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Comparison of Methods of Endotamponade Used During 23-Gauge Pars Plana Vitrectomy and the Risk of Raised Intraocular Pressure During 24-Month Follow-Up: A Retrospective Study of 196 Patients

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Background: Pars plana vitrectomy (PPV) is used to treat retinal conditions, including retinal detachment, and involves removal of the vitreous gel from the eye. Complications following PPV include raised intraocular pressure (IOP). This retrospective study aimed to compare methods of endotamponade used during 23-gauge PPV and the risk of raised IOP during 24-month follow-up at a single center.

Material/Methods: The study included 196 patients (age, 15–86 years; mean, 63.5 years) (196 eyeballs). There were 93 patients (47.45%) with a preoperative history of type 2 diabetes mellitus and 14 patients (7.14%) with a history of myopia. IOP was measured with Goldmann applanation tonometry at one-, three-, six-, 12-, and 24-month follow-up. The outcome was compared following endotamponade with silicone oil, sulfur hexafluoride (SF6), and balanced salt solution (BSS).

Results: Mean IOP at one-month follow-up was 17.2 mmHg (±3.61 mmHg; range, 9–45 mmHg), and at 24-month follow-up was 17.3 mmHg (±3.23 mmHg; range, 7–30 mmHg). IOP following PPV was significantly associated with the indication for PPV (P=0.023), and the type of endotamponade used (P=0.049). In patients with silicone oil endotamponade, the risk of IOP at 24 months was increased by 2.3 times compared with SF6 or BSS endotamponade. Patients with SF6 endotamponade had a risk of IOP that was 3.3 times lower than for silicone oil tamponade or BSS tamponade.

Conclusions: Silicone oil endotamponade in PPV was associated with an increased risk of IOP at 24-month follow-up.

MeSH Keywords: Glaucoma • Pressure • Retina • Silicone Oils

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Background

Pars plana vitrectomy (PPV) is a surgical procedure to treat retinal conditions, including retinal detachment, and involves removal of the vitreous gel from the eye. The complications of PPV include increased intraocular pressure (IOP). Vitrectomy is a surgical procedure that ensures a complete evaluation of the vitreous body and its base. The surgeon is then allowed the opportunity to provide a reliable intraoperative assessment of the retina, and may identify any tears and holes, and also has the chance to drain the subretinal fluid. However, vitrectomy procedures are associated with surgical complications that include the development of cataract, retinal detachment, and increased IOP.

Increased IOP is a common complication of vitrectomy during the early postoperative stage [1–6]. The risk factors for IOP include postoperative inflammation, the use of gaseous methods of endotamponade, excessive or poorly directed laser photocoagulation, and transient choroidal edema [1,3–8]. Previous clinical studies have shown that up to half of the patients developed IOP within two weeks following vitrectomy for macular hole [2,4]. The increase in IOP was usually transient and controlled with medication [4]. However, there have been few previous reports on the risk and associations between the early or transient increase in IOP following PPV.

Also, there have been few previous studies on the late development of open-angle glaucoma (OAG) after vitrectomy procedures. Aaberg and Van Horn reported that neovascularization or OAG developed in 26% of eyes after vitrectomy [9]. Chang et al. described the development and exacerbation of OAG in patients following vitrectomy and identified that in the case of phakic eyes, with an additional lens implant, the length of time between vitrectomy and development of OAG was much longer than in the case of non-phakic eyes [10]. Also, because the development of OAG may be associated with oxidative stress, the presence of a lens could be a factor in the prevention of OAG. Chang et al. evaluated patients who had undergone vitrectomy for indications that included macular hole, epiretinal membrane (ERM), retinal detachment, and hemorrhage into the chamber of the vitreous body [10].

Therefore, the aim of this retrospective study, conducted at our center, was to compare methods of endotamponade with silicone oil, sulfur hexafluoride (SF6), and balanced salt solution (BSS), used during 23-gauge PPV and the risk of raised IOP during a 24-month follow-up.

