Elevated Intraocular Pressure and Hypotony Following Silicone Oil Retinal Tamponade for Complex Retinal Detachment

Incidence and Risk Factors

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Objective: To evaluate the incidence of and risk factors for persistently elevated intraocular pressure (IOP) and hypotony in patients who have undergone pars plana vitrectomy with silicone oil injection for the management of complex retinal detachment.

Subjects and Methods: The medical records of 532 patients who underwent silicone oil injection for the management of complex retinal detachments between January 1, 1991, and December 31, 1996, at the Bascom Palmer Eye Institute, Miami, Fla, were reviewed. Elevated IOP was defined as elevated IOP requiring an operation at any time postoperatively or a persistently elevated IOP of greater than 25 mm Hg at or after the 6-month visit. Hypotony was defined as a persistent IOP of 5 mm Hg or less at or after the 6-month visit. Patients with transient perioperative IOP fluctuations were not counted.

Results: Survival analysis for patients without cytomegalovirus retinitis (n = 383) revealed that 12.9% had an elevated IOP and 14.1% had hypotony by 6 months, 21% had an elevated IOP and 20.3% had hypotony by 1 year, and 29.5% had an elevated IOP and 27.3% had hypotony by 2 years. Among patients with cytomegalovirus retinitis (n = 149), none had a persistently elevated IOP, 10% had hypotony by 6 months, and 5.9% had persistently elevated IOP and 10% developed chronic hypotony by 1 year. A history of glaucoma before silicone oil retinal tamponade (P = .03), diabetes mellitus (P = .02), and a high IOP on the first postoperative day (P = .006) were risk factors for elevated postoperative IOP in patients without cytomegalovirus retinitis. Risk factors for postoperative hypotony in patients without cytomegalovirus retinitis included preoperative hypotony (P < .001) and aphakia (P = .03).

Conclusions: An elevated or low IOP often develops postoperatively in patients without cytomegalovirus retinitis who undergo silicone oil injection for the management of complex retinal detachment. Risk factors for an elevated postoperative IOP include a history of glaucoma, diabetes mellitus, and a high IOP on the first postoperative day. Risk factors for hypotony include preoperative hypotony and aphakia.


INTRAVITREAL SILICONE oil is useful in the management of complex retinal detachments secondary to diabetes mellitus, giant retinal tear, proliferative vitreoretinopathy, trauma, and cytomegalovirus (CMV) retinitis. However, several complications, including the emulsification of oil, cataract, keratopathy, and problems with intraocular pressure (IOP) control have been described. These events can occur at any time postoperatively and may range from mild and transient to severe pressure spikes resulting in loss of vision.

Although the status of IOP after surgery with silicone oil has been documented previously, these series were often small and somewhat contradictory in their findings. In addition, changes in clinical practice, including the widespread use of an inferior peripheral iridectomy (PI), different surgical techniques, and the emergence of viral retinitis–induced detachments, make extrapolating data from older studies to current clinical practice difficult.

The present study was designed to assess the incidence and risk factors for persistently elevated IOP and hypotony in patients who have undergone pars plana vitrectomy with silicone oil injection for the management of complex retinal detachment.

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SUBJECTS AND METHODS

After the study design was approved by the University of Miami School of Medicine, Miami, Fla, Human Subjects Committee (Protocol 96/61), we reviewed the medical records of all patients who underwent their first intravitreal injection of silicone oil for the management of a retinal detachment between January 1, 1991, and December 31, 1996, at the Bascom Palmer Eye Institute, Miami. Eyes that had a prior silicone oil injection and second eyes were excluded. All patients' medical records were retrospectively reviewed for preoperative, operative, and postoperative data. Information was collected from referring ophthalmologists for those patients no longer being seen at our institution.

