Review Article

Elevated Intraocular Pressure after Pars Plana Vitrectomy: A Review

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Abstract

Intraocular pressure (IOP) elevation is a well-known complication after pars plana vitrectomy with or without tamponade. The mechanism of increase in IOP can be open angle, closed angle or both. Oxidative stress is hypothesized to have a significant role in the pathogenesis of post vitrectomy elevated IOP and the presence of the lens probably has a protective role. The use of silicone oil and intraocular gases as tamponade is related to higher risk of post-operative elevated IOP. Anti-inflammatory agents, mydriatics, anti-glaucoma medications especially aqueous suppressants, glaucoma surgery and laser procedures might be used for controlling post vitrectomy elevated IOP. Glaucoma shunt implantation and cyclodestructive procedures are the most important surgeries performed for treatment of uncontrolled intraocular pressure after vitrectomy.

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Introduction

Elevated intraocular pressure can occur after different types of vitreoretinal surgeries such as pars plana vitrectomy (PPV) [1,2]. The pathophysiology can be open-angle, closed-angle, or a mix mechanism [1, 3-6].

The vitreous is a very critical part in ocular homeostasis [7]. The vitreous gel has a higher concentration of ascorbate and consumes oxygen at a faster rate in comparison to liquefied vitreous [7]. It has been reported that 37 % to 95 % of patients undergo cataract surgery within 2 years after PPV [8-14]. Increased oxidative stress is a contributing factor to the pathogenesis of age-related ocular problems such as glaucoma [15,16]. The results of several studies have suggested that vitrectomy increases the Oxygen tension within the eye. The oxygen pressure is highly elevated in the vitreous cavity especially posterior to the lens in vitrectomized eyes because of the lack of vitreous as a barrier for the oxygen [17-19]. This elevated oxygen level leads to increased oxidative stress on the trabecular meshwork especially in aphakia and pseudophakia conditions, interfering with the conventional outflow facility. The final result of this phenomenon is the IOP elevation [20].

Incidence

The reported incidence of high intraocular pressure after vitrectomy is 20 % to 60 % [3,6,20-24]. The first day IOP elevation has been reported in 29.5 % of patients after vitrectomy but only in 0.5 % of patients after trans conjunctival sutureless procedures 25,26. In a study by Fang et al., [27] 19.5 % of patients had elevated IOP after vitrectomy at the 1-year follow-up, and in about 68 % of cases the elevated IOP occurred within the first month after vitrectomy [27].

Risk factors

Several studies have suggested different risk factors for elevated intraocular pressure following pars plana vitrectomy including combined scleral buckle and PPV, endophotocoagulation during surgery, vitrectomy combined with lens extraction , fibrin formation after surgery, proliferative vitreoretinopathy as the underlying cause of surgery, family history of open angle glaucoma, pre existing glaucoma, diabetes mellitus, rubeosis iridis, silicone oil in the anterior chamber, high IOP on the first post operative day, pre-operative vitreous hemorrhage, repeated vitrectomy and prominent surgical inflammation [3, 28-31]. High preoperative IOP, neovascular glaucoma, silicone oil emulsification and diabetes mellitus are risk factors for poor prognosis of glaucoma management post PPV [29]. Also post PPV elevated IOP occurs sooner in aphakic or pseudophakic eyes compared to phakic eyes [32]. An increase in IOP postoperatively is more frequent in males and patients undergoing surgery for retinal detachment and proliferative diabetic retinopathy [25, 33, 34].

Tamponade is a significant risk factor for elevated IOP. A study performed by Framme et al., [35] among eight hundred and fifty one patients comparing air, versus sulfur hexafluoride (SF6), versus silicone oil usage as tamponade showed that gas tamponade was associated with a prolonged elevated IOP, however the most significant risk factor for elevated IOP was the use of silicone oil. The cumulative rates of elevated IOP when using air, balanced salt solution, SF6, perfluoropropane (C3F8), and silicone oil as the tamponade have been reported to be 0 %, 10.8 %, 5.9 %, 19.8 %, and

28.4 %, respectively 27.

Pathophysiology

Secondary open-angle high intraocular pressure is the most common mechanism of post-vitrectomy elevated IOP, in comparison with angle closure mechanism that is responsible for only 20 % of cases [3]. Open-angle glaucoma is caused by several factors including gas expansion without angle closure, inflammation, silicone oil without pupillary block, corticosteroid response, and blood-mediated mechanisms [4]. Angle closure mechanisms include pupillary block mediated by intraocular gas, silicone oil, fibrin or intraocular lens, as well as ciliary body edema and iridocorneal apposition [3]. Acute post operative increase in IOP can be caused by replacement of anterior chamber with intra ocular tamponade, use of intra operative endo-photocoagulation or post operative fibrinous inflammatory reaction and late onset glaucoma can be due to topical steroid usage or pre existing causes such as angle recession or neovascular glaucoma [28].

