Unplanned Return to the Operating Room After Trabeculectomy

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• PURPOSE: **To determine the unplanned return to operating room (OR) rate within 180 days and at any time postoperatively after trabeculectomy performed or supervised by an attending surgeon and to identify associated factors.**

• DESIGN: **Retrospective case-control study.**

• METHODS: **Review of 881 eyes that underwent trabeculectomy at an academic glaucoma service between January 2014 and December 2016. Inclusion criteria included adult patients with postoperative follow-up > 180 days and no other glaucoma-related surgery within the prior year. For each eye that underwent reoperation, a control was time-matched within 1 month.**

• RESULTS: **The reoperation rate within 180 days was 9.5% (84/881) and at any time postoperatively was 23.3% (205/881). When intraoperative bleb needling cases were excluded, the reoperation rate was 6.5% (57/881) within 180 days and 13.6% (120/881) at any time postoperatively. Mean postoperative follow-up was 2.9 ± 1.1 years. The most common reoperations within 180 days were bleb revision (32.1%) and intraoperative bleb needling (28.6%) and at any time postoperatively were bleb needling (36.1%), bleb revision (23.9%), and tube shunt implant (13.2%). At last follow-up, eyes that returned to OR and control eyes were similar in terms of mean intraocular pressure (IOP), the proportion of eyes meeting target IOP, and change in visual acuity since the original trabeculectomy.**

• CONCLUSIONS: **Nearly 10% of eyes returned to OR within 180 days and over 20% of eyes required reoperation at any time postoperatively with a mean follow-up of nearly 3 years. Additional studies should evaluate unplanned return to OR as a measure of surgical quality within ophthalmology. (Am J Ophthalmol 2020;219: 132–140. © 2020 Elsevier Inc. All rights reserved.)**

UNPLANNED RETURN TO THE OPERATING ROOM (OR) has been used as a metric of quality across a number of surgical fields, including general surgery,[1] pediatric neurosurgery,[2] colorectal surgery,[3] and vascular surgery,[4] and has been associated with mortality and prolonged hospitalization.[1,3] Unplanned return to OR may serve as a useful metric of surgical quality, given its broad applicability to many procedures, nondiscretionary nature, and the ability to easily identify cases that underwent reoperation from administrative records.[2]

Some of the more traditional measures of surgical quality, such as mortality and length of hospital stay, have little utility in ophthalmology. Accordingly, unplanned return to OR may be useful in quality monitoring for ophthalmic surgery. Most studies of unplanned return to OR in ophthalmology thus far have focused on cataract and vitreoretinal surgeries performed by residents.[5–8] Hsia and associates have reported reoperation rates for glaucoma surgeries performed by residents.[9]

To improve upon the current standard of care with regard to trabeculectomy outcomes, it is important to better understand the patient-, surgeon-, and procedure-specific factors that are associated with unplanned return to OR in glaucoma surgeries performed by attending surgeons and fellows operating under the direct supervision of those attending surgeons. We therefore set out to evaluate unplanned return to OR after trabeculectomy at an academic glaucoma service. The results of this study may help predict which patients are at elevated risk for unplanned reoperation.

METHODS

THIS WAS A RETROSPECTIVE CASE-CONTROL STUDY EXAMining the outcomes of trabeculectomy performed by glaucoma specialists at the Wilmer Eye Institute between January 2014 and December 2016. The study protocol was reviewed and approved by the Johns Hopkins University School of Medicine Institutional Review Board. The study abided by the Declaration of Helsinki.

Patients included in the study were identified using surgical billing records for which the procedure was linked to CPT code 66170 or 66172. Inclusion criteria included postoperative follow-up of at least 180 days, age greater than 18 at the time of original surgery, and no other glaucoma-related surgery (trabeculectomy, tube shunt, bleb needling, or trabeculotomy) in the same eye within the year preceding the index surgery. If both eyes of the same patient underwent trabeculectomy within the study period, the first

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eye that met inclusion criteria was selected. In the few cases in which a patient had multiple trabeculectomy surgeries in the same eye within the study period, only the first trabeculectomy that met inclusion criteria was included. For each patient who was identified as having had an unplanned reoperation related to a direct complication from their trabeculectomy or progression of their glaucoma at any point after their original surgery, a control patient time-matched within 1 month was selected by a random-number generator for comparison.

