

# Clinical Analysis of Early and Mid-late Elevated Intraocular Pressure after Silicone Oil Injection

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## Abstract

**Purpose:** To discuss the incidence and clinical features of early and mid-late elevated intraocular pressure after pars plana vitrectomy and silicone oil injection, and to evaluate the clinical management of eyes with secondary glaucoma.

**Methods:** This was an observational consecutive case series of 691 eyes in 679 patients who were treated with pars plana vitrectomy and silicone injection. The diagnostic criteria of early elevated intraocular pressure after silicone oil injection was  $\geq 21$  mmHg two weeks after surgery, while mid-late elevated intraocular pressure was  $\geq 21$  mmHg after two weeks. The incidence and clinical management of elevated intraocular pressure were analyzed.

**Results:** In total, 211 of 691 eyes (30.54%) developed elevated intraocular pressure two weeks after pars plana vitrectomy and silicone injection. Of the 211 eyes, 101 eyes (47.87%) had ocular inflammation, 64 eyes (30.33%) showed hyphema, 35 eyes (16.59%) had silicone oil in the anterior chamber, 6 eyes (2.84%) had excess silicone oil injected, and 5 eyes (2.37%) had rubeosis irides. Eighty three of 691 eyes (12.01%) developed elevated intraocular pressure after two weeks. Of these 83 eyes, 25 eyes (30.12%) had rubeosis irides, 16 eyes (19.27%) had issues related to topic steroid therapy, 13 eyes (15.66%) had a papillary block, silicone oil in the anterior chamber, 10 eyes (12.05%) had a silicone emulsion, 10 eyes (12.05%) had peripheral anterior synchia, and 9 eyes (10.84%) had silicone oil in the anterior chamber. All eyes with elevated intraocular pressure were treated with antiglaucoma medications and surgeries.

**Conclusion:** The reasons for elevated intraocular pressure differed between early and mid-late after pars plana vitrectomy and silicone oil injection. The elevated intraocular pressure can be controlled effectively by immediate diagnosis and proper treatment with medicine and operation. (*Eye Science* 2014;

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**Keywords:** vitrectomy; silicone oil injection; elevated intraocular pressure

In 1962, Cibis et al. first utilized silicone oil as a vitreous substitute in retinal detachment surgery. Since then, vitrectomy combined with silicone oil filling has significantly improved the success rate of this surgery. At present, silicone oil has been used in treatment of fundus diseases, such as severe proliferative vitreoretinopathy, giant retinal tears, proliferative diabetic retinopathy, and serious traumatic retinal detachment. The widespread application of silicone oil and silicone oil filling has also led to a variety of clinical complications, such as secondary glaucoma, complicated cataract, corneal degeneration, retinal toxicity, and especially secondary ocular hypertension. This procedure is one of the primary causes of varying decreases in visual acuity following vitrectomy; the incidence of this complication greatly varies from 20% to 56%<sup>1,2</sup>.

Few studies have taken into account the timing of ocular hypertension occurring after silicone oil filling. Many investigations focused on analyzing the causes of early-stage rather than middle- and late-stage intraocular pressure elevation. We found that the causes and therapies of early-, middle-, and late-stage ocular hypertension after silicone oil filling greatly varied. Consequently, the subjects presenting with ocular hypertension within 2 weeks after vitrectomy combined with silicone oil filling were regarded as early-stage ocular hypertension and those showing ocular hypertension at 2 weeks were deemed as middle- and late-stage ocular hypertension. The causes, treatment strategies, reasonable

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prevention, and therapy of these complications were evaluated in this clinical trial.

## Materials and methods

### General data

A total of 679 patients (691 eyes) undergoing combined therapy of vitrectomy and silicone oil filling between 2010 and 2012 in our hospital were retrospectively analyzed, including 397 males (405 eyes) and 282 females (286 eyes), aged from 19 to 81 years ( $52.8 \pm 9.6$  years on average). In total, 332 eyes were affected by primary retinal detachment, 116 by diabetic retinopathy, 115 by vitreous hemorrhage, 75 by traumatic retinal detachment, and 53 had other diseases.

### Surgical approach

Standard 20 G pars plana vitrectomy was performed in combination with silicone oil filling. Lens surgery, intraocular photocoagulation, and IOL implantation could be additionally performed based upon each patient's severity of disease. Conventional topical corticosteroid eye drops were administered postoperatively in the operated eyes for 2–3 weeks.