Material and Methods

Patient clinical and demographic data

A retrospective study was conducted in the Department of Ophthalmology, St. Barbara Hospital, Centre for Traumatology, Sosnowiec, Poland. The medical records of 196 patients (196 eyeballs) who had undergone 23G pars plana vitrectomy (PPV) between January 1, 2011, and June 30, 2013, were reviewed. All patients underwent PPV procedures for the first time, which was performed by the same surgeon. The study was approved by the Research Ethics Committee of the Silesian Medical Chamber in Katowice (Approval No. ŚIL/KB/100p/17). The Bioethical Committee did not require patient consent to review their medical records due to the retrospective nature of this study and because the patient information was anonymized.

Demographic, preoperative, and postoperative information was collected. The inclusion criteria included no previous history of increased IOP or treatment with antiglaucoma medication and no previous surgical procedures. Patients were excluded if they had any factors affecting either the anatomy or function of the posterior segment of the eye that predisposed them to glaucoma, including retinal vein occlusion, central retinal vein occlusion (CRVO) or branch retinal vein occlusion (BRVO), uveitis, penetrating ocular trauma, or scleral buckling. The study group included 196 patients (196 eyeballs), between 15–86 years of age (median age, 63.5 years). There were 93 patients (47.45%) who had a preoperative history of type 2 diabetes mellitus and 14 patients (7.14%) had a history of myopia, as concomitant diseases.

Indications for PPV

The major indications for PPV were retinal detachment in 74 patients (37.8%), epiretinal membrane (ERM) in 44 patients (22.5%), macular hole (MH) in 34 patients (17.4%), proliferative diabetic retinopathy with vitreous-retinal traction, vitreous hemorrhage, and/or local traction retinal detachment (PDVR) in 22 patients (11.2%). Also, PPV with secondary sulcus intraocular lens implantation or transscleral fixation with a single-piece acrylic intraocular lens (IOL sulcus/fixation) was an indication in 17 patients (8.7%), and vitreous hemorrhage in Terson syndrome (VH/Terson) in five patients (2.6%). Fifty-eight patients (29.6%) showed more than one indication for surgery with PPV. There were 179 eyeballs that were pseudophakic, and 17 patients achieved pseudophakic status during PPV with secondary sulcus implantation or transscleral fixation of an intraocular lens, as recommended by the PPV indication.

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Table 1. Number and percentage of patient with an intraocular pressure (IOP) by range, from <11 mmHg to ≥50 mmHg, at subsequent follow-up visits (T1–T24).

IOP (mmHg)	Number of patients with an intraocular pressure (IOP) within a given range during subsequent follow-up									
	T1 N (%)		T3 N (%)		T6 N (%)		T12 N (%)		T24 N (%)	
<11	1	(0.51)	1	(0.51)	0	(0.00)	1	(0.89)	0	(0.00)
11–21	178	(90.82)	171	(87.24)	167	(92.78)	96	(85.71)	31	(83.78)
22–29	13	(6.63)	13	(6.63)	10	(5.56)	10	(8.93)	3	(8.11)
30–39	3	(1.53)	7	(3.57)	3	(1.67)	5	(4.46)	3	(8.11)
40–49	1	(0.51)	2	(1.02)	0	(0.00)	0	(0.00)	0	(0.00)
≥50	0	(0.00)	2	(1.02)	0	(0.00)	0	(0.00)	0	(0.00)
Total	**196**	**(100.00)**	**196**	**(100.00)**	**180**	**(100.00)**	**112**	**(100.00)**	**37**	**(100.00)**

Follow-up: One month (T1), three months (T3), six months (T6), 12 months (T12), and 24 months (T24).

Endotamponade used during 23-gauge PPV

The most frequently used type of endotamponade was silicone oil in 97 patients (49.49%) with 1,000 centistokes viscosity in every case. Sulfur hexafluoride (SF6) gas was used in 64 patients (32.65%), and balanced salt solution (BSS) was used in the remaining 36 patients (17.85%).