Clinical data were extracted from the electronic medical record, including age at the time of surgery, sex, race, eye laterality, type of glaucoma, history of prior incisional eye surgery, highest recorded intraocular pressure (IOP), visual acuity (VA), number of glaucoma eye drops, and use of oral medications to lower IOP at the last visit prior to surgery. Combination eye drops were counted as 2 glaucoma medications. The target IOP most recently documented by the treating surgeon was recorded. Surgical details recorded included surgeon and whether cataract extraction was combined with trabeculectomy. Details documented in the medical record from the postoperative course were recorded: postsurgical complications (bleb leak, blebitis, choroidal effusion, dysesthesia, endophthalmitis, flat anterior chamber, elevated IOP refractory to medical therapy, hyphema, hypotony, hypotony maculopathy, suprachoroidal hemorrhage, or other), use of postoperative medications and procedures to address complications, and whether the complication resolved without surgical intervention. Finally, whether a reoperation was performed at any time postoperatively, when it was performed, reason for reoperation, type of surgery, number of additional reoperations, and the final VA, IOP, number of glaucoma eye drops, and use of oral glaucoma medications at the last follow-up visit were recorded. Last follow-up was defined as the last clinical examination recorded on or before March 31, 2019. Postoperative hypotony was based on *clinician judgment* as recorded in the medical record, rather than an IOP cutoff value. Keywords abstracted from clinic notes included "hypotony," "IOP too low," and "low IOP affecting vision." Postoperative hypotony maculopathy was similarly based on clinician judgment and typically included retinal changes affecting the patient's vision. The majority of IOP measures on the glaucoma service were performed using applanation tonometry, most often by experienced technicians, but some measurements were with the iCare tonometer (Icare USA, Raleigh, North Carolina, USA). Snellen VA was converted to its logarithm of the minimum angle of resolution (logMAR) equivalent to assess changes in VA.[10]

All trabeculectomies used a fornix-based conjunctival flap. We have previously published a review of the complication rates of fornix-vs limbus-based trabeculectomy approaches.[11] Antimetabolites, most often mitomycin C, were used in the vast majority of eyes, with varying modes of administration and dosages. Flap construction, flap closure, and conjunctival closure techniques varied across surgeons.

• **STATISTICAL METHODS:** The main outcome measure was whether an unplanned reoperation, either related to the patient's glaucoma or as a result of a postoperative complication, was performed within 180 days of the original procedure. A second measure was whether a reoperation occurred at any time during the postoperative period. Student *t* test was used to compare the mean follow-up time, mean age at surgery, mean baseline IOP, mean target IOP, and mean number of glaucoma eye drops used prior to surgery between the reoperation and control cases, as well as the mean IOP and mean number of glaucoma eye drops at the last follow-up visit. Student *t* test was also used to evaluate the change in logMAR between the clinic visit just prior to trabeculectomy and at the last follow-up clinic visit. Pearson χ^2 test was used to compare eye laterality, sex, race, type of glaucoma, prior incisional and glaucoma surgery, surgeon, and whether the eyes attained their target IOP level at last follow-up between the reoperation and control cases. Kaplan-Meier survival analysis was performed, with failure defined as an unplanned return to the OR.

To identify factors associated with unplanned reoperation both within 180 days and at any time postoperatively, 31 factors were initially tested for inclusion in Cox proportional hazards models, and factors with univariate *P* values $\leq .1$ were used to construct multivariable models. These models were systematically tested by dropping the variable with the largest *P* value, and the most parsimonious model, identified as the model with the lowest Akaike information criterion, was chosen as the final model. A hazard ratio greater than 1 indicates a higher chance of failure compared with the reference group.

The 31 factors initially tested included mean age at the time of surgery, sex, race, eye laterality, type of glaucoma, maximum IOP prior to surgery, target IOP, number of preoperative glaucoma eye drops, use of preoperative oral glaucoma medications, prior incisional eye surgery (trabeculectomy, tube shunt, cataract surgery, complex cataract surgery, or pars plana vitrectomy), whether cataract extraction was combined with the trabeculectomy, surgeon, postsurgical complications (bleb leak, blebitis, choroidal effusion, dysesthesia, endophthalmitis, flat anterior chamber, elevated IOP refractory to medical therapy, hyphema, hypotony, hypotony maculopathy, suprachoroidal hemorrhage, or other complications), and postsurgical treatment to address the complication (bandage contact lens or in-office needling).

A *P* value $< .05$ was considered statistically significant. In situations in which multiple statistical comparisons were made, the *P* value threshold of .05 was adjusted by the number of statistical comparisons. These situations include the comparisons of follow-up time, age at surgery, eye laterality, sex, race, type of glaucoma, prior incisional

TABLE 1. Demographics of Patients who Returned to the Operating Room at Any Time Postoperatively and their Time-Matched Controls