All patients had a 3-port pars plana vitrectomy, retinectomy, and silicone oil instillation. The operating surgeon made the decision to use or not to use silicone oil. There was no defined protocol for selecting the use of silicone oil. Likewise, the surgeon decided to use or not to use a scleral buckle, lensectomy, or an inferior PI. An inferior PI was performed with a vitrectomy instrument if the surgeon deemed this appropriate. Because of the retrospective nature of the study, the size and patency of the inferior PI were not measured. Many patients had received a previous scleral buckle that was modified as needed. Silicone was either 1000 centistokes or 5000 centistokes, at the surgeon's discretion.

Two outcome variables were evaluated in this study. An elevated IOP was defined as an uncontrolled IOP requiring surgery at any time after silicone oil injection or a persistently elevated IOP (>25 mm Hg) at or after the 6-month visit. Hypotony, or a low IOP, was defined as an IOP of 5 mm Hg or less at or after the 6-month visit. Patients with transient, perioperative IOP fluctuations successfully treated with glaucoma medications were not considered to have elevated IOP.

The decision to treat and the choice of treatment of elevated IOP was made by the surgeon. Topical or oral medical therapy used included topical β-blockers, oral and topical carbonic anhydrase inhibitors, and nonselective α-agonists. Surgery was performed when medical therapy failed to control the IOP. Oil removal was usually not performed if there was persistent or recurrent retinal detachment. Trabeculectomy or glaucoma drainage tube implant was performed with or without oil removal.

To compare baseline characteristics and postoperative IOP changes between patients with CMV retinitis and those without CMV retinitis, the χ² test or the Student t test was used as indicated. Patients with CMV retinitis were separated from those without CMV retinitis in risk factor analysis because patients with CMV retinitis did not have the outcome (elevated IOP) or the risk factors (such as diabetes mellitus or history of glaucoma being analyzed), and they had limited follow-up. For survival analysis of elevated IOP, the time from silicone oil surgery to an operation for a high IOP (such as trabeculectomy, glaucoma drainage tube placement, silicone oil removal, or cyclodestructive procedure) was used as the time to failure. For those patients who had a high IOP (>25 mm Hg) at or after the 6-month visit, the first visit at which the IOP was high, ie, the 6-month, 1-year, or 2-year visit, was used as the failure time. Similarly, for hypotony, the first time a low IOP (≤5 mm Hg) occurred at or after the 6-month visit was considered the failure time. Patients who underwent other ocular surgery, such as cataract extraction or a second retinal procedure, were censored at the time of this further surgery because this is a study of the effect of a first silicone oil retinal procedure on IOP. Survival rates for patients with and without a given risk factor were compared using a Kaplan-Meier survival analysis (log-rank test). For continuous variables, the Cox proportional hazards regression model was used.

RESULTS

A total of 532 eyes of 532 patients fit the study criteria and were included in the analysis. Baseline demographic and clinical characteristics are summarized in Table 1. The mean preoperative IOP for the patients with CMV retinitis (9.3 mm Hg) was significantly lower than for the patients without CMV retinitis (11.2 mm Hg) (P = .006).

Figure 1. A, presents the survival curve for elevated IOP by CMV retinitis status. The patients with CMV retinitis had a lower failure rate (ie, an operation required for IOP control at any time postoperatively or a persistent IOP of >25 mm Hg at or after the 6-month visit) than the patients without CMV retinitis (P = .001, log-rank test). The 6-month rate for the patients with CMV retinitis was 0% vs 12.9% for the patients without CMV retinitis; the 1-year rates were 5.9% and 21%, respectively. Treatment failed in only 1 patient with CMV retinitis who had a high IOP, 27 mm Hg, at 1 year postoperatively; no patient with CMV retinitis required an operation for IOP control. Among the patients without CMV retinitis, 55 had an elevated IOP. Twenty-seven patients without CMV retinitis underwent an operation for IOP control: 22 before 6 months, 2 between 6 months and 1 year, and 3 after 1 year. Twenty-eight patients had persistently elevated IOP: 14 at the 6-month visit, 11 at the 1-year visit, and 3 at the 2-year visit.

