GLAUCOMA FILTERING SURGERY FACTORS THAT DETERMINE PRESSURE CONTROL*

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INTRODUCTION

THIS STUDY BEGAN WITH THE DEVELOPMENT OF A NEW GLAUCOMA FILTERING PROcedure and was expanded to an analysis of factors that determine pressure control. Control can be defined by the time course of the pressure reduction after surgery. However, this approach is complicated by additional treatment to certain cases and it is difficult to combine the treated and untreated groups. This had led to a second method, a division into success or failure by given criteria.

The literature shows a wide range of success without medication from 10%[1] to 98%.[2] Most fall between 65% and 85%.[3] The variation is attributed to a number of factors but the order of importance or ranking is unknown. It is likely that a significant part of the variation is caused by error from limitations in either the method of data collection or analysis. With some exceptions[4-14] these limitations have not been considered.

To encourage standardization I wish to emphasize two problems in analysis, variable follow-up periods and confounding of variables. Most studies have a spectrum of follow-up periods because of variable entry and drop-out times. In other disciplines the generally accepted approach, in terms of success or failure, is the cumulative probability or life table method of Kaplan and Meier.[15] It provides a cumulative percent success for all follow-up times. It is a superior method for handling incomplete or so-called "censored values," cases of success that are not followed to the end of the study, and is relatively resistant to bias in drop-outs. This method was applied to glaucoma surgery in 1982 by Inaba[9] and to date has been used only in Japan.[10]

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Two less regorous methods for assessing success have been used by others. The first is the percent success to a given follow-up time determined by the number of successes relative to number of cases examined at that time. Various times are used. The second is a single determination of percent success for all pooled follow-up times. It overestimates the true success rate for the longest follow-up period and has been labeled the "simple statistic" by Inaba.[9] These simpler methods do not permit adequate comparison among studies unless the distribution of follow-up times is similar, an unlikely event. An important exception is the occasional study that has followed all patients for the same length of time.[6,8] The above limitations do not apply.

When multiple factors are involved, confounding the effect of one with another is a common problem. In order to minimize this effect I have used a type of multiple regression analysis. The method also permits ranking of the relative significance of variables. Multiple regression analysis has not been applied to glaucoma surgery.

MATERIALS AND METHODS

Between July 1974 and July 1982, 260 eyes of 223 patients were entered into this retrospective study. This represents 260 consecutive unselected cases of glaucoma filtering procedures excluding infants. This was the first glaucoma procedure for each eye performed by me. Two eyes of two patients were excluded because the surgery was performed below. Nine eyes of nine patients were arbitrarily excluded because of unusual immediate postoperative complications consisting of retinal detachment, malignant glaucoma, phthisis, and persistent flat chamber requiring surgical intervention. Fifty-four patients with 55 eyes dropped out before 2 months of follow-up and did not contribute to the study. The final cohort was 194 eyes of 158 patients.

The follow-up on these eyes was ended for one of four reasons: (1) termination of the study, (2) the necessity for additional glaucoma surgery in 53 cases, (3) an ocular condition that could affect pressure in 13 eyes, primarily cataract extraction, and (4) late drop-out of 49 patients with 55 eyes.

Before surgery most of the eyes had progressive glaucomatous visual loss on maximum tolerable medication. A smaller number had advanced field loss with inadequate pressure control. A few had marked elevations of pressure without field loss. All fields were performed by the same highly skilled technician with the Goldmann instrument and the modified

TABLE I: CLASSIFICATION OF GLAUCOMA (EYES)

DIAGNOSIS	PHAKIC	APHAKIC	TOTAL
Primary open-angle	97	13	110
Primary closed-angle	12	—	12
Secondary open-angle	24	3	27
Secondary closed-angle	7	8	15
Congenital	10	2	12
Low-tension	6	—	6
Combined or uncertain	7	5	12
Total	163	31	194

method of Armaly.[16] All pressures were taken by the same individual with the Goldmann applanation instrument.

Table I shows the classification of the glaucomas. Low-tension glaucoma refers to cases with untreated pressures less than or equal to 22. The median age of all patients was 61 years with a range of 3 to 85 years. Fifty-one percent were female and 69% were Caucasian. Seventeen eyes were from patients with a history of diabetes and 13 eyes had previous filtering surgery elsewhere at least 6 months earlier. Two eyes had a peripheral iridectomy at least 6 months earlier.