Description	Reoperations	Controls
Number	205	205
Mean follow-up time (SD)	2.8 years (1.0 years)	3.0 years (1.2 years)
Mean age (SD)	68.4 years (11.9 years)	71.1 years (12.9 years)
Eye (% OD)	52.2%	48.8%
Sex (% male)	53.2%	47.3%
Race (n, %)		
White	104 (50.7%)	97 (47.3%)
Black	80 (39.0%)	84 (41.0%)
Asian	9 (4.4%)	11 (5.4%)
Hispanic	0 (0%)	7 (3.4%)
Other	12 (5.9%)	7 (3.4%)
Missing	0 (0%)	1 (0.5%)
Type of glaucoma		
OAG	152 (74.1%)	137 (66.8%)
ACG	25 (12.2%)	26 (12.7%)
Uveitic/inflammatory	7 (3.4%)	4 (2.0%)
PXF	11 (5.4%)	20 (9.8%)
NVG	1 (0.5%)	1 (0.5%)
Pigmentary	4 (2.0%)	6 (2.9%)
Traumatic	1 (0.5%)	2 (1.0%)
Suspect	0 (0%)	4 (2.0%)
Other	4 (2.0%)	5 (2.4%)
Prior incisional surgery, n (%)	65 (31.7%)	69 (33.7%)
Prior glaucoma surgery, n (%)		
Any	13 (6.3%)	11 (5.4%)
Prior trabeculectomy	13 (6.3%)	8 (3.9%)
Prior tube shunt	0 (0%)	0 (0%)
Prior trabectome	0 (0%)	3 (1.5%)
Mean baseline IOP (SD)	32.0 (10.5)	32.7 (11.2)
Mean target IOP (SD)	14.8 (2.7)	15.5 (3.8)
Mean number of glaucoma eye drops prior to surgery (SD)	2.7 (1.4)	2.7 (1.3)

ACG = angle-closure glaucoma; IOP = intraocular pressure; NVG = neovascular glaucoma; OAG = open-angle glaucoma; PXF = pseudoexfoliation.

surgery, prior glaucoma surgery, baseline IOP, target IOP, number of preoperative glaucoma eye drops, change in logMAR, and the IOP and number of glaucoma eye drops at the last follow-up visit between the reoperation and control cases. Study data were collected and managed using REDCap.[12,13] All statistical analyses were performed in STATA (StataCorp 2017. Stata Statistical Software: Release 15; StataCorp LLC, College Station, Texas, USA).

RESULTS

• **RATE OF UNPLANNED RETURN TO THE OPERATING ROOM:** Of 881 included eyes, 205 (23.3%) returned to the OR for an unplanned reoperation related either to their glaucoma or to a complication from their trabeculectomy at some point after surgery (mean follow-up 2.9 ± 1.1 years). Reoperation and control eyes did not vary in terms of mean follow-up, age at surgery, eye laterality, sex, race, type of glaucoma, history of prior incisional or glaucoma surgery, mean baseline IOP, or mean number of preoperative glaucoma eye drops (Table 1).

Eighty-four eyes (9.5%) underwent reoperation within the first 180 postoperative days. Stratification of the reoperation rates early within the postoperative period is shown in Figure 1.

The vast majority of trabeculectomy surgeries included intraoperative use of antimetabolite with varying modes of administration and dosages, including 203 eyes (99.0%) that ultimately returned to the OR and 202 control eyes (98.5%).

From Kaplan-Meier survival analysis, 86.9%, 81.8%, and 73.9% of the trabeculectomy surgeries avoided unplanned return to the OR at 1, 2, and 4 postoperative years,

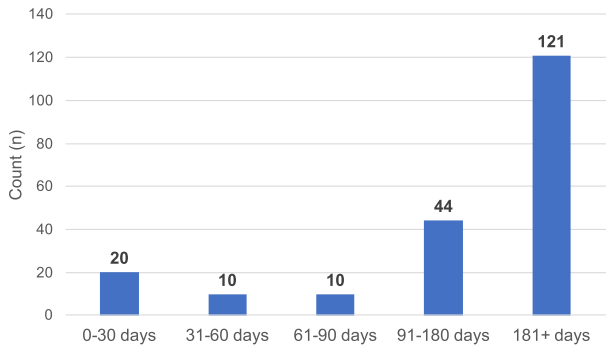

FIGURE 1. Timing of unplanned return to the operating room (OR). This graph depicts the stratification of reoperation rates early within the postoperative period. At any time during postoperative follow-up, 205 eyes (23.3%) returned to the OR. Of the 84 eyes (9.5%) that returned to the OR within the first 180 days, nearly half (4.5%) underwent reoperation within the first 90 days, with 20 eyes (2.2%) undergoing reoperation within the first 30 days.

