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Glaucoma management after vitreoretinal surgeries

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Abstract

Purpose of review—The surgical management of retinal disorders, including scleral buckling procedures, pars plana vitrectomy, and intravitreal injections of gas or silicone oil, can lead to short-term elevations in intraocular pressure (IOP) and ultimately long-term glaucomatous damage if not treated in a timely manner. Glaucoma in these cases is commonly refractory to conventional therapies. This review highlights the treatment strategies for glaucoma in eyes that have previously undergone vitreoretinal surgery.

Recent findings—Although medical therapy is often used initially to control a temporary rise in IOP, laser and surgical therapy may be required to treat sustained IOP elevation and subsequent glaucomatous damage in eyes that have undergone intraocular surgery for retinal disorders. Glaucoma drainage devices are an important treatment modality, particularly when there is high risk of failure with filtering surgery.

Summary—Previous vitreoretinal surgery is a known risk factor for the development of glaucoma. Treatment is usually initiated with medical therapy, however, surgical intervention is frequently required to control IOP and prevent progressive glaucomatous damage in patients with refractory glaucoma.

Keywords

glaucoma; medical and surgical management; vitreoretinal surgery

INTRODUCTION

Intraocular pressure (IOP) elevation and progressive glaucomatous damage are known postoperative complications following vitreoretinal surgeries. Moreover, eyes that require vitreoretinal surgery may already be prone to pressure elevations. Eyes with primary open angle glaucoma (POAG) experience retinal detachments at a higher rate than normal eyes, and the prevalence of POAG in eyes with a retinal detachment is reportedly 4–12 times higher than the general population [1,2]. Although it is not clear why POAG predisposes to retinal detachment, the prevalence of myopia as a common risk factor in both disorders [3] and the use of miotics in glaucoma therapy producing retinal detachments have been suggested as possible explanations [2,4,5]. Additionally, glaucoma may occur as a direct

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Conflicts of interest

There are no conflicts of interest.

consequence of the surgical repair of retinal detachment. Detecting glaucomatous damage may be difficult when the underlying retinal disorder precludes accurate assessments of visual fields or the optic nerve, but early recognition and treatment can reduce ocular morbidity.

GLAUCOMA AFTER SCLERAL BUCKLE

Incidence, risk factors, and pathogenesis

The incidence of angle-closure glaucoma after scleral buckling procedures has been reported to range from 1.4 to 4.4% [2,6–9]. Clinical and experimental data suggest that angle-closure occurs as a result of impaired venous drainage through the vortex veins by the scleral buckle, leading to congestion and swelling of the ciliary body. As the ciliary body swells, it rotates anteriorly and shifts the lens-iris diaphragm forward. These morphological changes have been demonstrated experimentally and can be seen on fundoscopic examination or by ultrasonography and ultrasound biomicroscopy [10,11]. Several factors are associated with the development and extent of angle shallowing, including preexisting narrow angles [6,8], use of an encircling band [7,12], placement of an encircling band anterior to the equator [8], high myopia [6], older age [6], and postoperative ciliochoroidal detachment [8].

Medical therapy

In most cases, angle-closure glaucoma after scleral buckling procedures resolves spontaneously over a period of several days to weeks as the ciliary body congestion and swelling improve. Medical therapy includes cycloplegics to relax the ciliary muscle and shift the lens-iris diaphragm posteriorly, and topical corticosteroids to reduce inflammation and peripheral anterior synechiae formation. Aqueous suppressants are used to reduce IOP. Miotics should be avoided, as they can worsen inflammation and exacerbate angle narrowing via forward movement of the lens-iris diaphragm.

Laser therapy

Laser iridotomy is generally not useful, as pupillary block does not typically play a role in the pathogenesis of angle-closure glaucoma after scleral buckling procedures. Laser iridoplasty, however, may result in reopening of the angle and reduction in IOP [13].

Surgical management

Medical therapy and laser iridoplasty are usually successful in controlling glaucoma after scleral buckling procedures. However, some develop permanent synechial angle-closure glaucoma with uncontrolled IOP requiring surgical intervention. These patients often present a surgical challenge because conjunctival scarring and recession from prior retinal surgery may make standard filtering surgery technically difficult and unlikely to succeed, even with the adjunctive use of antimetabolites. Cyclodestructive procedures have been used, but their irreversible and frequently unpredictable IOP-lowering effects make them a less attractive option in eyes with good visual potential.

