could account for the success of the procedure in spite of a penetration of the needle of only 7 mm. In Cases 2, 3, and 4 the failure of the first attempt could be explained by supposing the posterior vitreous detachment was less marked or situated superiorly, so that the inferior approach failed to open the posterior hyaloid. Indeed in Case 3 even the second attempt seemed unlikely to succeed until the needle was reintroduced and this time evidently opened a pocket of thin fluid. The inferior approach was chosen in an attempt to avoid interfering with the filtering scar, but since posterior vitreous detachment is usually most marked above, possibly a superior approach might be more successful. At any rate experience with these cases indicates that when only formed vitreous escapes after introduction of the needle, the posterior hyaloid has not been opened and the operation is doomed to failure. In such cases it is probably best to reintroduce the needle and probe in different directions, especially superiorly, until thin fluid escapes. Only then can one anticipate relief of the condition.

Frezzotti and Gentili⁶ have recently reported re-formation of the anterior chamber and lowering of tension in two cases of malignant glaucoma by a combination of intravenous infusion of urea and mydriatic-cycloplegic treatment, when neither treatment was adequate

individually, but they found it necessary to continue atropine to prevent recurrence. In the light of the experience of Frezzotti and Gentili it may be that the definitive treatment of malignant glaucoma may be found to be re-formation of the anterior chamber and lowering of tension with intravenous infusion of urea or mannitol, or possibly oral glycerol, plus the continuous use of mydriatic-cycloplegic drops thereafter. Time will tell whether or not this will be effective in all cases.

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DISCUSSION

DR. BRUCE FRALICK. I was very pleased to have Paul Chandler send me the first draft of his paper and thus permit me to study and analyze his cases, theories, operative approach, and results. Without this opportunity, one would be prone to agree with everything he had to say and to compliment him on his contribution because of his eminence in the field of glaucoma management.

Dr. Chandler very fairly raises the question as to whether the lenses in his four cases might better have been removed initially as the primary surgical procedure because after several operations incapacitating cataracts developed which will all have to be removed. If he had done so he would have had no assurance that his procedure would have been successful, and more important he would have not been able to test Shaffer's theory that aqueous trapped behind the vitreous was responsible for the malignant glaucoma.

He proposes an anterior approach through the circumferential space by passing a 17-gauge needle through the zonule and anterior and posterior vitreous hyaloid to reach this trapped fluid supposedly under pressure.

Anatomically this seems a hazardous route and fraught with serious consequences for the average surgeon. I believe the same end result could be achieved by making a meridional incision in the superior portion of the globe through sclera and pars planum of the ciliary body and then passing the needle through the anterior and posterior vitreous hyaloid to reach the

trapped fluid. This approach is known to most of us, is well tolerated by the eye, and avoids the lens and ciliary processes.

In studying Dr. Chandler's detailed case reports, I became confused as to the indications for his proposed operation. The operation is designed to reform the anterior chamber and control the ocular tension in malignant glaucoma and yet in Cases 1 and 3 the tension was 20 and 13 respectively through other medical and surgical procedures before the aspiration of the retrovitreal fluid was attempted. Obviously he was not now dealing with malignant glaucoma as we understand the condition but rather with the residual flat anterior chamber. Certainly he had unsuccessfully attempted to re-form the chamber with air and/or posterior sclerotomy plus medical measures and felt some other technique had to be used.

I was surprised at the statement with reference to the result of the second operation in Case 4. Here retrovitreal fluid was forced vertically upward 2½ cm., the length of the needle so that it overflowed. Translating 2½ cm. of water pressure to mm. of mercury would indicate that the pressure in the retrovitreal space was only 1.87 mm. (or approximately 2 mm.) of Hg. It might be assumed that this is an accurate measurement of the contribution to the intraocular pressure produced by the fluid trapped behind the vitreous. If this were the case, it would seem quite unlikely that such a small increment of pressure could make any significant contribution to the glaucoma. The assumption that the height of the column of fluid released can be used as a measure of contribution to the intraocular pressure of the fluid in this compartment is not valid for two reasons.

1. It is quite possible that before the column of fluid came into equilibrium with the atmospheric pressure, a small amount of formed vitreous plugged the needle tip.

2. The pressure volume curve in the eye, distended to its limit by glaucoma, is clearly non-linear. In this case the pressure being quite high (46 mm. Hg), very slight changes in volume are to be associated with very large changes in pressure.