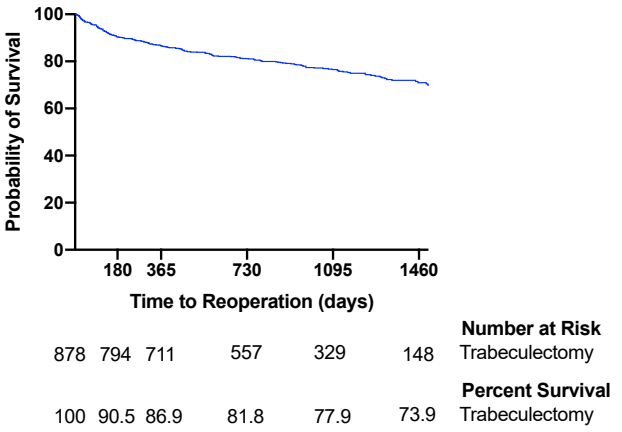

FIGURE 2. Kaplan-Meier survival curve for unplanned return to the operating room (OR). Failure is defined as an unplanned return to the OR. At 1, 2, and 4 postoperative years, 86.9%, 81.8%, and 73.9% of trabeculectomy surgeries avoided unplanned return to the OR, respectively.

respectively (Figure 2). Given that 1 surgeon at our institution performed a large number of intraoperative bleb needling procedures during the study period,[14] we also examined the rate of reoperation excluding those procedures. Without the intraoperative bleb needling cases, 120 (13.6%) eyes returned to the OR at any time postoperatively, including 57 (6.5%) eyes that underwent reoperation within the first 180 days.

• **POSTOPERATIVE COMPLICATIONS:** The most common postoperative complications for eyes undergoing reoperation, both within the first 180 days and at any time postoperatively, were elevated IOP refractory to medical therapy, choroidal effusion, hypotony, and bleb leak (Table 2). A bandage contact lens was placed in 21 eyes with bleb leaks; 13 of these eyes ultimately returned to the OR and 8 eyes did not. In-office needling was performed in an attempt to lower IOP in 10 eyes: 6 (2.9%) later underwent further surgery and 4 (2.0%) did not.

• **REOPERATION SURGERY:** Reasons for unplanned return to OR varied from complications that may have arisen as a direct result of the trabeculectomy, such as bleb leak, hypotony, choroidal effusion, or hyphema, to reasons that dealt with persistent inadequate IOP control postoperatively, owing to a failure of the surgery or progression of the patient's glaucoma. Among eyes that returned to the OR within the 180 days as well as at any time postoperatively, the primary reasons for return to OR were persistently elevated IOP refractory to medical therapy, bleb leak, hypotony, and choroidal effusion. With longer postoperative time prior to the second surgery, there were relatively more cases that underwent reoperation for persistently elevated IOP than the other postoperative complications. A further stratification of the reasons for unplanned return to the OR is presented in Figure 3.

Among eyes that returned to the OR within the first 180 postoperative days, the most common reoperation surgeries were bleb revision in 27 eyes (32.1%), intraoperative bleb needling in 24 eyes (28.6%), bleb revision with choroidal drainage in 9 eyes (10.7%), and choroidal drainage without bleb revision in 9 eyes (10.7%). Seven eyes (8.3%) underwent a new glaucoma surgery, either a trabeculectomy or a tube shunt implant. Among eyes that returned to the OR at any time postoperatively, the most common reoperations were intraoperative bleb needling in 74 eyes (36.1%), bleb revision in 49 eyes (23.9%), and a tube shunt implant in 27 eyes (13.2%). Additional detail showing the types and timeframe of the reoperations is shown in Table 3.

Among the 205 eyes that returned to the OR, 63 (30.7%) required additional surgery beyond the first return to OR, including 34 (40.5%) that had initially returned to the OR within 180 days. The mean number of additional surgeries after the original trabeculectomy among eyes that returned to the OR at least once was 1.45 ± 0.79 surgeries.

• **LAST FOLLOW-UP:** At the last available follow-up visit, mean IOP was similar between both groups: 12.3 ± 5.8 mm Hg for control eyes and 12.3 ± 5.6 mm Hg for eyes that returned to the OR. The proportions of eyes at or below their target IOP were similar between reoperation and control eyes: 142 eyes (69.3%) and 144 eyes (70.2%), respectively. Eyes that had returned to the OR were using more glaucoma eye drops on average than control eyes: 1.4 ± 1.5 eye drops vs 1.0 ± 1.4 eye drops ($P = .003$). The 2 groups did not differ in change in VA between the trabeculectomy and last follow-up visit. Eyes that eventually returned to the OR lost 0.13 ± 0.53 logMAR units of VA; control eyes lost 0.11 ± 0.48 logMAR units of VA.

TABLE 2. Counts of Postoperative Complications After Trabeculectomy Surgery

Complication	Control	Reoperation Within:					
		Any Time	0-30 Days	31-60 Days	61-90 Days	91-180 Days	181+ Days
Any	83	204	20	10	10	43	121
Bleb leak	14	31	5	1	3	8	14
Blebitis	1	2	0	0	0	0	2
Choroidal effusion	16	29	8	6	2	6	7
Dysesthesia	1	1	0	0	0	0	1
Endophthalmitis	0	1	1	0	0	0	0
Flat AC	4	8	3	1	1	2	1
Elevated IOP	25	129	4	3	5	23	94
Hyphema	6	11	3	1	1	5	1
Hypotony	41	41	8	5	2	11	15
Hypotony maculopathy	2	7	0	1	0	1	5
Suprachoroidal hemorrhage	1	2	0	1	0	0	1
Other	3	10	2	0	0	2	6

AC = anterior chamber; IOP = intraocular pressure.