Glaucoma drainage devices (GDDs) offer a useful alternative in the management of medically uncontrolled glaucoma after scleral buckling procedures. Sidoti *et al.* [14]

described the implantation of a silicone tube to shunt aqueous humor from the anterior segment to a preexisting episcleral encircling element, thereby using the fibrous capsule around the buckle as a reservoir for aqueous collection. Successful control of IOP with or without medication was achieved in 11 of 13 (85%) of eyes. Another technique described by Smith *et al.* [15] involved inserting a long-valved (plate-less) Krupin-Denver tube into the scleral buckle of seven patients with prior retinal detachment repair. Obstruction of the distal tube by fibrous tissue was a frequent complication following placement of an anterior chamber tube to an encircling band, occurring in five of 13 (38%) patients in Sidoti's series and in three of seven (43%) patients in Smith's series, and surgical revision was necessary in all cases to resolve the obstruction [14,15].

In the case series of modified aqueous drainage implants in eyes with preexisting episcleral bands described by Smith *et al.* [15], a 200-mm² or 250-mm² Baerveldt glaucoma implant (Pharmacia & Upjohn, Kalamazoo, Michigan, USA) was inserted in four eyes underneath the encircling band, with the 'wings' of the implant trimmed off. This was done out of concern that a full-sized implant might be unsafe in the presence of retinal hardware because of a 'crowding' effect. Scott *et al.* [16] described the technique of inserting a full-sized 250-mm² or 350-mm² Baerveldt glaucoma implant (BGI) in 16 eyes with preexisting episcleral bands. The quadrant with the least amount of retinal hardware was selected for implantation, and the implant was placed over or behind the encircling band with an effort to excise the capsule overlying the band. The authors hypothesized that this allowed for contiguous encapsulation of the encircling band and Baerveldt plate, providing a greater surface area and subsequent reduction in IOP. All patients achieved successful IOP control during the follow-up period of 19.1–45.5 months with no reports of implant migration, diplopia, or epithelial downgrowth [16].

GLAUCOMA AFTER PARS PLANA VITRECTOMY

Incidence, risk factors, and pathogenesis

Par plana vitrectomy (PPV) is one of the most frequently performed ophthalmic surgeries [17] and is used in the treatment of many vitreous and retinal diseases. There are few studies that report the incidence of glaucoma after uncomplicated PPV, but estimates range from 15 to 20% [17]. Koren *et al.* [18] observed an overall 11.6% incidence of late-onset open angle glaucoma among 285 vitrectomized eyes, although rates were higher in eyes that had undergone cataract extraction (15.0%) versus phakic eyes (1.4%). These rates are similar to those reported by Luk *et al.* [19], who reported an overall incidence of 7.9% (eight eyes) with a higher rate in pseudophakic (13%) compared with phakic (2%) eyes. More recently, a retrospective study by Wu *et al.* [20] examined 198 patients who underwent PPV for idiopathic epiretinal membrane. The incidence of elevated IOP was 19.2% in vitrectomized eyes, compared with 4.5% in the unoperated fellow eye. As a result of these findings, PPV has been suggested as a risk factor for the development of secondary open-angle glaucoma [17–19,20]. Other studies, however, have not found a link between open-angle glaucoma or IOP elevation and uncomplicated PPV [21,22].

The exact pathogenesis of late-onset glaucoma after vitrectomy is unknown. Chang postulated that the main reason for the late development of glaucoma relates to the diffusion

of oxygen from the vitreous cavity to the anterior chamber [17]. This could cause alterations in the trabecular meshwork by inducing oxidative stress, ultimately leading to reduced aqueous outflow, and a resultant increase in IOP [23–26].

Medical therapy

If IOP elevation develops after PPV, aqueous suppressants are generally used as treatment.