In normal vitreous, there is a gradient of oxygen tension with the highest level being near the retinal surface and decreasing gradually toward the lens [19]. In vitrectomized eyes, oxygen tension near the lens rises to 2-3 times the preoperative levels [19]. In phakic eyes, high oxygen level behind the lens causes cataract, but in pseudophakic and aphakic eyes, excess oxygen tension causes some changes in the extracellular matrix in trabecular meshwork and resultants in increased IOP [20].

Prevention

In aphakic and pseudophakic eyes, it is preferable to perform at least 150-200 microns of iridectomy during surgery to prevent pupillary block, but it can close in about 32 % of cases; which can be successfully resolved using Nd YAG laser [36, 37]. It is important to know extra-large peripheral iridectomy can cause forward migration of the oil [38]. The usage of transconjunctival (TSV) sutureless small gauge ports has a positive impact on postoperative IOP. The evidence to support immediate use of prophylactic oral or topical anti glaucoma medication is currently deficient [30].

Management

Most patients with post vitrectomy elevated IOP without a previous glaucomatous optic neuropathy can tolerate a transient postoperative IOP elevation and the majority of patients are managed medically [1,9].

Surgical interventions if needed include anterior chamber paracentesis, laser iridotomy, laser iridoplasty, laser membranectomy, and intracameral injection of recombinant tissue plasminogen activator in patients who have a fibrin clot in anterior chamber [39,40]. Because of conjunctival scarring, trabeculectomy does not have favorable results. Inoue et al., [31] reported that the success rate of trabeculectomy with adjunctive mitomycin-C is 55.1 % at 1 year, decreasing to 43.1 % at 3 years. Glaucoma drainage devices and trans-scleral cyclophotocoagulation can be considered in eyes with extensive conjunctival scarring. Several studies have reported high success rates with Molteno and Baerveldt glaucoma implants [41,42] .

Elevated intraocular pressure following intravitreal gas usage

Intraocular gases like SF6 and

perfluoropropane (C3F8) are frequently used as retinal tamponade. These gases are expansile with long resorption time, which results in more time for choroidal-retinal adhesions. However, these properties may also result in IOP elevation [43]. The incidence of IOP rise following intravitreal SF6 and C3F8 injection has been estimated to range from 6.1 % to 67 %, and 18 % to 59 %, respectively [44- 47]. The higher incidence associated with C3F8 is thought to be related to its greater maximal volume expansion and longer intraocular longevity [2].

Changes in the atmospheric pressure can cause further expansion of these gases, and an acute elevation in IOP [48]. Thus the patients are advised against a flight travel during the presence of intravitreal gas in the early postoperative period [48]. Johnstone et al., [49] showed that trabecular meshwork collapse at low IOP, for example due to a decrease in altitude, which increases aqueous production in the eye. Upon altitude ascent, the gas bubble expands to the same size as when it was at hospital discharge, but with a larger volume of aqueous, which results in IOP rise [49]. Furthermore, self-compensatory mechanisms which include choroidal compression, sclera expansion, and increased aqueous outflow need time to fully accommodate [48,50]. Therefore, a rapid rate of ascent can overcome the compensatory mechanisms and induce high IOP and pain.

Risk factors

There are several variables associated with IOP elevation after vitrectomy including higher concentrations of the expansile gas, use of C3F8, patient age, intraoperative use of photocoagulation, concurrent lensectomy or placement of circumferential scleral buckle, and fibrinous anterior chamber exudates [1].

Pathophysiology

Secondary glaucoma following intravitreal gas injection may be due to both open-angle and closed-angle mechanisms. Open-angle mechanisms occur when expansion of the intraocular gas bubble exceeds the rate of outflow of intraocular fluid, or when the intraocular gas volume causes posterior chamber pressure build-up without angle-closure [1,3]. Secondary closed-angle glaucoma results from anterior displacement of the lens-iris diaphragm causing iridocorneal apposition as a result of either pupillary block or non-pupillary block mechanisms [1,3].