Eyes experiencing multiple postoperative complications at once are counted once in the "any complications" category but counted multiple times among the further breakdown of specific postoperative complication.

• **FACTORS ASSOCIATED WITH UNPLANNED RETURN TO THE OPERATING ROOM:** In multivariable regression analysis, postoperative choroidal effusion (hazard ratio [HR] = 3.99, 95% confidence interval [CI] 2.35-6.78, $P < .001$), hyphema (HR = 2.96, 95% CI 1.45-6.01, $P = .003$), and elevated IOP refractory to medical therapy (HR = 1.69, 95% CI 1.05-2.73, $P = .03$) were associated with increased risk of unplanned return to OR within the first 180 days (Table 4). An increased maximum IOP prior to trabeculectomy was associated with a small decreased risk of return to OR within 180 days (HR = 0.98, 95% CI 0.97-1.00, $P = .01$). Other variables not significantly associated with return to OR within 180 days were eye laterality, postoperative bleb leak, and postoperative use of a bandage contact lens. The factors with univariate P values ≤ .10 for reoperation within 180 days that were initially entered into the model were eye laterality, maximum IOP prior to surgery, prior cataract surgery, whether cataract extraction was combined with trabeculectomy, postoperative use of a bandage contact lens, postoperative bleb leak, choroidal effusion, flat anterior chamber, hyphema, hypotony, and other complications (vitreous hemorrhage and dislocated IOL as a result of the trabeculectomy). Postoperative endophthalmitis was not included in the model, given that it was a very rare complication.

In multivariable regression analysis for unplanned return to OR at any point postoperatively, bleb leak (HR = 3.25, 95% CI 2.12-4.98, $P < .001$), choroidal effusion (HR = 3.08, 95% CI 1.95-4.88, $P < .001$), elevated IOP refractory to medical treatment (HR = 5.41, 95% CI 3.85-7.60, $P < .001$), suprachoroidal hemorrhage (HR = 8.35, 95% CI 1.97-35.37, $P = .004$), and hypotony maculopathy (HR = 2.43, 95% CI 1.07-5.55, $P = .04$) were all significantly associated with increased risk of reoperation (Table 4). Increased maximum IOP prior to trabeculectomy was again associated with a small decreased risk of return to OR (HR = 0.98, 95% CI 0.97-0.99, $P = .001$). Other variables not significantly associated with return to OR at any time postoperatively were use of preoperative oral glaucoma medications and whether cataract extraction was performed alongside the trabeculectomy. The factors with univariate P values ≤ .10 for reoperation at any point in the postoperative period that were initially entered into the model were type of glaucoma, maximum IOP prior to surgery, use of preoperative oral glaucoma medications, whether cataract extraction was combined with trabeculectomy, postoperative bleb leak, choroidal effusion, flat anterior chamber, elevated IOP refractory to medical therapy, hypotony maculopathy, suprachoroidal hemorrhage, and other complications (vitreous hemorrhage, dislocated IOL as a result of the trabeculectomy, and progression of visual fields despite achieving target pressure), as well as postoperative use of a bandage contact lens. Postoperative endophthalmitis was not included in the model, given that it was a very rare complication.

DISCUSSION

AMONG EYES THAT UNDERWENT TRABECULECTOMY SURgery, 23.3% of eyes returned to the OR for further surgery related either to their glaucoma or to a complication associated with their trabeculectomy, including 9.5% of eyes that returned to the OR within the first 180 postoperative