Surgical management

Depending upon the surgical indication for PPV, filtering and GDD surgery may be indicated if medical therapy does not adequately control IOP. Trabeculectomy with mitomycin C is a widely performed glaucoma surgery, but success depends on bleb survival, and conjunctival scarring after ocular surgery is a major risk factor for surgical failure [27]. In a recent study by Inoue *et al.* [28], higher preoperative IOP and neovascular glaucoma were identified as prognostic factors for surgical failure of trabeculectomy with mitomycin C in vitrectomized eyes. This study, however, was limited by the relatively slanted patient profile (67.2% eyes with neovascular glaucoma), and the results may thus reflect poor prognostic factors in neovascular glaucoma rather than previous vitrectomy. Additionally, nonproliferative vitreoretinal diseases requiring vitrectomy, such as retinal detachment or macular disease, were not included because of the small sample size.

The decision to use a GDD may be especially appropriate for eyes with complicated ocular disorders or previously failed surgery. Rososinski *et al.* [29] evaluated the efficacy of Baerveldt glaucoma implantation into the pars plana compared to the anterior chamber. The indications for Baerveldt implantation (34 eyes) were glaucoma or grossly elevated IOP uncontrolled on maximal medical therapy, history of previously failed trabeculectomy, or when trabeculectomy carried a particularly high risk of failure. Pars plana tubes (29 eyes) were placed for corneal edema or corneal graft, and PPV was performed either prior to or concurrent with tube placement. After 2 years, the mean average decrease in IOP was 57% in the pars plana and 60% in the anterior chamber groups. The major surgical complications included one retinal hemorrhage, one retinal detachment, and one case requiring tube replacement; all occurred in the anterior chamber group. No complication related to PPV or corneal decompensation was noted. Although the study population was heterogeneous with respect to ocular disorder, it did suggest that pars plana tube placement was not associated with an increased risk of complications compared with conventional anterior chamber placement in this population.

GLAUCOMA AFTER INTRAVITREAL GAS INJECTION

Incidence, risk factors, and pathogenesis

Expansile gases, such as sulfur hexafluoride (SF₆) and perfluoropropane (C₃F₈), have been widely used in pneumatic retinopexy, as well as vitrectomy and scleral buckling procedures. Compared with air, intraocular gases have the advantage of providing a prolonged tamponade of retinal breaks to promote chorioretinal adhesions [30]. When injected into the vitreous cavity, the volume of SF₆ doubles within 24–48h [30–32], whereas C₃F₈ can expand to four times its original volume within 48–72 h [30,33,34].

The incidence of IOP elevation after SF₆ injection has been reported to range from 6.1 to 67% [35,36], and a significantly higher incidence is observed when 100% SF₆ is used, with an alarming rate of 11 of 101 (11%) of patients developing a central retinal artery occlusion in one study [35]. Postoperative IOP elevation has been described in 18–59% of patients after the use of perfluorocarbon gas [36,37]. Titrating the concentration and volume of these intraocular gases is critical to prevent the development of glaucoma postoperatively. The Silicone Study Group found that only three of 49 (6.1%) patients had an IOP greater than 30 mmHg using 20% SF₆ [36], and 12 of 67 (18%) patients had an IOP of more than 30 mmHg, when C₃F₈ at a concentration of 14% was used [38].

Injection of expansile gases into the vitreous cavity can produce an anterior displacement of the lens-iris diaphragm, even with the patient positioned face down. Secondary angle-closure glaucoma may result with or without pupillary block. The greatest pressure elevation generally occurs during the period of maximum gas expansion, when the rate of liquid vitreous and aqueous egress cannot keep pace with the increasing gas volume. Patients should always be advised to maintain a face down position to avoid forward displacement of the lens-iris diaphragm secondary to anterior pressure from the gas bubble. Changes in atmospheric pressure can produce an expansion of the intraocular gas volume and result in an acute IOP increase [39–42]. Therefore, patients with intravitreal gas should be discouraged from traveling to high altitudes. IOP measurements should be performed with Goldmann applanation tonometry or Perkins tonometry, since pneumatic and Schiøtz indentation tonometry may underestimate IOP in gas-filled eyes [43–45].

Medical therapy

Mild IOP elevations may occur during the early postoperative period and usually responds to aqueous suppressants. If IOP remains uncontrolled, particularly if it is elevated to a level that may compromise ocular perfusion, aspiration of a portion of the intraocular gas may be performed to normalize the pressure.

Laser therapy

If pupillary block is thought to be involved in the mechanism of glaucoma, a laser iridotomy is indicated.