### Intraocular pressure measurement

A Topcon non-contact tonometer was utilized to measure intraocular pressure before surgery, during the 7-day hospitalization, and at postoperative days 7, 14, 21, and 30. Intraocular pressure was measured during the outpatient visit each month. The follow up was from 6 to 14 months ( $7.8 \pm 0.8$  months on average). The subjects presenting with IOP  $\geq 21$  mmHg within postoperative 2 weeks were diagnosed with early-stage ocular hypertension and those with IOP  $\geq 21$  mmHg after 2 weeks after surgery were defined as middle- and late-stage ocular hypertension. Different medication therapies were adopted according to IOP levels. The individuals with 21–30 mmHg IOP received topical application of a  $\beta$  receptor blocker and those with IOP  $>30$  mmHg were additionally treated with an  $\alpha$  receptor agonist and carbonic anhydrase inhibitor. If clinical efficacy was poor, a prostaglandin depressant and hyperosmotic agents were supplemented. The subjects with IOP  $>40$  mmHg underwent anterior chamber paracentesis. According to the severity of diseases, anterior chamber irrigation, ciliary cryotherapy, laser cyclophoto

coagulation, Ahmed glaucoma valve implantation, and removal of silicone oil were chosen to control IOP.

## Results

### Early-stage ocular hypertension after vitrectomy combined with silicone oil filling

An IOP  $\geq 21$  mmHg was observed in 211 eyes (30.54%) within the postoperative 2 weeks, including 84 eyes (39.81%) with diabetic retinopathy, 62 (29.38%) with retinal detachment (42 retinal detachment associated with choroidal detachment), and 23 (10.90%) with trauma. Among the 211 eyes, 137 (64.32%) additionally received lens surgery intraoperatively. The main causes of IOP elevation included inflammatory ocular hypertension (101/47.87%), hyphema (64/30.33%), entry of silicone oil into the anterior chamber (35/16.59%), excessive silicone oil filling (6/2.84%), and iris rubeosis (5/2.37%).

Among the 211 eyes, 135 (63.98%) were treated with 1 to 3 types of IOP-reducing agents to maintain IOP within normal range, 34 (16.11%) underwent anterior chamber paracentesis to lower the IOP, 23 underwent anterior chamber irrigation, 10 (4.74%) underwent anterior chamber valve implantation, 6 (2.84%) underwent removal of silicone oil in the vitreous chamber, and 3 (1.42%) underwent ciliary cryotherapy.

### Middle- and late-stage ocular hypertension after vitrectomy combined with silicone oil filling

Eighty-three eyes (12.01%) presented with IOP  $\geq 21$  mmHg at 2 weeks after combined therapy of vitrectomy and silicone oil filling; 29 (34.94%) of these 83 eyes had diabetic retinopathy and 9 (10.84%) had undergone trauma. Fifty-one eyes additionally underwent lens surgery. Major causes of elevated IOP included neovascular glaucoma (25/30.12%), glucocorticoid glaucoma (16/19.27%), seclusion of the pupil (13/15.66%), silicone oil emulsification (10/12.05%), anterior synechia (10/12.05%), and entry of silicone oil into the anterior chamber (9/10.84%). (Table 1).

Of the 83 eyes, 44 (53.01%) were administered with 1 to 3 types of IOP-reducing agents to maintain IOP within a normal range, 12 (14.46%) presented with normal IOP after undergoing removal of silicone oil, 11 had IOP recovery after ciliary cryother-

**Table 1** Analysis of causes of ocular hypertension after vitrectomy combined with silicone oil filling

	Within postoperative 2 weeks		After 2 weeks	
	Number of eyes	Percentage (%)	Number of eyes	Percentage (%)
Inflammatory response	101	47.87	–	–
Hyphema	64	30.33	–	–
Entry of silicone oil into anterior chamber	35	16.59	9	10.84
Excessive silicone oil filling	6	2.84	–	–
Neovascularization	5	2.37	25	30.12
Hormone	–	–	16	19.27
Silicone oil emulsification	–	–	10	12.05
Seclusion of pupil	–	–	13	15.66
Anterior synechia	–	–	10	12.05

apy or laser cyclophotocoagulation, and 16 (19.28%) underwent Ahmed glaucoma valve implantation.

## Discussion

Silicone oil is stable, transparent, and non-toxic. It has relatively good biocompatibility, which contributes to the observation of postoperative retinal recovery. Consequently, vitrectomy combined with silicone oil filling has gradually become a main surgical treatment for complex vitreoretinopathy, which has significantly improved the surgical success rate and considerably enhanced postoperative visual acuity. Use of silicone oil may cause certain complications, such as corneal edema, corneal degeneration, cataract, glaucoma, silicone oil emulsification, and hypotony, *etc.* Postoperative transient and persistent IOP elevation may cause central retinal artery occlusion and/or optic nerve ischemia-induced visual acuity loss, which is one of the primary causes of loss of visual acuity after vitrectomy<sup>3</sup>.