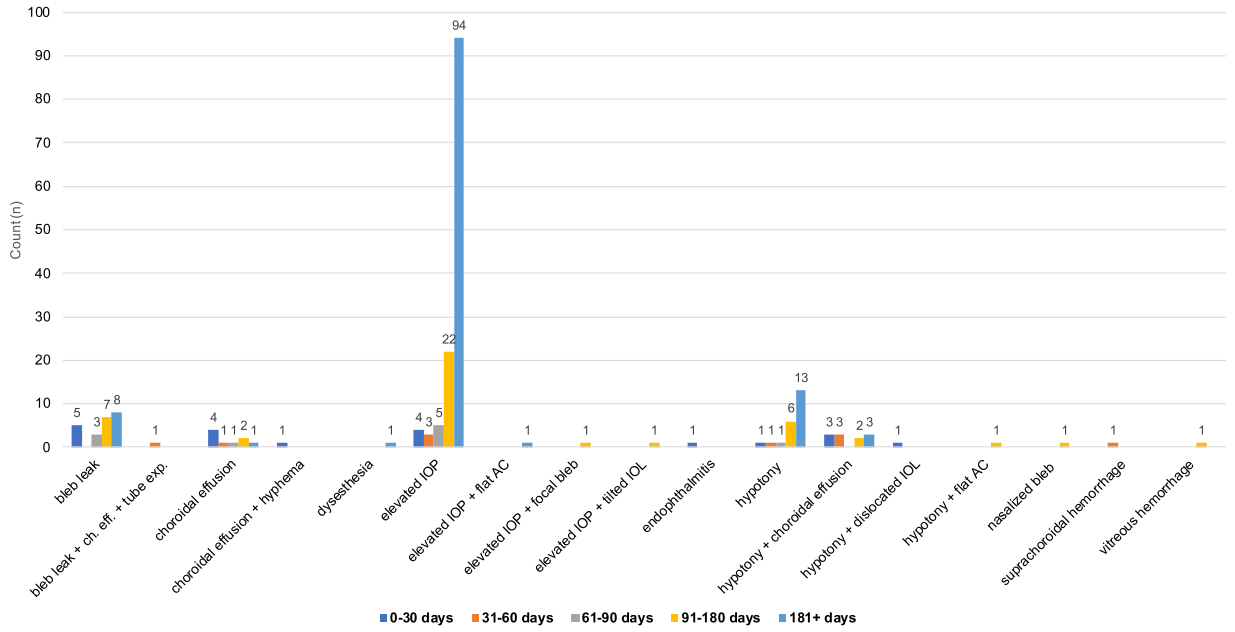

FIGURE 3. Reasons for unplanned return to the operating room (OR) by time after the original surgery. This graph shows the indications for return to OR stratified by the time period in which cases underwent unplanned reoperation. The most common reasons for unplanned return to OR, both within 180 days and at any time postoperatively, were persistently elevated intraocular pressure (IOP) refractory to medical therapy, bleb leak, hypotony, and choroidal effusion. Most cases that returned to the OR owing to postoperative choroidal effusion were early in the postoperative period. With longer time prior to reoperation, there were relatively more cases that underwent reoperation for persistently elevated IOP and hypotony than any other indication for return to OR.

days. When cases that underwent intraoperative bleb needling were excluded, 13.6% of eyes returned to the OR at any time postoperatively, including 6.5% of eyes that returned to the OR within 180 days.

The most common postoperative complications were elevated IOP refractory to medical therapy, choroidal effusion, hypotony, and bleb leak; these were similarly the most commonly reported reasons for return to OR. The most common reoperation surgeries within the first 180 postoperative days were bleb revision, intraoperative bleb needling, and choroidal drainage; the most common reoperation surgeries at any point postoperatively were intraoperative bleb needling, tube shunt implant, and bleb revision. Thirty percent of reoperated eyes required further surgery after the first reoperation, including 40% of eyes that had returned to the OR within the first 180 postoperative days. This has important implications in setting appropriate expectations that patients may have to undergo multiple surgeries. Our group has previously reported the outcomes of intraoperative bleb needling[14] and revision of trabeculectomy surgery.[15–17]

Of note, more than 100 eyes that underwent trabeculectomy at our institution during the study period were excluded for postoperative follow-up less than 180 days. Many of these eyes were referred to our institution for their trabeculectomy and, after the initial postoperative care, likely followed up with their referring eye care professional for long-term care. It seems likely, though not certain, that those patients would have returned to the original surgeon should they have had serious postoperative complications or required further surgery. Thus, the actual postoperative complication and return to OR rates may be lower than reported here, given the likely existence of a selection bias with those managed elsewhere and not needing reoperation being excluded.

A substantial portion of eyes that returned to the OR underwent intraoperative bleb needling. While multiple senior surgeons at our institution perform intraoperative bleb needling, some tend to choose medical therapy to lower IOP postoperatively, while others tend to turn to intraoperative bleb needling relatively earlier in the postoperative period. These nuances are based not solely on surgeon but also on patient preferences.