The difference in rates of hypotony (IOP of ≤5 mm Hg at or after the 6-month visit) (Figure 1, B) was not statistically significant between the 2 groups (P = .26, log-rank test). Six patients with CMV retinitis vs 45 patients without CMV retinitis had hypotony at or after the 6-month postoperative visit. The 6-month rate for hypotony in the patients with CMV retinitis was 10% vs 14.1% for the patients without CMV retinitis; the 1-year rates were 10% and 20.3%, respectively. Too few patients with CMV retinitis were observed for 2 years to report their rates.

The mean (SD) rise in the IOP on the first postoperative day was less in the patients with CMV retinitis (9.5 [7.4] mm Hg, n = 83) than in the patients without CMV retinitis (13.6 [12.8] mm Hg, n = 231) (P = .006, Student t test). The rise in IOP from preoperative levels did not differ between the 2 groups at 1 week (6.1 vs 5.9 mm Hg), 1 month (3.1 vs 2.4 mm Hg), 3 months (1.5 vs 1.6 mm Hg), 6 months (1.1 vs 2.0 mm Hg), or 1 year (1.2 vs 3.1 mm Hg). Early perioperative IOP rises of greater than 25 mm Hg occurred in 12 (13.5%) of 89 patients with CMV retinitis at 1 day postoperatively, 16 (11.4%) of 140
The analysis of preoperative and intraoperative risk factors for increased IOP in patients without CMV retinitis is summarized in Table 2. Survival analysis revealed that a preoperative diagnosis of glaucoma (P < .03, log-rank test), diabetes mellitus (P < .02, log-rank test), and an IOP of 30 mm Hg or greater on the first postoperative day (P < .006, log-rank test) are significant risk factors for persistently elevated IOP. The survival curves for these 3 risk factors are presented in Figure 2 (A through C). For the patients with a history of glaucoma (n = 23), the 6-month and 1-year success rates were 75.0% and 60.0%, respectively. For those without a glaucoma history (n = 360), the 6-month, 1-year, and 2-year rates were 88.0%, 80.1%, and 71.5%, respectively; these rates are similar to those for the total population because few patients had a glaucoma history.

For the diabetic patients, a subgroup analysis of patients with proliferative diabetic retinopathy (PDR) alone (n = 46), proliferative vitreoretinopathy (PVR) alone (n = 28), both PDR and PVR (n = 12), and neither PDR nor PVR (n = 22) revealed that at 6 months, 68.5% of those with PDR alone, 100% with PVR alone, 56% with both PDR and PVR, and 83.4% with neither PDR nor PVR had a successfully controlled IOP. At 1 year, the IOP of 68.5% of patients with PDR, 92.3% of patients with PVR, 42% with both PDR and PVR, and 53.7% with neither PDR nor PVR was controlled. By 2 years, the IOP of 57.1% of those with PDR, 92.3% with PVR, 42% with both PDR and PVR, and 53.7% with neither PDR nor PVR was controlled. This was statistically significant for the group with PVR alone compared with the group with PVR alone (P < .007, log-rank test).

An analysis of risk factors for hypotony in patients without CMV retinitis is presented in Table 3. Survival analysis demonstrated that preoperative hypotony and aphakia are risk factors for postoperative hypotony (Figure 3, A and B). Among patients with hypotony, postoperative anterior PVR was present in 50% (3/6) of patients with CMV retinitis and in 77.5% (31/40) of patients without CMV retinitis. Recurrent posterior retinal detachments were present in 60.9% (28/46) of all patients with hypotony.

**COMMENT**

An elevated IOP is a relatively common complication in eyes that have undergone pars plana vitrectomy with silicone oil injection for the management of complicated retinal detachment. First reported by Cibis,4 the rates of IOP elevation range from 2.2%70 to 56.0%,76 depending on the definition of elevated IOP and the time considered. The present study found, in patients without CMV retinitis, an incidence of elevated IOP of 12.9% at 6 months, 21% at 1 year, and 29.5% at 2 years.