Measurement of IOP

IOP was measured with applanation tonometry. An IOP of between 11–21 mmHg was defined as normal, provided that no intervention was needed, or successfully controlled if antiglaucoma agents were administered. An increased IOP was ≥22 mmHg, which required an antiglaucoma agent at any point during the postoperative follow-up. A consistently increased IOP was defined as an IOP of ≥22 mmHg but requiring an antiglaucoma agent during at least three consecutive follow-up points. Management of increased and consistently increased IOP involved administration of topical β blockers, prostaglandin analogs, nonselective α-agonists, and oral and topical carbonic anhydrase inhibitors. The follow-up period ranged from between 3–24 months.

Statistical analysis

Data were expressed at the mean, median, range, percentage, and standard deviation (SD). Data were analyzed using R Project software (R Development Core Team, Vienna, Austria). Pearson's chi-squared (χ^2) test was used to analyze the associations between the variables. P-values were obtained using the Monte Carlo simulation. McNemar's test was used for paired nominal data.

The Mann-Whitney test was used to compare two independent assays with variables and to compare two independent assays for continuous variables when the assumptions of the parametric tests were not fulfilled. The Wilcoxon signed-rank test was used to compare two paired tests. The normality of the distribution of individual variables was verified with the Shapiro-Wilk test. A P-value <0.05 was considered to be significant.

Results

Intraocular pressure (IOP) measurements following 23-gauge PPV

Intraocular pressure (IOP) was measured at follow-up of one month (T1), three months (T3), six months (T6), 12 months (T12), and 24 months (T24) after pars plana vitrectomy (PPV), as shown in Table 1. The percentage of patients with normal or well-controlled IOP at the consecutive follow-up points was 90.82%, 87.24%, 92.78%, 85.71%, and 83.78%, respectively. The percentage of patients who required antiglaucoma medication during consecutive follow-up appointments was 3.06% (six patients), 4.59% (nine patients), 3.89% (seven patients), 2.68% (three patients), and 2.70% (one patient) (Table 2). The mean IOP at one-month follow-up was 17.2±3.61 mmHg (min: 9 mmHg; median: 17 mmHg; max: 45 mmHg). The mean IOP at 24-month follow-up was 17.3±3.23 mmHg (min: 7 mmHg; median: 17 mmHg; max: 30 mmHg). No significant difference was observed between IOP values during all follow-up points (V=6642.5; P=0.9468). During the follow-up period, 20 patients (10.2%) showed increased IOP. Consistently increased IOP was observed in 28 patients (14.29%), and 148 patients (75.51%) required no antiglaucoma medication during the follow-up period.

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Table 2. Number and percentage of patients treated with antihypotensive drugs at subsequent follow-up visits (T1–T24).

Number of antihypotensive drugs	Number of patients receiving medication during subsequent follow-up visits				
	T1 N (%)	T3 N (%)	T6 N (%)	T12 N (%)	T24 N (%)
One	3 (1.53)	4 (2.04)	2 (1.11)	1 (0.89)	1 (2.70)
Two	2 (1.02)	4 (2.04)	2 (1.11)	1 (0.89)	0 (0.00)
Three	1 (0.51)	0 (0.00)	2 (1.11)	1 (0.89)	0 (0.00)
Four	0 (0.00)	1 (0.51)	1 (0.55)	0 (0.00)	0 (0.00)
Number of patients receiving medication	**6 (3.06)**	**9 (4.59)**	**7 (3.89)**	**3 (2.68)**	**1 (2.70)**

Follow-up: one month (T1), three months (T3), 6 months (T6), 12 months (T12), and 24 months (T24).

Table 3. Number and percentage of patients with normal, increased, or consistently increased intraocular pressure (IOP) by indication for pars plana vitrectomy (PPV).

Diagnosis	IOP Normal N (%)	IOP Increased N (%)	IOP Consistently increased N (%)	Number of patients with a given diagnosis
1 – Ablation	48 (32.43)	11 (55.00)	15 (53.57)	74
2 – ERM	37 (25.00)	2 (10.00)	5 (17.86)	44
3 – Retinal hole	31 (20.95)	2 (10.00)	1 (3.57)	34
4 – PDVR	14 (9.46)	2 (10.00)	6 (21.43)	22
5 – IOL Sulc/Fix	14 (9.46)	3 (15.00)	0 (0.00)	17
6 – VH/Terson	4 (2.70)	0 (0.00)	1 (3.57)	5
Total	**148 (100.00)**	**20 (100.00)**	**28 (100.00)**	**196**

ERM – epiretinal membrane; PDVR – proliferative diabetic retinopathy with vitreous-retinal traction; IOL – intraocular lens; VH – vitreous hemorrhage.