How then could we utilize this information to estimate the contribution of the fluid in the retrovitreal spaces to produce malignant glaucoma? If one assumes that a vitreous plug is not a source of artifact it should be possible to connect a 17-gauge needle to a counterpressure device which would measure how much counterpressure must be applied to the fluid to contain it within the retrovitreal space. This would be best accomplished through a pars planum approach and would give information which would be useful in evaluating the role of the trapped fluid in producing malignant glaucoma as proposed by Shaffer.

We can all hope that the contributions of Chandler and Grant, and recently Frezzotti and Gentili, utilizing medical management of malignant glaucoma will largely obviate the need for Dr. Chandler's valuable contribution.

DR. LEONARD CHRISTENSEN. It is my feeling that postoperative malignant glaucoma is essentially an acute congestive, narrow-angle glaucoma. In both processes, the pressure rises from closure of the angle by anterior displacement of the iris root. In both, the anterior displacement is due to pressure from behind the iris diaphragm and I feel that this pressure is created by the damming of aqueous flow. In both it is necessary that formed vitreous is present anteriorly for neither could occur if the vitreous was totally liquefied. They differ in the circumstances leading to the onset and in the immediate causes of derangement of aqueous flow.

As shown in the following photograph of an enucleated eye removed because of far advanced narrow-angle glaucoma, there is a posterior fluid pool and a thick layer of formed vitreous between the pool and the lens. In this specimen the vitreous was coagulated with Bouin's solution. You will note that the vitreous envelops the lens and that the anterior face of the vitreous is displaced considerably farther forward than normal. This is not an isolated specimen. It closely conforms to several other specimens of the same disease that we have in our laboratory. In all there is formed vitreous displaced far forward in the anterior vitreous cavity with fluid behind. Since these globes were opened and then photographed, some objection may arise considering the validity of the observation because the position of the vitreous can shift after opening. We have, however, observed these findings in globes that were first frozen and then opened while in the frozen state. On melting, the vitreous was found to be in a similar position.

Because of these observations several years ago I attempted to treat acute narrow-angle glaucoma by aspiration of the posterior pool of fluid vitreous and simultaneous dilation of the pupil. It was my hope that the formed vitreous would fall back and would permit posterior displacement of the lens iris diaphragm. The chamber was to be kept deep by restoring free forward flow of aqueous. In the following movie you will observe the obvious deepening of the anterior chamber following aspiration of the posterior fluid vitreous and dilatation of the pupil. The aspiration was made by simply puncturing the conjunctiva, sclera, and pars plana by a sharp needle and directing the needle posteriorly and superior temporally. This procedure was performed on two occasions and both were initially successful. The anterior chamber deepened and the pressure remained at a normal level. Postoperatively the pupils were kept dilated but over a period of seven to eight days there was a gradual shallowing of the anterior chamber. At the end of this period it was necessary to perform an iridectomy. In both situations, the problem was solved following iridectomy.

The above findings support the thesis of Drs. Chandler and Shaffer. It is a matter of a simple physics that if the root of the iris is displaced forward something has to push it. With the possible exception of intraocular hemorrhage or choroidal hemorrhage, there is no source of energy in the eye other than the flow of aqueous. Since hemorrhage is not a factor in the

present situation, it is apparent that interference with the free flow of aqueous (damming) can be the only cause since the eye is no more immune to simple physical laws than any other system.

DR. DERRICK VAIL. I continue to marvel at the tenacity of Dr. Chandler in his efforts to conquer malignant glaucoma, and to admire his helpful contributions in this field.

In the present instance I should like to draw your attention to the classic work of Favre and Goldmann, "The etiology of posterior detachment of the vitreous" (*Ophthalmologica*, 132:87, 1956). These authors show that beginning in the second decade of life, the vitreous constantly undergoes degeneration so that by the time patients are in middle life more than 50 per cent of them show marked degeneration of the vitreous and its posterior detachment. Pockets of "trapped" fluid, presumably aqueous in nature, located in front of the retina and behind the posterior hyaloid, are almost universally present in older patients.

I am a little disturbed therefore, by Dr. Chandler's procedure as a cure for malignant glaucoma, since drainage of these almost senile physiologic pockets would be but temporary. I am sure that they would refill in a short time. Nor do I believe that the evacuation of the retrovitreal fluid results in backward displacement of the vitreous, especially in the presence of malignant glaucoma.