From personal observations and previous studies[17] the following findings on Tenon's capsule were made (Fig 1). A customary surgical reference point is the base of the conjunctival reflection separating the cornea from the limbus. Clear cornea is present both in front of and behind this reflection. In most eyes the bulk of the Tenon's capsule inserts into the sclera approximately 2 mm behind the reflection. This forms two poten-

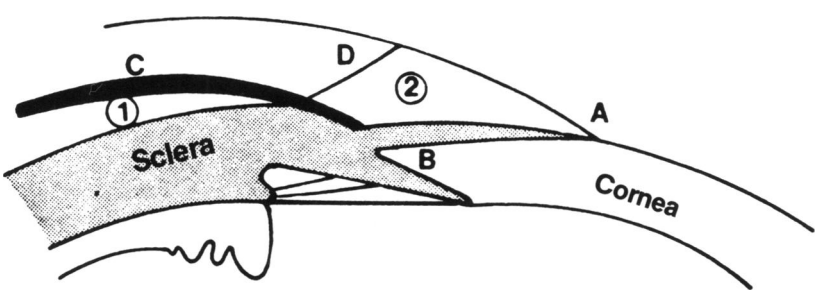

FIGURE 1
Schematic anatomy of Tenon's capsule at limbus. Conjunctival reflection (A) separates cornea from limbus. Note clear cornea both in front and behind (B) reflection. Most of capsule (C) inserts into sclera behind this landmark. This creates two potential spaces, sub-Tenon's (1) and subconjunctival (2). Septa (D) join conjunctiva to capsule.

tial separate spaces, sub-Tenon's and subconjunctival. The separation of two spaces is clearly seen if one has a hemorrhage during the placement of a bridle suture through the superior rectus. The blood is limited to the sub-Tenon's space.

Three different filtering procedures were performed over successive periods of time: a standard posterior lip sclerectomy, trabeculectomy by the method of Cairns[2] with minimal modifications, and a new procedure termed "guarded keratostomy." Random assignment was not done but during each of the three periods all cases were done by the same procedure.

The rationale for the new procedure was to avoid the bulk of Tenon's capsule attached to sclera (Fig 2). This produces two distinct characteristics. The usual limbal based thick conjunctival-Tenon's flap dissected from above is replaced by a limbal based thin conjunctival flap dissected from the limbus to one side. Septa between the conjunctiva and Tenon's capsule are cut. The second characteristic is the extreme anterior placement of the superficial flap and underlying opening entirely within clear cornea in front of the conjunctival reflection. This determined the term "guarded keratostomy." Postoperatively one can easily see the thinned cornea with the slit lamp.

In some respects this procedure resembles that described by others. Gorin[18] described a thin conjunctival flap with avoidance of Tenon's capsule. Anwar[19] described a guarded opening within the cornea. The new procedure should be distinguished from a guarded opening in clear cornea behind the conjunctival reflection.[20]

The postoperative care consisted of atropine once or twice daily, corticosteroid-antibiotic drops four times daily, and stopping carbonic anhydrase inhibitors for several weeks. If the bleb started to fail, digital massage was initiated with continuation of the corticosteroid drops.

The postoperative state was divided into three progressive stages by additional treatment for pressure control (Table II). Stage I did not require treatment. Stage II required medication and stage III required reoperation. The criteria for advancing a case to a higher stage were pressure and glaucomatous field loss, primarily the former. Movement to stage II occurred if the untreated pressure exceeded 21 twice. Movement to stage III occurred if the treated pressure exceeded either 27, or the preoperative treated baseline, twice. For the six cases of low-tension glaucoma, movement to stage II occurred if the pressure drop was less than 5 and movement to stage III was made if the treated pressures returned to the treated preoperative baseline level. In 12 patients with monocular surgery the use of carbonic anhydrase inhibitors for the fellow