Indications for PPV and IOP

A significant association was observed between the indications for PPV and the occurrence of consistently increased IOP, using Pearson's chi-squared (χ^2) test with simulated P-value, based on 1e+05 replicates (χ^2=13.0315; df=NA; P=0.023) (Table 3). No significant associations were observed between concomitant diseases and the presence of increased or consistently increased IOP (χ^2=0.8068, df=NA, P=0.767). A significant association was observed between the type endotamponade used during 23-gauge PPV and an increased IOP (χ^2=6.2051, df=NA, P=0.049) and a consistently increased IOP (χ^2=16.8809, df=NA, P<0.001) (Table 4).

Consistently increased IOP was most often observed in patients who had undergone surgery for retinal detachment. The risk of increased or consistently increased IOP in patients diagnosed with retinal detachment was 1.9 times higher compared with the other patients (RR=1.95; 95% CI, 1.20–3.18). However, the risk of increased or consistently increased IOP in patients who had undergone surgery for macular hole was 3.1 times lower compared with the other patients (RR=0.32; 95% CI, 0.10–0.96).

Method of endotamponade and risk of increased IOP

No significant differences were observed in the distribution of the type of endotamponade between the increased and consistently increased IOP values. In patients with silicone oil endotamponade, the risk of increased IOP was 2.3 times higher (RR=2.30; 95% CI, 0.95–5.94), the risk of consistently increased IOP was 4.7 times higher (RR=4.70; 95% CI, 1.86–11.85). The risk of increased or consistently increased IOP was 3.4 times higher compared with SF6 or BSS endotamponade (RR=3.40; 95% CI, 1.86–6.33). Patients who had SF6 tamponade showed a significant risk of increased or consistently increased IOP, which was 3.3 times lower compared with silicone oil endotamponade or BSS endotamponade (RR=0.30; 95% CI, 0.13–0.66).

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Table 4. Number and percentage of patients with normal, increased, or consistently increased intraocular pressure (IOP) by type of endotamponade.

Diagnosis	IOP Normal N (%)	IOP Increased N (%)	IOP Consistently increased N (%)	Number of patients with a given diagnosis
1 – Silicone oil	60 (40.54)	14 (70.00)	23 (82.14)	97
2 – SF6	58 (39.19)	4 (20.00)	2 (7.14)	64
3 – BSS	30 (20.27)	2 (10.00)	3 (10.71)	35
Total	**148 (100.00)**	**20 (100.00)**	**28 (100.00)**	**196**

IOP – intraocular pressure; SF6 – sulfur hexafluoride; BSS – balanced salt solution.

Table 5. Number of patients with normal, increased, or consistently increased intraocular pressure (IOP) and silicone oil removal time.

Intraocular pressure (IOP)	Silicone oil removal time (months)					N
	Mean	Standard deviation (±SD)	Minimum	Median	Maximum	
Normal	3.1	±1.93	1	2	12	54
Increased	3.5	±1.39	2	3	6	13
Consistently increased	4.6	±2.34	2	4	11	22

Indications for PPV and risk of increased IOP

Evaluation of the effect of retinal detachment and macular hole was evaluated for the risk of increased IOP, depending on the type of tamponade used. There were 66% of patients with silicone oil endotamponade who underwent surgery for retinal detachment, while for patients with SF6 or BSS endotamponade, 10% suffered from retinal detachment (χ^2=65.0967; df=1; P<0.001). There were 45% of patients with SF6 endotamponade who underwent surgery for macular hole, while among the patients with silicone oil endotamponade or BSS endotamponade, 3.8% suffered from macular hole (χ^2=51.8355, df=1, P<0.001).