### Early-stage (within 2 weeks) ocular hypertension after vitrectomy combined with silicone oil filling

Primary causes of postoperative early ocular hypertension included inflammatory responses, hyphema, entry of silicone oil into the anterior chamber, excessive silicone oil filling, and iris neovascularization, *etc.* In this study, postoperative early ocular hypertension (within 2 weeks after surgery) mainly resulted from inflammatory responses and postoperative hyphema, accounting for 78.2% in total. Previous study suggested that the postoperative incidence of an IOP peak might be correlated with postoperative ciliary body edema and an acute inflammatory response<sup>4</sup>. A variety of events, such as postoperative

inflammatory stimulation, blockage of the trabecular meshwork by inflammatory cells and debris, hemorrhage and edema, and forward rotation of the ciliary body could lead to anterior chamber narrowing or blockage of the trabecular meshwork by pigment granules. Inflammatory edema in the trabecular network may decrease the filtration rate of the aqueous humor, thereby causing IOP elevation. After the surgery, fibrinous or inflammatory products are likely to block the anterior chamber angle, creating an aqueous humor outflow barrier and thus eventually increasing IOP. For patients with postoperative IOP elevation induced by an inflammatory response, topical administration of corticosteroid and non-steroidal agents in combination with anti-glaucoma drugs could decrease IOP to the normal range.

Since the patients lay in a prone position after vitrectomy combined with silicone oil filling, remnant or fresh hemorrhage tended to enter the anterior chamber along with silicone oil, blocking the trabecular meshwork and elevating the IOP. Consequently, remnant hemorrhage within the vitreous chamber and on the retinal surface should be completely eliminated during vitrectomy. Before the surgery is concluded, the eye should be carefully examined for any signs of retinal errhysis and electrocoagulation should be adopted for hemostasis.

Patients with IOP elevation induced by slight hyphema were advised to stay in a sitting position and were administered with IOP-reducing agents for 1-2 days. After medical therapy, hyphema was absorbed and the IOP declined to a normal range. For patients with hyphema > 1/3 of the anterior chamber, anterior chamber puncture was recommended as an early

intervention to discharge partial hyphema, accelerate aqueous humor circulation, and mitigate trabecular meshwork blockage. Patients with refractory hyphema underwent anterior chamber irrigation to completely remove hyphema, alleviate trabecular meshwork blockage, and thus reduce IOP.

Our study found that the incidence of IOP elevation induced by entry of silicone oil into the anterior chamber accounted for 16.59% of the cases. This entry of silicone oil probably results from zonular dialysis or laxity caused by different external forces, peripheral iris incision block by anterior fibrinous membrane of the aphakic eyes, or untreated/improperly treated intraoperative entry of silicone oil into anterior chamber, etc. The presence of silicone oil within the anterior chamber should be treated by different methods in phakic versus aphakic eyes. Patients without a pupillary block in phakic eyes should be closely monitored and treated when necessary. Those with a pupillary block of the anterior chamber should be immediately treated with anterior chamber irrigation and undergo silicone oil removal from the vitreous chamber when necessary. Patients with aphakic eyes who have silicone oil entering the anterior chamber should undergo anterior chamber puncture; alternatively, recanalization of the peripheral subiris incision by laser may be considered. Silicone oil within the vitreous chamber could be removed following body posture adjustment.

Excessive silicone oil filling in the vitreous chamber may cause an anterior shift of the iris lens, anterior chamber flattening, anterior synechiae, and IOP elevation. The incidence of postoperative ocular hypertension at the 1st day after silicone oil filling is possibly correlated with excessive filling of silicone oil<sup>5</sup>. The incidence of excessive silicone oil filling has been rarely seen along with improvement of surgical expertise and accumulation of clinical experience. In this clinical trial, only 6 cases presented with excessive silicone oil filling. The following criteria could be utilized to evaluate silicone oil filling-induced IOP elevation. First, the regurgitation of silicone oil indicates that the IOP exceeds 20 mmHg. Second, venous pulsations suggests IOP>30 mmHg. Third, central retinal arterial pulsations, blockage, or optic disc paleness indicated IOP  $\geq$ 45 mmHg.

Generally, the injection of silicone oil should be stopped when venous pulsation is observed<sup>6</sup>. Excessive silicone oil filling may increase postoperative IOP. The elevated IOP should be reduced by a second removal of part of the silicone oil.