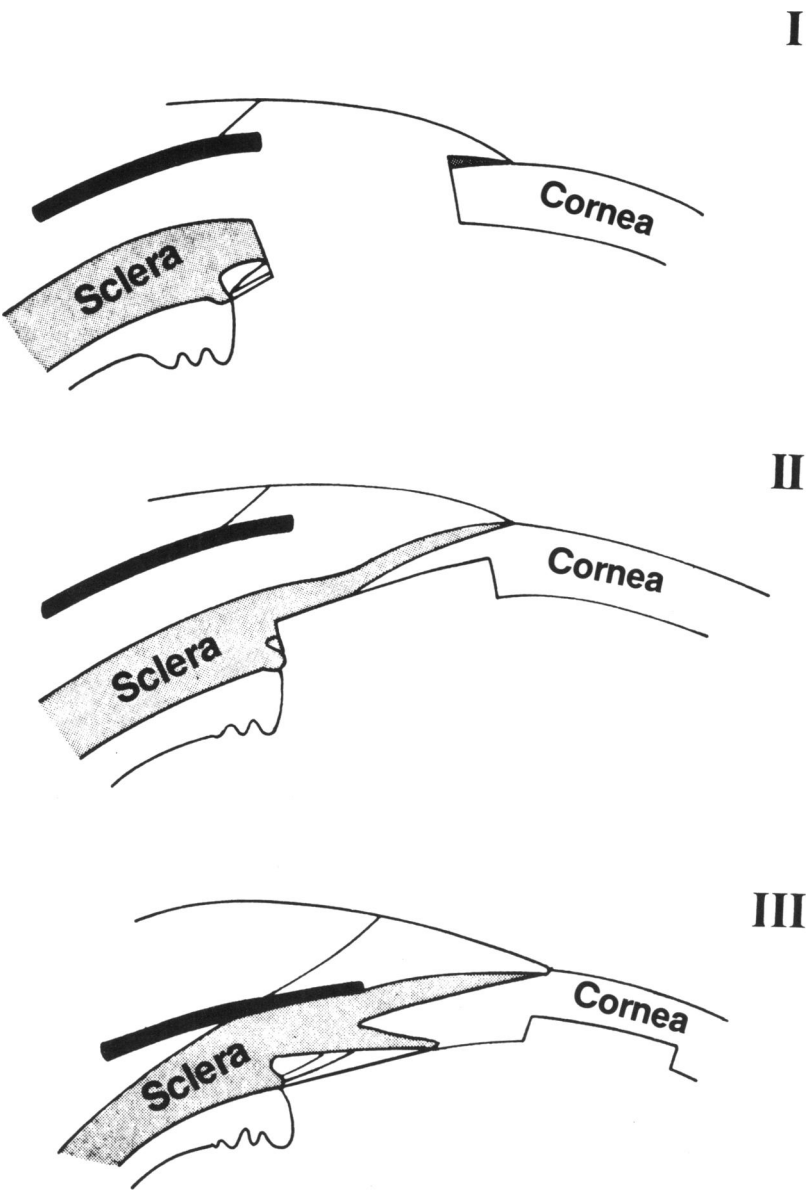

FIGURE 2
Schematic representation of excised deep tissue in three filtering procedures: sclerectomy (A), trabeculectomy (B), and guarded keratostomy (C). Note that Tenon's capsule is not detached in C.

TABLE II: DEFINITIONS OF STAGES BY PRESSURE

Stage I	≤ 21 without medication
Stage II	≤ 27 or *baseline with medication
Stage III	> 27 or *baseline with medication

*Preoperative, on medication.

eye obscured the classification between stages I and II. The drug was stopped for 3 days before an examination for three consecutive visits to determine the classification.

A case was also advanced to a higher stage if there was progressive field loss. In most cases of field loss there was agreement with the above pressure criteria. In a small number of cases field loss progressed at pressures lower than 22. If a case met the criterion for stage III but, for one reason or another, did not have the reoperation it was still classified as stage III.

The treated preoperative baseline pressure was defined as the median of all readings, usually three, within a period of 6 months or less before surgery. The untreated baseline pressure was the median of all readings, usually two or three, within a period of 1½ years or less before surgery. Only a limited number of untreated pressures were available. The final postoperative pressure was the median of all readings, usually two, during the last 3 months or less of follow-up in the final stage.

The life table method of Kaplan and Meier[15] was used for the two criteria of success in Table III. Note that the second criteria for success, with or without medication, has a much higher upper limit of pressure than usual because this group included all cases that did not require reoperation. Stepwise multiple regression analysis was done according to the method of Harrell[21] to determine and rank the factors that contributed to success. It was performed on four groups of cases; each of the filtering procedures separately over their respective entire follow-up periods and all cases combined with truncation of the longer follow-up

TABLE III: DEFINITIONS OF SUCCESS

TYPE	FINAL STAGE	PRESSURE CRITERIA
Without medication	I	≤ 21
With and without medication	I and II	≤ 27 or *baseline

*Preoperative, on medication.

periods to 14 months, the longest follow-up in the guarded keratostomy series.

For all four analyses the following factors were studied: eye (right or left), race, (Caucasian or black), sex, age (under 30 or older), diabetes by history (yes or no), past cataract surgery (yes or no), past glaucoma filtering surgery elsewhere (yes or no), type of glaucoma (primary open-angle phakic and aphakic or all others), and presence of surgical bleb at last visit (yes or no). For the analysis of all cases combined the type of glaucoma filter was included (sclerectomy, trabeculectomy, guarded keratostomy). The analysis was done with one eye chosen at random from binocular cases and with all eyes. The results were similar and only the latter data are presented.

A correction for the lack of random assignment of the surgical procedures was done by adjustment for the concomitant variables.[21] Each factor for success listed above is given a value corresponding to its importance. The life table curves for the three surgical procedures are remodeled to compensate for the different distributions of these factors in the three populations.

A standard two-tailed sign test was used for comparison of pressure between the two operated eyes of the same patient in the same stage. A standard two-tailed chi-square test was used to compare variation between operated eyes of the same patient and different patients. Standard linear regression analysis was used for the relationship between preoperative and postoperative pressures.

RESULTS

The treated baseline pressures before surgery and the final pressures after surgery, for all cases, are shown in Table IV.

Fig 3 shows success without medication for the three surgical procedures, for all cases. Trabeculectomy is superior to the other procedures ($P < 0.03$). The cumulative probability of success and standard error is 0.60 ± 0.05 at 2 years and 0.46 ± 0.05 at 5 years. By simple analysis the

TABLE IV: BASELINE AND FINAL PRESSURES FOR ALL CASES MEDIAN (25TH, 75TH PERCENTILES) (NO OF EYES)

BASELINE* BEFORE SURGERY	FINAL, AFTER SURGERY BY STAGES		
	I	II	III
35 (28-40) (194)	14 (12-17) (97)	20 (15-22) (45)	37 (29-42) (52)

*On medication.