Our study sample had a high proportion of black patients and patients with a history of prior incisional surgery among subjects who returned to the OR and their matched controls. It remains unclear whether these high proportions of black patients and patients with a history of prior ocular surgery are potential drivers of the unplanned return to OR rate, or if they are simply a reflection of the patient population of our institution, a tertiary care center located in Baltimore, Maryland, USA. Given the similar proportions of both black patients and patients with a history of incisional eye surgery among eyes that returned to the OR and control eyes, coupled with the fact that black race and history of any prior incisional surgery were not

TABLE 3. Types of Unplanned Additional Surgeries Performed After Trabeculectomy

Surgery	All Reoperations	0-30 Days	31-60 Days	61-90 Days	91-180 Days	181+ Days
Total	205	20	10	10	44	121
Trabeculectomy	7 (3.4%)	0	0	0	2	5
Trabeculectomy with cataract extraction	1 (0.5%)	0	0	0	0	1
Tube shunt surgery	27 (13.2%)	0	0	0	3	24
Tube shunt surgery with cataract extraction	3 (1.5%)	0	0	0	2	1
External cytophotocoagulation	4 (2.0%)	0	0	0	0	4
Bleb revision	49 (23.9%)	7	1	4	15	22
Bleb revision with choroidal drainage	11 (5.4%)	3	4	0	2	2
Bleb revision with intraoperative bleb needling	1 (0.5%)	1	0	0	0	0
Bleb revision with cataract extraction	2 (1.0%)	0	0	0	0	2
Choroidal drainage	9 (4.4%)	4	2	1	2	0
Choroidal drainage with vitrectomy	1 (0.5%)	1	0	0	0	0
Bleb needling	74 (36.1%)	2	3	5	14	50
Bleb needling with cataract extraction	10 (4.9%)	0	0	0	3	7
Bleb needling with vitrectomy	1 (0.5%)	0	0	0	0	1
Vitrectomy	2 (1.0%)	1	0	0	0	1
Vitrectomy with cataract extraction	1 (0.5%)	0	0	0	1	0
Ab-interno goniotomy	1 (0.5%)	0	0	0	0	1
IOL repositioning	1 (0.5%)	1	0	0	0	0

IOL = intraocular lens.

significantly associated with a higher risk of return to the OR on univariate analysis, these observations are more likely to be characteristics of the broader patient population at our institution rather than factors driving the return to OR rate.

In a similarly structured study, Hsia and associates reported no reoperations within the first postoperative 90 days among the 27 fornix-based trabeculectomies performed by residents; this is in comparison to the 40 eyes (4.5%) in the present study that returned to the OR within the first 90 postoperative days.[9] This difference could be explained by the fact that attending surgeons have a lower threshold of returning to the OR to address postoperative complications than residents. Of note, intraoperative bleb needling, which counted as an unplanned return to OR in this study, was more commonly performed at our institution than in-office bleb needling and contributed to 10 of the 40 eyes that returned to the OR within the first 90 days.

We were encouraged by the minimal loss in VA for patients from the time of the original trabeculectomy to the last follow-up visit, a mean loss of slightly more than 0.1 logMAR. Given the average follow-up of nearly 3 years, multiple factors unrelated to the trabeculectomy and the patient's glaucoma could have contributed to this mild loss of vision, including the development of age-related retinal pathology as well as progression of cataracts in phakic eyes. Of course, it is important to note that some patients may have experienced a substantial loss of vision while others experienced a substantial gain in vision, especially among eyes that underwent combined trabeculectomy and cataract extraction.

Perhaps unsurprisingly, the factors that were mostly strongly associated with unplanned return to the OR were postsurgical complications that often required surgical intervention, including choroidal effusion, bleb leak, hypotony maculopathy, and elevated IOP refractory to medical treatment. A higher maximum IOP prior to trabeculectomy was associated with slightly decreased risk of return to OR both within the first 180 days and at any time postoperatively. However, given the hazard ratios of almost 1.00 (0.98 per mm Hg in both cases), this finding is likely of little clinical significance. One possible explanation for this finding is a more relaxed target IOP resulting in less need for additional surgery for IOP control.

An important limitation of this retrospective review is our limited ability to determine if certain surgical approaches were more prone to early return to OR. Other limitations of this study are mainly related to its retrospective nature. Intraoperative complications were not consistently recorded in the medical record and so were not included. Because all surgeries were performed at a teaching hospital, some surgeries reviewed here may have been partly performed by assistant surgeons, including other attendings, glaucoma fellows, and residents. Unfortunately, it is impossible to discern from the medical record how much of the surgery, if any, was performed by assistant surgeons. Of course, all surgeries were performed under the direct supervision of the attending surgeon. Finally, although the surgeries reported here were performed by multiple

TABLE 4. Multivariable Regression Analysis of Factors Associated With Unplanned Return to Operating Room Within the First 180 Postoperative Days and at Any Time During the Postoperative Period