I should like to hear Dr. Chandler discuss this issue if he will.

DR. FREDERICK H. VERHOEFF. I should like to call attention to an operation I described many years ago (1924) but which has been generally ignored. I termed it cyclectomy because it involved cutting away a piece of the ciliary body. It is effective for any type of glaucoma including malignant glaucoma. A conjunctival flap is dissected up and then an incision is made through the sclera over the pars plana of the ciliary body. The then protruding uveal tissue is excised to prevent it from later proliferating into the scleral opening. I have found that the effect of the operation is due chiefly to drainage through the scleral incision and that if this closes, it can be easily and quickly reopened by passing a discission knife needle through the conjunctiva some distance from the scleral scar and then with this instrument cutting through the scar. The reopening operation can be done in the office and as often as needed. It produces a relatively large opening in the sclera but only a minute puncture in the conjunctiva.

DR. CHANDLER. I am most appreciative of the valuable contributions of the discussion of the paper. Dr. Fralick properly raises the question as did the author, as to whether or not it might have been better to have removed the lens as the definitive treatment since in three of the four cases the lens will have to be or has been removed. Eyes have certainly been saved by removing the lens in cases of malignant glaucoma, but as Shaffer pointed out, in

many cases the malignant course continues after lens extraction though it is generally relieved by deep incision into the vitreous. Lens extraction in malignant glaucoma is a formidable procedure fraught with many possible complications including corneal edema and persistence of the glaucoma. In regard to removing the postvitreal fluid by means of the simpler pars plana approach, there is no reason to think that this would have any lasting benefit since the fluid would only accumulate again and the malignant course continue. This was beautifully demonstrated in Dr. Christensen's case. The principle of the operation is to open both anterior and posterior hyaloid and not only release the postvitreal fluid but to provide a passageway forward into the anterior chamber. A pars plana approach would leave the anterior hyaloid intact. In regard to the relatively low tension in Cases one and three at the time of operation, the suggestion is made that this could not be malignant glaucoma. In Case 1 before the final operation two other procedures had been carried out, first opening the sclera to see if there was separation of choroid and ciliary body as a cause of the flat anterior chamber and air injection. No fluid was encountered when the sclera was opened. Later a quantity of vitreous was released by posterior sclerotomy. Very commonly after one or more surgical procedures tension remains normal or subnormal for a period due to suppression of aqueous formation and there is every reason to believe the anterior chamber would have remained flat and tension eventually have been again elevated as in the fellow eye. The same is true in Case 3.

I am not sure that I follow correctly Dr. Fralick's discussion in regard to the pressure in the postvitreal space. It seems to me that when the eye is open the intraocular pressure should be the same as atmospheric pressure and any shrinking of the sclera from lowering the pressure on opening the eye should occur very quickly. The fact that when the needle was pushed well back into the vitreous cavity fluid did in fact run uphill $2\frac{1}{2}$ cm. is I believe of significance as indicating that the fluid was under pressure greater than atmospheric pressure. Whether or not the increased pressure in the postvitreal space was induced by pressure from the outside of the globe by orbital contents would be difficult to determine. The fact is that only when the needle reached a certain level did fluid run over the top.

Dr. Christensen's observations certainly lend support to the thesis that aqueous trapped behind a posteriorly detached vitreous body provides the force which pushes the vitreous still further forward and causes the syndrome of malignant glaucoma.

Since preparing this report I have seen two other cases of malignant glaucoma and a third was reported to me by a colleague. In one of the three cases mydriatic-cycloplegic treatment failed to form the anterior chamber, but this treatment plus intravenous mannitol was successful. In the other two both mydriatic-cycloplegic treatment plus intravenous hypertonic solutions failed. In the case reported to me by a colleague the lens

was removed and the condition relieved. In the other the new operation was successfully employed. Most cases of malignant glaucoma are relieved by mydriatic-cycloplegic treatment. When this fails the added use of intravenous hypertonic solutions will be successful in some cases, but it appears that there still remain a few cases where this treatment fails and more radical measures are necessary. Whether or not the operation described is the best method of dealing with the situation must be determined by further experience. The results in these cases certainly lend support to Shaffer's theory of the mechanism of malignant glaucoma.