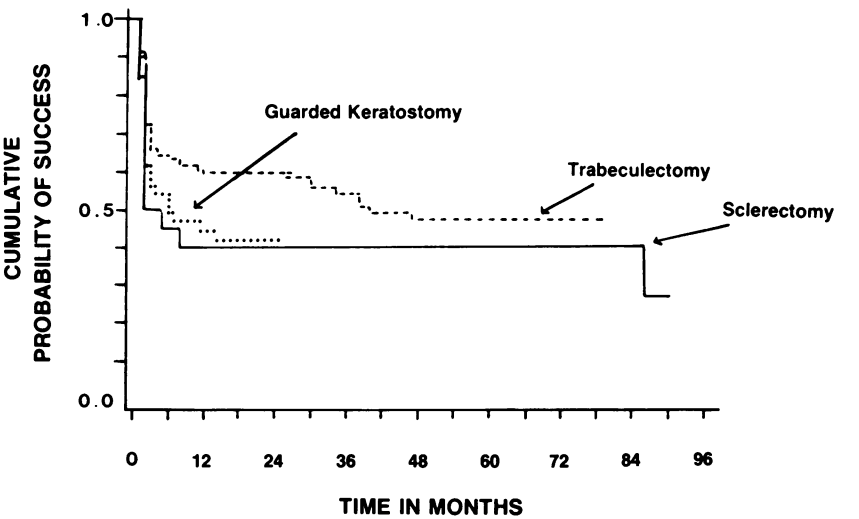

FIGURE 3
Cumulative probability of success without medication by type of filtering surgery. Number of eyes: sclerectomy 20, trabeculectomy 124, guarded keratostomy 50.

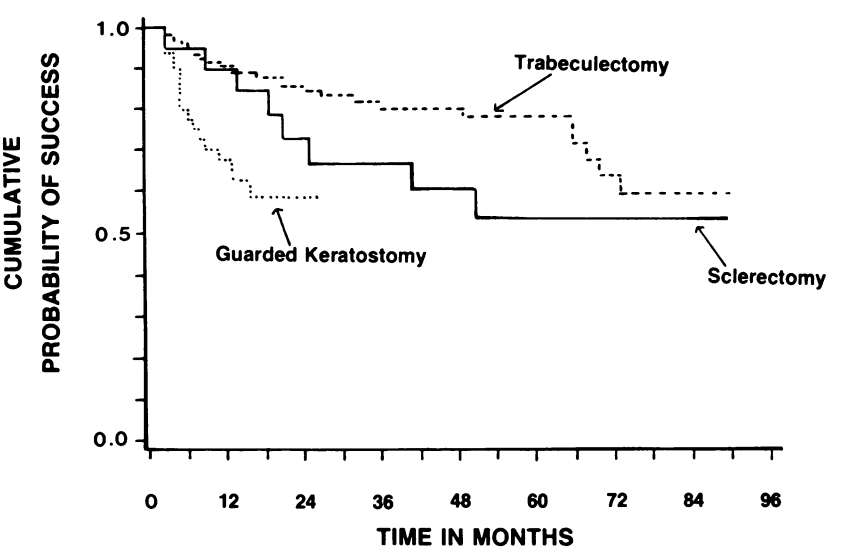

FIGURE 4
Cumulative probability of success, with and without medication, by type of filtering surgery. Number of eyes: sclerectomy 20, trabeculectomy 124, guarded keratostomy 50.

percent success at 5 years is 55.2. Most of the failures occur within the first 6 months.

Fig 4 shows success with and without medication. The guarded keratostomy is worse than the other two procedures ($P < 0.0001$). The rate of failure for all procedures is more gradual than in success without medication (Fig 3).

Correction of the life table curves (Figs 3 and 4) for differences in populations among the three surgical procedures was performed by adjustment for the concomitant variables. The relative relationships among the curves was unchanged.

Additional analyses were done in phakic primary open-angle glaucoma and low-tension glaucoma. Table V shows that for success without medication for the entire follow-up period, the median pressures are similar for the three procedures, approximately 12. For transient successes the pressures are higher. The median postoperative pressures are lower in low-tension glaucoma but the number of cases is limited.

The effect of the preoperative baseline pressure, either treated or untreated, was studied in phakic primary open-angle glaucoma cases that were successful without medication over the entire follow-up period. Fig 5 shows that the change in pressure 6 months after surgery is directly proportional to the treated baseline pressure in 48 eyes. The intercept and standard error are 9.7 ± 2.2. A similar result was obtained in 16 eyes in which the untreated baseline pressures were available. The intercept was 11.2 ± 3.8. The two intercepts are not significantly different. Thus, all pressures in successful cases tend toward the same value.