Patients with retinal detachment and silicone oil endotamponade showed a significant risk of increased IOP that was 1.7 times higher (RR=1.69; 95% CI, 0.74–3.87), consistently increased IOP was 2.4 times higher (RR=2.38, 95% CI, 1.20–4.70), and increased or consistently increased IOP was twice as high (RR=2.06; CI, 1.28–3.34), compared with the remaining cases. The patients diagnosed with conditions other than retinal detachment and with silicone oil endotamponade had a significant risk of increased or consistently increased IOP, which was 1.8 times higher than in all the remaining cases (RR=1.84; 95% CI, 1.10–3.07). The patients diagnosed with conditions other than detachment and with SF6 or BSS had a significant risk of increased IOP, 3.3 times lower (RR=0.30; 95% CI, 0.10–0.87), consistently increased IOP, 3.8 times lower (RR=0.26, 95% CI, 0.10–0.66), and increased or consistently increased IOP, 3.6 times lower (RR=0.28; 95% CI, 0.14–0.54), compared with the remaining cases.

The relative risk (RR) of increased or consistently increased IOP in patients with detachment and with silicone oil endotamponade was evaluated compared with patients with SF6 or BSS endotamponade. No significant differences were identified, which might have been due to the small size of the study group. The RR of an increased or consistently increased IOP in patients with retinal detachment and with silicone oil endotamponade was evaluated compared with patients diagnosed with other conditions, and no significant differences were found (RR=0.95; 95% CI, 0.56–1.61).

Patients diagnosed with conditions other than retinal detachment and with silicone oil endotamponade showed a significantly increased risk of increased IOP, which was 4.3 times higher (RR=4.30; 95% CI, 1.52–12.26), while the risk of increased or consistently increased IOP was 3.8 times higher (RR=3.80; 95% CI, 1.84–8.25) compared with patients with SF6 or BSS endotamponade. Silicone oil was removed between one-month and 12-months after PPV, and was removed at three months in 56 cases, at four to six months in 27 cases, and between seven to 12 months after PPV in six cases. In eight patients, the silicone oil was not removed. A significant association was shown between the time of silicone oil removal and the occurrence of increased IOP (W=317; P<0.001) and a consistently increased IOP (W=250.5; P=0.048) (Table 5).

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The requirement for repeat PPV

During the follow-up period, 25 patients underwent repeat PPV, either for the same or a different indication, and endotamponade oil removal was not taken into account. No significant association was observed between the repeat PPV procedure and the occurrence of increased or consistently increased IOP (χ^2=3.7491; df=NA; P=0.139).

Discussion:

Many conditions can affect the eye, and surgical procedures vary. Pars plana vitrectomy (PPV) is used to treat retinal conditions, including retinal detachment, and involves removal of the vitreous gel from the eye. Complications following PPV include raised intraocular pressure (IOP). This retrospective study aimed to compare methods of endotamponade used during PPV using the 23-gauge transconjunctival system and the risk of raised IOP during 24-month follow-up at our center. Endotamponade with silicone oil, sulfur hexafluoride (SF6), and balanced salt solution (BSS) were compared, and silicone oil endotamponade in PPV was associated with an increased risk of IOP at 24-month follow-up.

Previous studies have shown that the type of endotamponade used in PPV has a significant effect on the development of postoperative glaucoma. Silicone oil has been used clinically for more than 50 years as an endotamponade agent to treat retinal detachment [11]. There have been rapid developments in complex surgical procedures used in the posterior segment of the eye, and the use of silicone oil endotamponade increased [12]. Although silicone oil can provide a long duration of tamponade and enhances efficacy in difficult cases, applying the oil frequently leads to complications, such as keratopathy, glaucoma, or cataract [13–16]. Glaucoma is one of the most common complications following the use of silicone oil endotamponade, which occurs due to several pathophysiological mechanisms, including the pupillary block, inflammatory angle closure by synechiae, rubeosis of the iris, and migration of emulsified and non-emulsified silicone oil to the anterior chamber [14–18]. Infiltration and occlusion of the trabecular reticulum are believed to drive the pathophysiology of silicone-induced secondary open-angle glaucoma (OAG) [14–18].