Surgical management

The conjunctiva may be in poor condition with significant scarring and/or recession from prior vitrectomy. GDDs provide an important surgical option, when there is a high risk of failure with standard filtering surgery. Insertion of the silicone tube of a GDD through a pars plana scleral fistula after complete vitrectomy has been described [46–55]. This technique is particularly valuable in patients with extensive peripheral anterior synechiae and inadequate space between the corneal endothelium and iris to allow optimal positioning of the tube within the anterior chamber. IOP control is comparable to limbal tube insertion, and complications such as tube-corneal touch are avoided [55].

The incidence of posterior segment complications appears to be higher with pars plana tube insertion compared with limbal tube placement, including serous choroidal detachment,

suprachoroidal hemorrhage, retinal detachment, and vitreous hemorrhage [55]. Additionally, immediate postoperative hypotony may result if the tube is inserted through a vitrectomy sclerostomy [53]. Creation of a new sclerostomy through the pars plana using a 23-gauge needle decreases leakage around the tube and reduces hypotony [53].

GLAUCOMA AFTER SILICONE OIL INJECTION

Incidence, risk factors, and pathogenesis

Intravitreal silicone oil is used as an adjunct in the surgical repair of complex retinal detachments, especially in eyes with proliferative vitreoretinopathy. Like air and fluorinated hydrogen gases, silicone oil is lighter than aqueous or vitreous allowing it to act as a retinal tamponade. IOP increases can occur postoperatively at any time, ranging from mild and transient to severe and permanent. The true incidence of glaucoma after silicone oil injection is difficult to ascertain. The rates of elevated IOP or glaucoma range from 2.2% at 6 months to 56% at 8 months [56–75], with more recent studies reporting lower rates, likely as a result of improvements in surgical techniques and materials. Higher viscosity silicone oil (5000 centistokes) has been noted to result in fewer emulsified silicone droplets in the anterior chamber and a lower risk of glaucoma [76].

Risk factors for elevated IOP after silicone oil injection include preexisting glaucoma [58,59,65], diabetes mellitus [58,59,77], and aphakia [58,78]. Care must be taken by the vitreoretinal surgeon to avoid overfilling the eye with silicone oil, as this may produce secondary glaucoma. Mechanisms of glaucoma with silicone oil use include pupillary block [57–60,71–73,79–83], inflammation [58–61,73,79–81], synechial angle closure [57,59,61,80], rubeosis iridis [58,60–62,71], migration of emulsified and nonemulsified silicone oil into the anterior chamber [57–60,62–66,80,83–86], and idiopathic open-angle glaucoma [57,60,80].

Because silicone oil is buoyant within the eye, a prophylactic inferior iridectomy should be performed in pseudophakic and aphakic eyes to prevent pupillary block. Although pupillary block angle-closure glaucoma after silicone oil injection has been well described in aphakic eyes, it occurs infrequently in phakic and pseudophakic eyes because the zonule-lens barrier prevents anterior migration of the silicone oil. However, the presence of zonular weakness may predispose these eyes to silicone oil migration and the development of pupillary block [79,81,83].

Medical therapy

Should IOP elevation develop after silicone oil injection, medical therapy is initiated with cycloplegics and corticosteroids to decrease inflammation. Aqueous suppressants are used to reduce IOP. In a study by Al-Jazzaf *et al.* [75], 78% of patients (40 of 51) with glaucoma after PPV and silicone oil injection were treated successfully with medications alone. The IOP was controlled in most eyes with topical beta-blockers and prostaglandin analogues.

Laser therapy

Although a prophylactic inferior iridectomy at the time of surgery lessens the risk of angle-closure glaucoma after silicone oil injection, the iridectomy may close in an estimated 11% to 32% of cases [58,72,73,87,88]. Usually, a neodymium-doped yttrium aluminum garnet laser can be used to reopen an iridectomy closed by fibrin, blood, or a retroiridal membrane.

In a recent pilot study by Alkin *et al.* [89], selective laser trabeculoplasty (SLT) was performed in 11 patients with glaucoma secondary to emulsified silicone oil and resulted in a mean IOP decrease from 25 to 16.2 mmHg at 6 months. Although this study was limited by a short duration of follow-up, a small cohort, and the lack of a control group, SLT may play a role in managing open angle glaucoma associated with silicone oil.