Significant factors in success ($P < 0.05$) as determined by stepwise multiple regression analysis are shown in Table VI for success without medication and in Table VII with and without medication. In each table the analysis was performed in four separate groups; by the number of times a given factor was significant and the probability value an approximate ranking of factors was made. Aphakia and the absence of a bleb are the most important factors. Age and type of surgical procedure are next. Race and race-sex interaction are the least important factors. The coefficient of determination showed that only 6% to 16% of the total variation was accounted for by the above factors. The following factors were not significant: right or left eye, previous filtering surgery done elsewhere, the presence of diabetes, and type of glaucoma.

The presence or absence of a detectable surgical bleb is not a predictive factor because it occurs after surgery. Although most successful cases had blebs, there were a few exceptions. Some cases were successes without blebs and others were failures with blebs. The latter group can be divided

TABLE V: PRESSURE AFTER SURGERY IN SUCCESS WITHOUT MEDICATION
MEDIAN (RANGE) NUMBER OF EYES

GLAUCOMA	DURATION SUCCESS	SURGERY	TIME AFTER SURGERY (YEARS)						
			0.5	1	2	3	4	5	6
Primary open-angle	Entire follow-up period	Sclerectomy	12 (10-12)	14 (10-20)	12 (10-16)	9 (8-10)	18 (15-18)	—	15 (15)
			4	4	3	2	3		2
		Trabeculectomy	12 (4-21)	12 (6-21)	12 (6-20)	13 (6-21)	14 (6-21)	13 (6-18)	14 (10-16)
			40	31	24	17	14	12	7
		Guarded keratostomy	10 (6-15)	14 (6-18)	6	—	—	—	—
			7	7	1				
	Transient but ≥ 6 mos	Sclerectomy	21	21	18	14	17	20	15
			1	1	1	1	1	1	1
		Trabeculectomy	18 (12-20)	19 (13-21)	15 (13-17)	20 (20)	—	—	—
			7	6	2	2			
		Guarded keratostomy	20	18	—	—	—	—	—
			1	1					
Low-tension	Entire period	Trabeculectomy	8 (5-8)	8 (6-10)	8 (8-10)	8	11 (10-12)	11 (9-12)	—
			4	4	3	1	2	2	
	Transient but ≥ 6 mos		13 (13)	12 (10-14)	15 (14-15)	16	17 (15-18)	—	—
			2	2	2	1	2		

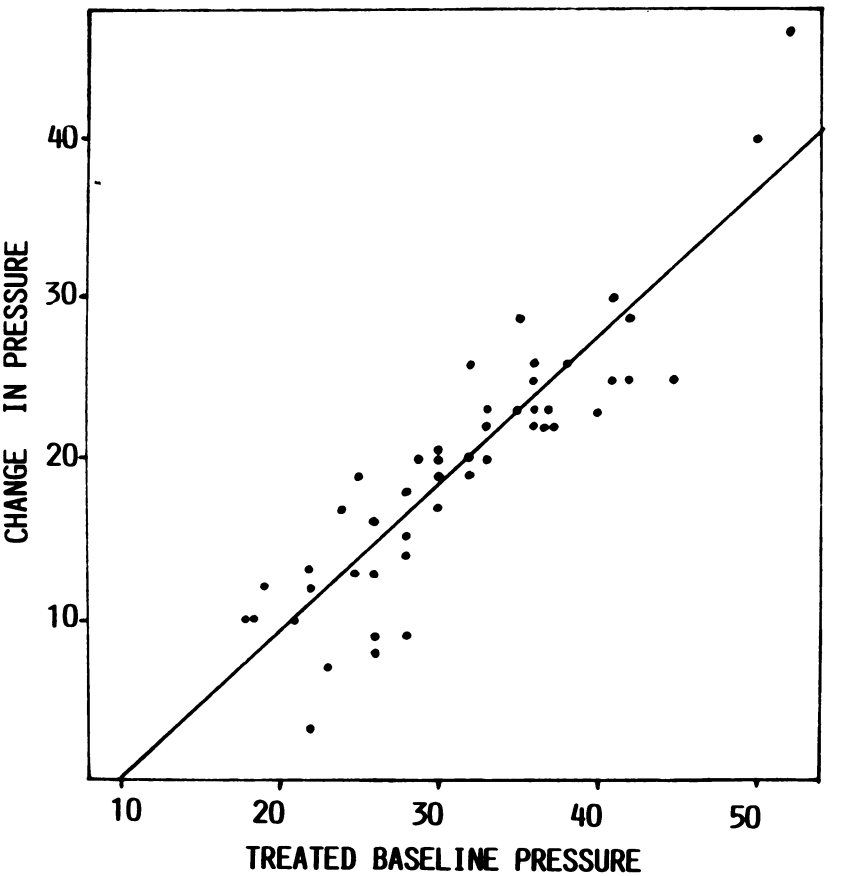

FIGURE 5
Linear regression of change in pressure 6 months after surgery to treated baseline pressure before surgery in 48 eyes with primary open-angle glaucoma. All eyes were successes without medication over their entire follow-up period. Coefficient of correlation is 0.90 with a probability of 0.0001. Slope is 0.93. Intercept and standard error are 9.7 ± 2.2

into those where the circumscribed appearance of the bleb was sufficient to determine failure without a pressure reading and others where the appearance was deceptive and insufficient to determine failure without a pressure reading.