An elevated IOP may occur by one of several mechanisms. These include acute pupillary block,63,81-85,87-89 emulsified oil in the angle,59,80,90 choroidal effusions with an-
Several previous studies have addressed risk factors for elevated IOP after silicone oil injection. Nguyen et al. found that eyes with preexisting pressure problems were more likely to have postoperative pressure problems. Burk et al. found no correlation with a history of glaucoma. de Corral et al. found that diabetes mellitus was not associated with pressure problems, but Ando found that diabetic patients with aphakia were likely to have a postoperative pressure rise. Silicone oil in the anterior chamber has been associated with a rise in the IOP, but normal pressures have been documented despite oil globules in the angle. An elevated IOP before emulsification has been demonstrated as well. In the present study, a history of glaucoma, diabetes mellitus, and high IOP on the first postoperative day were found to be risk factors for a persistently elevated IOP. Diabetic patients with isolated PDR detachments had a higher risk of an elevated IOP than those with isolated PVR detachments. A scleral buckle done either before or at the time of surgery was not shown to be significant for either an elevated IOP or hypotony. Petersen and Ritzau-Tondrow found that 1000 centistoke of oil was more likely than 5000 centistoke of oil to cause an elevated IOP, but in this study, there was no demonstrable difference.

Among patients with CMV retinitis, an elevated IOP after silicone oil injection has been shown to be rare. Our study found a similarly low incidence of 0% at 6 months and 5.9% at 1 year. The explanation for this is unclear. All of the patients with CMV retinitis in this study were positive for the human immunodeficiency virus (HIV). Patients infected with HIV have a lower preoperative IOP in general than HIV-negative patients. In this series, the group with CMV retinitis had a lower preoperative IOP, and the rise in IOP on the first postoperative day was also less than in patients without CMV retinitis. One possible explanation is the lack of inflammatory response from the compromised immune system of HIV-positive patients. Likewise, the mechanism of detachments in patients with CMV retinitis is different from that in patients without CMV retinitis. Detachments in patients with CMV retinitis are associated with necrotic retinal holes, whereas in patients without CMV retinitis, they are the result of posterior vitreous detachments. Therefore, patients

Figure 1. A, Cumulative proportion of patients who did not undergo an operation for elevated intraocular pressure (IOP) and who did not have an IOP greater than 25 mm Hg (P = .001). B, Cumulative proportion of patients who did not have an IOP of 5 mm Hg or lower (P = .26), by days after silicone oil surgery and by cytomegalovirus (CMV) retinitis status. Broken line indicates patients without CMV retinitis (n = 383); solid line, patients with CMV retinitis (n = 149).
with CMV retinitis who have detachments are at a lower risk of anterior PVR and thus may have a lower risk of postoperative persistent IOP abnormalities. Surgical technique, which was not controlled or evaluated in this study, may also play a role.

In this study, the presence of a PI did not appear to protect against an IOP rise higher than 25 mm Hg at any point in the postoperative period and, in fact, may have been a risk factor for hypotony \( (P = .07) \). An inferior PI, as first proposed by Ando in 1985,\(^8\) theoretically allows aqueous to pass between the posterior and anterior chambers underneath the oil and thereby prevents pupillary block in patients with aphakia and those with pseudophakia. This has been shown not only to work in the short term\(^8\),\(^8\) but also to reduce anterior segment and pressure complications over the long term.\(^6\),\(^4\),\(^8\) A superior PI also has been effective in eyes that undergo intracapsular cataract extraction after silicone oil injection.\(^8\) The major reason for PI failure is closure due either to inflammation,\(^8\),\(^6\),\(^9\) especially in diabetic patients, or to oil block.\(^8\) Because of the retrospective nature of this study, we were unable to accurately assess the patency of the PI. One other study, by Lucke et al,\(^9\) also showed that the incidence of IOP elevation was unaffected by the presence of an inferior PI.