Sulfur hexafluoride (SF6) or perfluoropropane (C3F8) gas are now used for endotamponade at least as often as silicone oil, depending on the indications and surgical experience and preference. The most frequently observed complications of gas endotamponade include the transient postoperative increase in intraocular pressure (IOP), associated with the displacement of the lens iris diaphragm, and the development of closed-angle glaucoma (CAG), with or without retinal blockage. The risk of OAG is also present with the use of this gas endotamponade [19,20]. The reasons for these complications may include the development of inflammation, metabolic damage of the reticulum by gas particles, infusion of fluids, cells, cytokines, proteins, and particulate material [21–24].

A transient or permanent increase in IOP following PPV is not a rare phenomenon and have been described since the development of this surgical procedure [25,26]. The fluctuation of IOP has been reported in patients who underwent PPV for retinal detachment, although good control of IOP was successfully achieved in most cases [6]. In the present study, the main reason for PPV was retinal detachment. Anti-glaucoma treatment was administered on subsequent follow-up in 3.06% of patients after one month, in 4.59% of patients after three months, in 3.89% of patients after six months, in 2.68% of patients after 12 months, and in 2.70% of patients after 24 months. IOP measurements <22 mmHg were achieved with the use of anti-glaucoma medications during consecutive control in the majority of patients, including 90.82% after one month, 87.24% after three months, 92.78% after six months, 85.71% after 12 months, and 83.78% after 24 months. The IOP scores at the beginning and end of the follow-up period were not significantly different. The findings from the present study are supported by several studies that have shown that endotamponade with silicone oil predisposed patients undergoing PPV to developing secondary glaucoma [17,27,28].

The findings from the present study showed that the risk of increased IOP was significantly increased with the use of silicone oil endotamponade but there was no significant difference between the patients with silicone oil endotamponade diagnosed with retinal detachment compared other indications. Recently, vitreoretinal surgery, including the treatment of retinal detachment, have increasingly used gas endotamponade [29,30]. In our department, SF6 has been increasingly used, but silicone oil endotamponade is used in the increasing numbers of cases of retinal detachment with concurrent proliferative diabetic retinopathy [30]. The findings from the present study have shown that to evaluate the significance of the risk of developing raised IOP in patients with retinal detachment with endotamponade other than silicone oil, a larger study group is needed, with a multicenter approach. In the present study, patients who underwent PPV with silicone oil endotamponade showed increased or consistently increased IOP more frequently. Patients who had normal IOP throughout the follow-up period had more rapid removal of the silicone oil. Increased and consistently increased IOP was observed more often in patients who received the oil endotamponade for a longer period. The duration of the silicone oil endotamponade is a risk factor that contributed to increased and consistently increased IOP.

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The effect of diabetes on the risk of developing glaucoma after PPV is an important consideration [31]. In the present study, 47.96% of patients had a history of diabetes, but they did not show a significant increase or consistent increase in IOP compared with other patients. Although multiple surgical procedures carry the risk of an intraoperative and postoperative increase in IOP, the patients in this study did not show a significant association between increased and consistently increased IOP and subsequent PPV.

This study had several limitations, as it was a retrospective study conducted at a single center with a small study population. Also, many diseases may occur at the same time as the primary indication for vitrectomy, which may not have been evaluated in this study. Neovascular glaucoma in patients with diabetes or ocular ischemic syndrome affecting the anterior segment of the eye may not be recognized at the initial stage of the disease [32]. Also, the formation of retrocorneal membranes may precede the migration of inflammatory cells into the filtration angle [33]. These conditions are very difficult to recognize, especially as keratopathies after vitrectomy develop very slowly. Therefore, the diagnosis of glaucoma after vitrectomy may depend on the individual and local predisposition to ischemic or inflammatory diseases of the eye.

Conclusions

This retrospective study aimed to compare methods of endotamponade used during 23-gauge pars plana vitrectomy (PPV) and the risk of raised intraocular pressure (IOP) in 196 patients during 24-month follow-up at a single center. Increased IOP was observed soon after surgery and during the long-term follow-up. The duration of antiglaucoma therapy was variable but achieved IOP measurements comparable with those before PPV. The use of silicone oil endotamponade was a risk factor contributing to increased and consistently increased IOP, but early removal of silicone oil reduced this risk.

Conflict of interest

None.

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