Characteristic	Hazard Ratio	Standard Error	$P > \|z\|$ (95% CI)
Unplanned return to OR within first 180 postop days			
Maximum IOP prior to surgery	0.98	0.01	.01 (0.97, 1.00)
Postsurgical complication: choroidal effusion	3.99	1.08	<.001 (2.35, 6.78)
Postsurgical complication: hyphema	2.96	1.07	<.01 (1.45, 6.01)
Postsurgical complication: elevated IOP refractory to medical treatment	1.69	0.41	.03 (1.05, 2.73)
Eye laterality (left)	0.64	0.15	.06 (0.41, 1.02)
Postsurgical treatment: bandage contact lens	2.07	0.92	.10 (0.86, 4.95)
Postsurgical complication: bleb leak	1.74	0.63	.13 (0.86, 3.52)
Unplanned return to OR at any time postop			
Maximum IOP prior to surgery	0.98	0.01	.001 (0.97, 0.99)
Postsurgical complication: bleb leak	3.25	0.71	<.001 (2.12, 4.98)
Postsurgical complication: choroidal effusion	3.08	0.72	<.001 (1.95, 4.88)
Postsurgical complication: elevated IOP refractory to medical treatment	5.41	0.94	<.001 (3.85, 7.60)
Postsurgical complication: hypotony maculopathy	2.43	1.02	.04 (1.07, 5.55)
Postsurgical complication: suprachoroidal hemorrhage	8.35	6.15	.004 (1.97, 35.37)
Use of oral IOP-lowering medications prior to surgery	0.69	0.15	.08 (0.45, 1.04)
Combined CE + trabeculectomy surgery	0.73	0.12	.05 (0.53, 1.00)

CE = cataract extraction; IOP = intraocular pressure; OR = operating room; Postop = postoperative.

experienced senior surgeons, our surgeons represent only a single center. A multicenter prospective study would provide a better confirmation of the unplanned return to OR rate and may avoid some of the limitations of retrospective review.

In the fields of general surgery, pediatric neurosurgery, and vascular surgery, return to the OR within 30 days is used as a metric of quality.[1,2,4] However, for many of these surgeries, the patients are often admitted to the hospital and have much closer follow-up care than after ambulatory surgery in ophthalmology. To our knowledge, there is no validated quality care indicator for return to OR within the field of ophthalmology. Some studies of resident-performed cataract, vitreoretinal, and glaucoma surgeries report return to OR within 30 days,[6] whereas others report return to OR within 90 days.[5,9] In the present study, we chose to report return to OR within 180 postoperative days, but also provide a breakdown of the reasons for return to OR and types of reoperation surgeries within 30 and 90 days for comparison. We chose a longer time period for several reasons. First, any surgery is a substantial event for the patient, and having to undergo multiple surgeries within a short time period may have a particularly notable impact on the patient's psyche and confidence in the surgeon. Second, reporting reoperation within 180 days, at any time postoperatively, and with further stratification allows us to examine both the early reoperations and the trends that may occur relatively later in the postoperative period to provide the best possible estimates of postoperative course, both to patients and to surgeons.

Ultimately, patients who returned to the OR and their matched controls fared similarly in terms of mean IOP and proportion of eyes meeting their target IOP at last follow-up, as well as change in VA from the time of the original trabeculectomy to the last follow-up visit. Patients that underwent reoperation were using more glaucoma medications on average than control eyes, perhaps indicating that eyes that returned to OR may have an increased need for IOP control that was successfully managed with a combination of surgical and medical intervention. Going back to the OR to achieve what only took 1 operation for most patients is a suboptimal result, and monitoring how often this is required is a reasonable way to assess for surgical quality. That said, there was little difference in outcomes between patients that underwent reoperation and matched controls. As stated previously, other contributory factors that may make unplanned return to OR difficult to implement as a standard quality metric include the loss of patients to follow-up, individual surgeon biases in preferring postoperative medical management vs early surgical intervention, and variations in the use of in-office vs surgical approaches to address complications. Perhaps most important, if unplanned return to OR were to be adopted as a quality care metric, surgeons may have an incentive to avoid or delay surgical intervention even in situations in which it may benefit the patient, negatively impacting patient care.

In summary, this large retrospective case-control study of trabeculectomies performed by attending glaucoma surgeons determined that nearly 1 in 10 eyes undergoing

trabeculectomy returned to the OR within the first 180 postoperative days, and over 1 in 5 eyes ultimately returned to the OR within the mean 3 years of postoperative follow-up. The most common reasons for return to the OR were elevated IOP refractory to medical therapy, choroidal effusion, hypotony, and bleb leak. This study provides an examination of the postoperative course following trabeculectomy surgery that leads to reoperation, while also serving to provide a potential benchmark value for the unplanned return to OR rate among attending glaucoma surgeons, both early in the postoperative period and over the course of years of postoperative follow-up.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

NUR CARDAKLI: CONCEPTUALIZATION, METHODOLOGY, Formal analysis, Investigation, Writing - original draft, Visualization. **David S. Friedman:** Conceptualization, Methodology, Validation, Resources, Writing - review & editing, Supervision. **Michael V. Boland:** Methodology, Validation, Resources, Writing - review & editing, Visualization, Supervision, Project administration.

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