After sclerectomy or trabeculectomy the frequency of peripheral anterior synechiae to the wound was low as determined by gonioscopy. They were rarely of sufficient extent to cause failure. After guarded keratos-

TABLE VI: FACTORS IN SUCCESS (WITHOUT MEDICATION) PROBABILITY VALUES

FACTORS THAT DECREASE SUCCESS	ANALYSIS GROUPS			
	ALL CASES (n = 194)	SCLERECTOMY (n = 20)	TRABECULECTOMY (n = 124)	GUARDED KERATOSTOMY (n = 50)
Absent bleb	0.0000	—	0.0000	0.0001
Aphakia	0.0006	—	0.0006	—
Young	0.0233	—	—	—
Other procedures less than trabeculectomy	0.0289			
Black	—	—	0.0076	—
Female	—	—	—	0.0366

tomy the frequency and extent of peripheral anterior synechiae was greater as determined by slit lamp biomicroscopy and gonioscopy. Approximately 20% of guarded keratostomy cases showed synechiae and the more extensive ones were associated with failure. The guarded keratostomy involved less surgical dissection and bleeding than the other two procedures.

In 32 patients with phakic primary open-angle glaucoma, both eyes had the same type of filtering procedure with similar follow-up periods. Another 64 eyes of 64 patients with phakic primary open-angle glaucoma were divided into 32 pairs, each pair with the same surgical procedure and as similar a follow-up period as possible within the constraints of the data. In both groups the difference in follow-up between pairs was less than or equal to 4 months in approximately 90%. Table VIII compares the intrapatient and interpatient differences. The former was significantly less by chi-square analysis ($P < 0.05$). However, there was still a considerable degree of intrapatient difference in that only 22 of 32 pairs ended in the same final stage. In addition, the pressure was significantly different ($P <$

TABLE VII: FACTORS IN SUCCESS (WITH AND WITHOUT MEDICATION) PROBABILITY VALUES

FACTORS THAT DECREASE SUCCESS	ANALYSIS GROUPS			
	ALL CASES (n = 194)	SCLERECTOMY (n = 20)	TRABECULECTOMY (n = 124)	GUARDED KERATOSTOMY (n = 50)
Aphakia	0.0003	—	0.0000	—
Guarded keratostomy less than other procedures	0.0000			
Absent bleb	0.0011	—	—	0.0022
Young	0.0175	0.0086	0.0111	—
Black-female	—	—	0.0082	—

TABLE VIII: DIFFERENCE IN SUCCESS BETWEEN PAIRED EYES IN PHAKIC PRIMARY OPEN-ANGLE GLAUCOMA

SAME PATIENT (32 PAIRS)		DIFFERENT PATIENT (32 PAIRS)	
SAME FINAL STAGE	DIFFERENT FINAL STAGE	SAME FINAL STAGE	DIFFERENT FINAL STAGE
22	10	14	18

0.05) in 8 of the 22 pairs with the same final stage as determined by the signed rank test.

DISCUSSION

The evaluation of filtering surgery in terms of pressure control alone is a simplification since it does not take into account visual loss and surgical complications. In addition, we were not able to isolate pressure control in all cases. In a small number of eyes the progression of stages was determined by field loss despite adequate pressure control by the usual criteria. This confirms the observations made by others.[8,22-24]

The method of data collection in this paper has strengths and weaknesses. The study is retrospective rather than prospective. The three filtering procedures were allocated in successive time periods rather than by random assignment. Correction for the lack of random assignment was done by adjustment for the concomitant variables. The relative relationships among the life table curves was unchanged. Although this method is reasonable, it may not entirely overcome the defect. There was a high number of drop-outs. The cohort is a series of successive cases with minimal exclusions. There is a degree of homogeneity with one surgeon and one technician throughout the study.

As expected, the success rate by the life table analysis is lower than that by the simple pooled method, confirming the results by the Japanese.[9,10] This emphasizes the need for a uniform rigorous method of time analysis for all studies.