Hypotony has been a substantial problem in eyes undergoing repair of complex retinal detachment with silicone oil. Preoperative and postoperative anterior PVR has been shown to be a risk factor for poor anatomic outcome\(^9\),\(^7\) and a higher incidence of hypotony.\(^9\),\(^6\) In our patients in whom hypotony developed, we noted a high incidence of anterior PVR (77.5%) and a significant incidence of recurrent posterior retinal detachment. These results are similar to those in the Silicone Study,\(^1\) suggesting that a factor for the development of hypotony in patients undergoing repair of a complex retinal detachment with silicone oil may be the development of anterior PVR or posterior recurrent retinal detachment.

### Table 3. Risk Factors for Hypotony Among Patients Without Cytomegalovirus Retinitis

<table>
<thead>
<tr>
<th>Variable*</th>
<th>Patients, No.</th>
<th>6 mo</th>
<th>1 y</th>
<th>2 y</th>
<th>P</th>
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<tr>
<td>Diabetes mellitus</td>
<td>Yes 108</td>
<td>83.6</td>
<td>78.2</td>
<td>66.2</td>
<td>.47</td>
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<td>No 275</td>
<td>86.8</td>
<td>80.2</td>
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<td>History of glaucoma</td>
<td>Yes 23</td>
<td>71.4</td>
<td>71.4</td>
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<td>86.9</td>
<td>80.3</td>
<td>73.3</td>
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<td>Aphakia</td>
<td>Yes 324</td>
<td>84.5</td>
<td>77.3</td>
<td>69.9</td>
<td>.03</td>
</tr>
<tr>
<td>No 52</td>
<td>96.7</td>
<td>96.7</td>
<td>96.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil weight, centistoke</td>
<td>1000 335</td>
<td>85.1</td>
<td>78.1</td>
<td>72.1</td>
<td>.36</td>
</tr>
<tr>
<td>5000 43</td>
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<td>91.3</td>
<td>76.1</td>
<td></td>
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<tr>
<td>Inferior PI</td>
<td>Yes 239</td>
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<td>73.6</td>
<td>71.1</td>
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<td>No 144</td>
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<td>90.0</td>
<td>94.1</td>
<td></td>
<td></td>
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<tr>
<td>Scleral buckle</td>
<td>Yes 281</td>
<td>85.3</td>
<td>79.9</td>
<td>72.4</td>
<td>.88</td>
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<td>No 102</td>
<td>87.7</td>
<td>79.0</td>
<td>73.3</td>
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<tr>
<td>Age, &lt;50 y</td>
<td>Yes 159</td>
<td>88.6</td>
<td>82.9</td>
<td>82.9</td>
<td>.16</td>
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<tr>
<td>No 224</td>
<td>84.2</td>
<td>77.7</td>
<td>66.6</td>
<td></td>
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<tr>
<td>Preop IOP, (\leq) 5 mm Hg</td>
<td>Yes 82</td>
<td>73.6</td>
<td>62.7</td>
<td>56.4</td>
<td>.001</td>
</tr>
<tr>
<td>No 281</td>
<td>90.1</td>
<td>85.1</td>
<td>79.6</td>
<td>79.6</td>
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</tr>
<tr>
<td>Total 383</td>
<td>85.9</td>
<td>79.7</td>
<td>72.7</td>
<td>72.7</td>
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*PI indicates peripheral iridectomy; Preop IOP, preoperative intraocular pressure. †Success indicates no IOP of 5 mm Hg or less at or after the 6-month visit; failure, a persistent IOP of 5 mm Hg or less at or after the 6-month visit; and NA, not available.

CONCLUSIONS

Twenty-one percent of patients without CMV retinitis by 1 year and 29.5% by 2 years who receive silicone oil for the management of complex retinal detachment may de- velop persistently elevated IOP (>25 mm Hg) or re- quire surgery for IOP. In patients without CMV retinitis, hypotony develops in 22% by 1 year and 27.3% by 2 years. Survival analysis of elevated postoperative pres- sures in patients without CMV retinitis identified a his- tory of glaucoma, diabetes mellitus, and high IOP on the first postoperative day as risk factors. Risk factors for hy- potony included the presence of preoperative hypotony and of aphakia.

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