#### **Middle- and late-stage (after 2 weeks) ocular hypertension after vitrectomy combined with silicone oil filling**

The underlying mechanism of middle- and late-stage ocular hypertension after vitrectomy combined with silicone oil filling is probably associated with neovascularization, long-term administration of hormones, silicone oil emulsification, seclusion of the pupil, chamber angle synechia and closure, and entry of silicone oil into the anterior chamber. Popovic et al found that 37.77% of patients with complex retinal detachment presented with IOP elevation within 1 to 6 months after undergoing vitrectomy combined with silicone oil filling. In these patients, 52.98% of the increased IOP resulted from silicone oil emulsification, 23.54% from peripheral iris incision closure, and 23.54% from idiopathic chamber angle closure. The majority of patients had declined IOP measurements after removal of silicone oil. Hence, silicone oil filling could cause merely a temporary rather than a persistent ocular hypertension<sup>7</sup>. In this study, the incidence of middle- and late-stage ocular hypertension following silicone oil filling was 12.01%, which was significantly lower than the results reported by Mangouritsas in 25 eyes with neovascular glaucoma (30.12%). Neovascular glaucoma mainly occurs following vitrectomy in patients with diabetic retinopathy. The risk factors of iris rubeosis include serious preoperative retinal neovascularization, not undergoing preoperative panretinal photocoagulation, and postoperative retinal detachment. Treating retinal detachment and panretinal photocoagulation could prevent postoperative iris rubeosis and promote the disappearance of neovascularization. Those patients not suited for retinal laser therapy might undergo retinal freezing, ciliary body photocoagulation, or cryotherapy to reduce IOP.

Postoperative topical use of corticosteroid is another risk factor of ocular hypertension that cannot be ignored. Topical administration of glucocorticoid eye drops that is typically prescribed for 2–4 weeks

after vitreoretinal surgery could be replaced by non-hormonal anti-inflammatory agents based upon the severity of disease. Some patients may present with elevated IOP after 4 to 6 weeks of treatment with glucocorticoid eye drops. This increased IOP could decline to a normal level after discontinuing the use of glucocorticoid eye drops and administering timoprol eye drops instead.

During silicone oil emulsification, the silicone oil droplets are likely to migrate to the chamber angle, block the trabecular meshwork, exert toxic effects on the trabecular meshwork, cause injury to the filtering function, and form a barrier to drainage of aqueous humor, thereby leading to IOP elevation. The amount of emulsified silicone oil in the anterior chamber is positively correlated with IOP elevation<sup>8</sup>. Removal of silicone oil is an effective measure against the incidence of glaucoma after silicone oil emulsification. Previous studies reported that the success rate of IOP control after silicone oil removal was 62%<sup>9</sup>. The results in the present study indicated that IOP elevation induced by silicone oil emulsification was properly controlled in 9 of 10 eyes (90%) by silicone oil removal. Only 1 eye had a mild retention of silicone oil and irreversible injury of trabecular meshwork filter function, leading to uncontrolled IOP. Eventually, the IOP was maintained by anti-glaucoma surgery.

#### Other influencing factors

Our previous studies revealed that the proportion of glaucoma in patients with diabetic retinopathy was significantly increased, probably because the majority of patients requiring silicone oil filling had advanced diabetic retinopathy with complex intraocular situation. This surgery is demanding and time-consuming. Another reason is the specific pathological changes that occur in diabetic patients. The incidence of early-, middle- and late-stage ocular hypertension was significantly increased after vitrectomy combined with lens surgery. Potential reasons included intraoperative residual viscoelastic agents and trabecular meshwork blockage by the lens cortex and lens capsule. Combined surgery is relatively complex and time-consuming, and it causes relatively severe injury to intraocular tissues while yielding postoperative inflammatory responses. Lens defects, peripheral

iris incision blockage, and entry of silicone oil into the anterior chamber could block the trabecular meshwork or form a pupillary block. Therefore, during vitrectomy combined with lens surgery, intraocular tissue injury should be avoided as much as possible. If retention of the lens capsular membrane was selected, either the anterior or posterior lens capsules should be preserved completely. If lens excision was chosen, the lens capsular membrane should be completely removed to reduce the incidence of blockage of the peripheral subiris incision.

Taken together, ocular hypertension following vitrectomy combined with silicone oil filling can occur due to multiple factors. Proper intraoperative prevention of controllable factors and timely postoperative monitoring and effective treatment could reduce the postoperative incidence and injuries associated with ocular hypertension and lead to good surgical outcomes.

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