The time course of pressure control has two phases, a rapid decrease over the first 6 months followed by a gradual decrease or stability.[5,6,8-10,13,25-32] The general shape of the curve is similar whether or not cases with medication are included. In our expanded definition of success with and without medication (Fig 4) the two phases are not clearly separated. Studies limited to primary open-angle glaucoma are more likely to have a stable second phase. In our study some of the late failures could be

identified early by the grouping of their pressures toward the upper limit of success. This confirms the observations by others.[33]

Pressure control after filtering surgery is probably determined by the interaction of two major groups of factors, those determined by the surgeon, and those determined by the patient. The former includes skill and experience, criteria for surgery, choice of procedure, and postoperative treatment. The latter consists of nonocular factors that include age, sex, race, systemic disease, and tissue reaction as well as ocular factors that include type and severity of the glaucoma, previous surgery, and other ocular disease. What is the relative importance of the two major groups? The enormous effort that has been expended in devising new or modified procedures assumes that the surgeon has considerable control over the final result. Others suggest that all procedures produce more or less the same pressure results[3,34-36] and tissue reaction is the limiting factor.[35,37]

There are several studies with adequate design[5,12-14] that show a significant difference in pressure control between different filtering procedures. In general, full thickness openings show better control than partial thickness procedures. The present study also shows a significant difference among filtering procedures in terms of success. However, trabeculectomy was the best procedure. A failure to demonstrate a difference in pressure control between surgical procedures might be valid, or the result of inadequate design, or the use of unproductive variation in technique.[7,11] Overall, despite inconsistencies, the type of filtering surgery probably plays a significant role in pressure control.

The lower success rate of the guarded keratostomy is probably caused by the higher frequency of peripheral anterior synechiae. If this could be minimized, the procedure would be more useful because of less surgical dissection and hemorrhage.

What determines the pressure level in the selected group of successful cases without medication? Two observations are pertinent. The three filtering procedures have similar postoperative pressures. The final pressure is independent of the preoperative baseline pressure confirming the results of others.[23,29,38] These findings suggest that all eyes have a lower limit of pressure that can be attained but not exceeded by any successful procedure. The level may be determined by the episcleral venous pressure as suggested by Watson and Grierson.[23] In low-tension glaucoma there is a lower final pressure suggesting a lower episcleral venous pressure.

The present study confirms the well known inimical influence of aphakia,[28,29,39-41] absence of a bleb,[23,42] and youth.[6,9,27,36,40,43-45] The effect of race, between blacks and Caucasians, has been controver-

sial.[1,4,27,29,30,40,42,46] In the present study race was a significant but relatively unimportant factor. There is a suggestion that the Japanese may have a lower success rate than Caucasians[9,10] but this may well reflect a confounding of variables.

The failure to demonstrate an effect of the type of glaucoma probably represents the binary division of the data into primary open-angle glaucoma with and without aphakia and all other types (Table I). In the stepwise regression analysis the well known difficulty with congenital glaucoma[9,47] is probably accounted for under the age factor. Others[6,23,28,30,44,48] have shown that the success rate in phakic primary open-angle glaucoma is similar to that in angle-closure glaucoma but higher than in most secondary types.[9,28,41,44,45,49] In the present study previous glaucoma surgery was not a significant factor as noted by D'Ermo et al.[6] Others have noted a lesser success after previous surgery.[9,10,25,41]

As expected, the postoperative difference between eyes of the same patient was less than that between eyes of different patients for the same procedure by the same surgeon. This enhances the value of intrapatient comparisons in that the same statistical power can be obtained with a smaller number of pairs. However, the intrapatient difference itself was surprisingly high and this limits the advantage. The cause of the intrapatient variation may be inadvertent small variations in technique[8] or unknown differences between the two eyes.

The above factors only account for 6% to 16% of the total variance, emphasizing our limited knowledge of pressure control. Perhaps the investigation of tissue factors will be productive.[35] The strong clinical impression that postoperative care is important[50] merits further rigorous study. This includes the study of corticosteroids[51,52] and maintaining an adequate[50,53-55] but not excessive[56] flow of aqueous through the wound. The use of a postoperative topical antiprostaglandin increases failure.[57] The use of postoperative 5-fluorouracil increases success.[58] The use of sodium hyaluonate (Healon) during surgery may predispose to success[59] but this is not my clinical impression. Transient hyphemas and flat chambers do not affect the success rate.[6] The problem in evaluating surgical skill and experience has been discussed.[40] A lower blood coagulability may predispose to success.[60]

SUMMARY

Factors that determine pressure control after filtering surgery were studied in 194 eyes of 158 patients in a retrospective study. Emphasis was placed on the cumulative probability method of Kaplan and Meier[15] and

multiple regression analysis. Aphakic and the presence of a surgical bleb were the most important factors. Age and type of surgical procedure were next. Race and race-sex interaction were the least important factors. The above factors accounted for only 6% to 16% of the total variance. The difference between eyes of the same patient was less than that between paired eyes of different patients but the former was surprisingly high. In the selected group of successful cases without medication the postoperative pressure was independent of the baseline pressure and choice of surgical procedure.

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DISCUSSION

Dr Clement McCulloch. Two aspects of Doctor Levene's paper are of particular interest, namely, the handling of the mathematic data by the method of cumulative probability or life table, and the introduction of a new filtering operation, which he has named a keratostomy. I will discuss both aspects.