Prevention

Patient education is an important part of management of pars plana vitrectomy with intravitreal gas injection to avoid IOP elevation. The recommendation for maintaining a prone position must be given to prevent anterior displacement of the lens-iris diaphragm and angle closure. Advice for avoiding flight travel is essential for preventing gas expansion and IOP elevation, but if a moderate altitude ascent is necessary during the post-operative period, the physician should prescribe prophylactic medication for IOP control, recommend gradual ascent and consider modifying the amount of gas placed, according to the probable traveling [51]. Patients should avoid rapid altitude changes [51].

Management

Elevations in IOP frequently respond to systemic or topical aqueous suppressants or oral carbonic anhydrase inhibitors within 24 to 72 hours [28]. When increase in IOP causes a compromise in ocular perfusion, aspiration of a portion of intravitreal gas may be necessary

and when there is pupillary block due to closed PI, laser iridotomy may be helpful [28].

Elevated intraocular pressure following use of silicone oil

A known complication of silicone oil (SO) use has been reported to be the development of secondary elevated intraocular pressure [4]. The incidence varies widely among studies, ranging from 2.2 % to 56 % [29, 52]. In a study by Matić et al., [53] the mean IOP values in patients who received silicone oil during surgery were significantly higher compared to the control group a month after vitrectomy. In another study the onset of IOP elevation was early (≤ 1 week) in 61.5 % of the eyes, intermediate (1–6 weeks) in 28.7 %, and late (> 6 weeks) in 9.8 % of the eyes [54].

Silicon oil can induce early onset post operative elevated IOP with several mechanisms including overfill with total anterior chamber fill resulting in trabecular meshwork obstruction, pupillary block with silicone oil, denaturation of silicone oil into micro droplets with sweeping into the trabecular meshwork and inflammation 55-66. Possible mechanisms for intermediate- late-onset elevated IOP after SO injection include infiltration of the trabecular meshwork by silicone bubbles [67,68], chronic inflammation 60, and synechial angle closure [55, 61, 63], rubeosis iridis [29,55,59, 65, 69], migration of emulsified and non emulsified silicone oil into the anterior chamber [29,42, 55, 58, 61, 63, 65, 66, 69-71], and idiopathic open-angle glaucoma [55, 63, 65]. There may also be a direct toxic effect of silicone oil on the optic nerve.

Also emulsification of the silicone oil in the micro globules has been associated with a rise in the IOP [60, 69,73-75]. Emulsified silicone oil droplets, which migrate to the trabecular meshwork, may cause inflammation of the trabecular meshwork, decreased outflow facility and secondary open-angle glaucoma [4].

Prophylaxis

Prophylactic peripheral inferior iridectomy or superior iridectomy is performed when heavy silicone oil is used as tamponade and is helpful for avoiding pupillary block [42]. Many complications may be prevented or their progression arrested when the silicone oil is removed a few weeks or months after surgery [55,76]. The intensive use of topical steroid to prevent the inflammatory reactions is important because the postoperative inflammation can lead to occlusion of the iridectomies [76-79].

Management

Treatment of elevated intraocular pressure secondary to vitrectomy and silicon oil injection depends basically on the mechanism of IOP elevation. At first cycloplegic and corticosteroids drugs should be started to decrease inflammation 4. Then anti glaucoma medications especially aqueous production inhibitors are used for controlling the intraocular pressure [29]. Glaucoma drainage devices are acceptable surgical options in cases that are not controlled with medical therapy [42]. Because of the possibility of tube obstruction with silicone some surgeons insert the device plate at the inferotemporal quadrant [80].

Discussion

Elevated IOP post 20G vitrectomy is well documented [3,25,80,81]. Emulsified SO causes macrophage mediated trabeculitis in the conventional outflow pathway and also can cause some changes in the collagen network

of this area which is why it is better to perform silicon oil removal as soon as possible before permanent structural changes [82].

According to Fang et al., [27] study the elevated IOP due to silicon oil is more permanent compared to gas tamponade [27]. A simple removal of silicone oil may not to be enough for controlling the IOP considering the probability of organic changes of trabecular meshwork due to contact with emulsified silicon oil and it seems preferable to remove the oil as soon as possible [28].

Conclusion

It is important to control intraocular pressure post vitrectomy due to possible irreversible effects on the optic nerve. The use of silicone oil and intraocular gases as tamponade is related to higher risk of post-operative elevated IOP and causes longer-term IOP elevation. Drugs, surgical procedures like shunt implantation and cyclodestructive procedures as well as laser procedures might be used for controlling post vitrectomy elevated IOP.

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Footnotes and Financial Disclosures

Conflict of interest:

The authors have no conflict of interest with the subject matter of the present study.