Cyclodestructive procedures

Transscleral cyclophotocoagulation has been used to treat glaucoma secondary to silicone oil. Successful IOP control has been reported in 66–82% of patients at 1 year [90–92]. However, Sivagnanavel *et al.* [93] reported a 56% treatment failure rate despite the use of higher mean laser energies and a higher retreatment rate. Multiple treatments may ultimately be required to achieve adequate pressure control. Unfortunately, visual loss is not uncommon after cyclophotocoagulation. For this reason, cyclodestructive procedures are a less desirable treatment option in patients with good visual potential.

Surgical management

Although most patients who develop secondary glaucoma can be managed medically, some require surgical intervention. Silicone oil removal with or without concurrent glaucoma surgery has been performed to lower IOP, but oil removal carries some risk of retinal detachment. The benefit of silicone oil removal in patients with elevated IOP remains controversial. Jonas *et al.* [60] found that 93.4% (185 of 198) of patients with a secondary increase in IOP after silicone oil endotamponade had normalization of IOP after oil removal, and concluded that oil removal was the preferred glaucoma surgery to reduce pressure in these patients. However, Flaxel *et al.* [70] reported that elevated IOP persisted in all eyes (62 eyes) after silicone oil removal. Furthermore, silicone oil removal itself can cause IOP elevation by splitting oil droplets into smaller bubbles, which are more likely to obstruct the trabecular meshwork [94].

Budenz *et al.* [80] retrospectively reviewed the outcomes of surgical intervention for secondary glaucoma in 43 eyes that had PPV with silicone oil injection. Success was achieved in 69, 60, 56, and 48% of eyes at 6, 12, 24, and 36 months, respectively. Surgical treatment consisted of silicone oil removal alone in 32 of 43 (74%) patients, and 11 of 12 failures in this group were because of uncontrolled IOP. Glaucoma surgery was performed with silicone oil removal in eight of 43 (19%) patients, and three of four failures occurred because of hypotony. Only three of 43 (7%) were treated with glaucoma surgery alone, and one failed because of hypotony. It was concluded that patients who undergo silicone oil removal alone to control IOP are more likely to have persistent IOP elevation and possibly require reoperation for glaucoma, whereas patients who undergo concurrent silicone oil removal and glaucoma surgery are more likely to develop hypotony.

The surgical management of patients with silicone oil glaucoma should be modified according to the individual clinical presentation. Patients with complete synechial angle closure would not be expected to have normalization of IOP with silicone oil removal alone. Glaucoma surgery would seem to be indicated in such cases, and the decision as to whether to concomitantly remove the silicone oil depends on an assessment of the relative risk of redetachment with oil removal. When emulsified or nonemulsified oil blocks the trabecular meshwork directly, it is reasonable to proceed with silicone oil removal alone if the retina is completely attached with closure of all tears and release of all areas of traction. Patients should be warned, however, of the possible need for subsequent glaucoma surgery. GDDs offer a good surgical option in cases of refractory glaucoma associated with silicone oil, but there is also a possibility of oil escape via the drainage tube [95]. If silicone oil remains in the eye, the GDD should be positioned in one of the inferior quadrants. With the tube located inferiorly, any migration of oil into the anterior chamber is less likely to drain through the tube into the subconjunctival space, where it can incite an inflammatory reaction [96].

CONCLUSION

Vitreoretinal surgery is a known risk factor for IOP elevation and progressive glaucomatous damage, and therefore, clinicians must closely monitor these patients postoperatively. Depending on the procedure performed, patients may respond to medical therapy, but laser or glaucoma surgery may be required in some cases. GDDs are an important treatment modality for these patients, although the surgical technique may need to be modified. Prompt diagnosis and treatment of elevated IOP after retinal surgery can prevent further ocular damage and improve patient outcomes.

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KEY POINTS

- Vitreoretinal surgery is a known risk factor for IOP elevation and progressive glaucomatous damage.
- Although medical therapy is usually first-line treatment, some patients require laser or surgical therapy to manage IOP elevation.
- GDDs provide an important surgical option when there is a high risk of failure with standard filtering surgery.
- These cases may be especially challenging to diagnose and treat if IOP measurements are difficult to obtain or assessments of the optic nerve and visual field are not possible because of the underlying retinal disorder.