In the acceptance of cases he has included a number of types of glaucoma (Levene's Table I). This produces a diversity which I feel does not allow a grouping for mathematic analysis. For example, there are 12 cases of primary closed angle glaucoma and 15 of secondary closed angle glaucoma. Some of these may have been curable by an iridectomy alone. A number of years ago I did iridectomies on a group of 40 eyes with extremely shallow chambers but running

the course of chronic simple glaucoma. After operation I found one third carried normal pressures without medication, one third were controlled with medication, and one third continued as poorly controlled chronic simple glaucoma. Inclusion of closed angle cases gives a false sense of success to a series of filtering operations, for many of those cases may be controlled without filtration.

The inclusion of the other special types of glaucoma similarly weakens the significance of the whole series.

I have redrawn Figs 3 and 4, amalgamating the results for stage I and stage II.

First, nine eyes were excluded from the study because of immediate postoperative complications. These may have been bizarre, but we all know that bizarre happenings are part of medicine. Their exclusion gives a false sense of success to the surgery.

Second, one can see, using trabeculectomy, stage I, as an example, that the cumulative failure rate was much higher than for stage II. Obviously, a lot of cases failed out of stage I early but were transferred to stage II and held by medication for a considerable time. But these happenings are clouding the mathematics. Failure out of stage I decreases the cohort in stage I but increases that in stage II. Drop-outs for extraneous reasons, for example lost to follow-up, are occurring continually. The purity, or lack of bias, in the cohorts are continually becoming more suspect. Also, the cohorts are getting smaller and of less mathematic significance. Also note that these are not death drop-outs—death is an exact thing and applies cleanly to a death table. Here the need for drops, pressure levels, field changes, special rules for low-tension glaucoma, and the necessity to employ acetazolamide have all been used to designate failures. The statistical power of a death table is greatly weakened by the employment of these multiple criteria and we should accept only the most gross conclusions about this data.

Even so, just eyeballing these curves, they indicate to me that if one gains good filtration, moves past the phase of early failures, pressures may remain at satisfactory levels for long periods of time. In the longer follow-up periods drugs will help. These are possibly all the conclusions one should make.

I find it interesting that no matter what the preoperative pressure was, if good filtration is achieved the postoperative pressure will lie in the region of 10 mm of mercury. This, of course, does not include the inadequate, poorly adsorbing bleb or the thin walled, watery bleb with hypotony.

Concerning the new operation, guarded keratostomy, I would question the wisdom of a limbal bleb in front of Tenon's capsule. To me the good bleb is more posterior, under Tenon's capsule. It is well covered, soft, and with pitting edema beyond its obvious confines. The bleb at the limbus, in front of Tenon's capsule, is thin walled, likely to become thinner with time, tends to have minute transepithelial leaks demonstrable by fluorescein, is bounded on its sides by fibrous tissue and does not show surrounding pitting edema. I find these are dangerous blebs, liable to lead to hypotony, liable to infection, and I consider them surgical failures. To me one of the advantages of the trabeculectomy operation is that the blebs are further back and therefore deeper, widely succulent and safer. The

keratostomy procedure, draining in front of Tenon's capsule, is going to produce exactly the bleb I do not like.

DR DANIEL M. TAYLOR. I was interested in Doctor Levene's comments regarding the poor response of aphakic glaucoma to trabeculectomy and other filtering procedures. Our results have been similar and we have usually assumed that the failure was due to formed vitrous prolapse into the drainage channels. In those aphakic cases where an initial trabeculectomy has failed to control the pressure, we have experienced some success with a secondary trabeculectomy combined with an anterior vitrectomy through the trabeculectomy incision. We have also had some success by reopening the original trabeculectomy flap and performing a vitrectomy through this site. I believe it worthwhile, however, to try a simple trabeculectomy first, since an anterior vitrectomy can lead to other complications (retinal detachment, subretinal hemorrhage, etc). There are also scattered reports in the literature indicating that the plugged vitrectomy site can be reopened internally with a YAG laser. Another variation we believe to be effective is the use of the drainage wick under the trabeculectomy flap to keep the drainage channels open. We have employed this technique when operating on highly inflamed eyes (corneal ulcers) that have require a reconstructive keratoplasty combined with a trabeculectomy. The wick does not have to be a fancy device. We usually fashion a small 5 × 2 mm strip taken from the polyethylene drape or from an anterior chamber glide (Sheets) and place it under the flap so that it reaches to the anterior chamber and extends slightly beyond the trabeculectomy flap at the opposite end. These are only technical suggestions and are not backed by a carefully controlled study.

DR RALPH LEVENE. I would like to thank the two discussants. Doctor McCulloch notes that many types of glaucoma are included in the study. This complicates matters but one can still apply the life table method of analysis. He likes the protection of Tenon's capsule over the bleb. I do not think it is necessary if you obtain a diffuse bleb without it. Doctor Taylor obtains better results when he includes an anterior vitrectomy with an aphakic glaucoma procedure. I am not convinced over the long term. Many clinical impressions are not confirmed with rigorous analysis. There is considerable interest in Setons but again, I am not convinced over the long term.