Original Article

Secondary Glaucoma as a Complication of Pars Plana Vitrectomy in an Eye Care Centre in Indonesia

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ABSTRACT

Aim: To determine the clinical characteristics of secondary glaucoma after pars plana vitrectomy and the risk factors involved in the pathogenesis of secondary glaucoma following pars plana vitrectomy.

Study Design: Retrospective descriptive study

Duration and Settings of the Study: Data review was conducted from October 2022 to January 2023 in the Cicendo National Eye Hospital.

Methods: Clinical data were obtained from medical records of patients diagnosed with secondary glaucoma after undergoing pars plana vitrectomy from January 2019 until December 2019. Data obtained included gender, age, initial diagnoses, lens status, type of intraocular tamponades, types and onset of secondary glaucoma, and intraocular pressure (IOP) of the first and last visit of each patient in the glaucoma unit.

Results: A total of 102 patients were diagnosed with secondary glaucoma out of 1792 patients who underwent pars plana vitrectomy. Out of which 74 (72.5%) were male. Mean age was 49.54 ± 12.35 years. Most of the patients (76.4%) had a rhegmatogenous retinal detachment as an indication for vitrectomy. Phakia was the dominant lens status of the study, observed in 74 patients (72.5%). Vitrectomy with silicone oil constituted the most frequently performed procedure (74.5%). Silicone oil 1300 cSt was the most predominant tamponade employed in 48 patients (47.1%). Open-angle secondary glaucoma was the most prevalent in this study, seen in 90 patients (88.2%). Secondary glaucoma was commonly diagnosed within 1 week to 3 months post-op (64.7%).

Conclusions: Secondary glaucoma is a common complication following pars plana vitrectomy, generally presenting as an open-angle glaucoma. Secondary glaucoma can develop in both early and late postoperative periods, often linked to the tamponade agents employed. The natural crystalline lens demonstrates a protective mechanism against secondary glaucoma.

Keywords: Secondary Glaucoma; Pars Plana Vitrectomy; Intravitreal Tamponades.

INTRODUCTION

Glaucoma is a group of progressive optic neuropathies characterized by degeneration of retinal ganglion cells and their axons, alongside changes in the optic disc and visual field defects.[1] The rise of Intra-Ocular Pressure (IOP) is recognized as the predominant risk in progression of glaucoma.[1] Other factors associated with glaucoma include race, sex, family history of glaucoma, old age, diabetes, severe myopia, and reduced central corneal thickness.[2,3] Glaucoma is the number one cause of irreversible blindness globally.[4] In 2010, an estimated 60.6 million individuals globally were affected by glaucoma, with projections indicating an increase to 76 million by 2020 and 111.8 million by 2040.[5] In Indonesia, based on the 2007 'Riset Kesehatan Dasar', the prevalence of glaucoma is approximately 0.46%. This equates to 4 to 5 individuals per 1000 people in Indonesia who suffer from glaucoma.[6]

The rise of IOP is a frequently documented occurrence following vitreoretinal surgeries. The phenomenon occurs in 19 to28% of all procedures, with many cases

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progressing into secondary glaucoma.[7] In addition, Gadia, *et al* reported that 14% of total cases of secondary glaucoma is caused by vitreoretinal surgeries.[8] The mechanisms underlying secondary glaucoma following pars plana vitrectomy may arise directly from the surgical procedure or due to the utilization of tamponade agents, such as Silicone Oil (SO) and gas. The estimated incidence of secondary glaucoma post Pars Plana Vitrectomy (PPV) ranges from 15% to 20%. Furthermore, the incidence of secondary glaucoma associated with silicone oil and gas tamponade is 56% and 58.7%, respectively. These findings indicate that PPV and the use of tamponade agents are major factors to the development of secondary glaucoma.[9,10]This study describes the clinical characteristics of secondary glaucoma following PPV at Cicendo National Eye Hospital Bandung from January to December 2019.

METHODS

The research method used in this study was a retrospective descriptive method. The subjects of the study were patients diagnosed with secondary glaucoma after undergoing PPV during the period from January to December 2019 at the Cicendo National Eye Hospital Bandung.

The inclusion criteria in this study comprised of the following: (1) Patients diagnosed with secondary glaucoma after undergoing pars plana vitrectomy, exhibiting elevated IOP above 21 mmHg measured by Goldmann applanation tonometer. (2) Patients who have undergone anterior chamber examinations via gonioscopy. (3) Patients with at least 2 consultations in the glaucoma unit. The exclusions were the presence of an IOP rise attributable other causes, such as prior history of primary open angle glaucoma, and incomplete or inaccessible medical records.

Variables obtained from medical records included age, sex, history of prior ocular surgery, types of tamponade agent used, onset of secondary glaucoma, and IOP at first and final visit in the glaucoma unit.

RESULTS

Between January 1 and December 31 of 2019, a total of 1792 patients underwent PPV. Based on the inclusion and exclusion criteria, 102 patients were enrolled in this study.

Table 1: Clinical Characteristics of Patients

Characteristics	Frequency (N=102)	(%)
Male	74	72.5
Female	28	27.5
Age in year		
<20	3	2.9
21-40	20	19.6
41-60	62	60.8
>60	17	16.7
Diagnosis		
Retinal Detachment	78	76.4
Macular Hole	7	6.9
Diabetic Retinopathy	6	5.9
Lens Drop	5	4.9
Vitreous Hemorrhage	3	2.9
Vitreous Fibrosis	1	1
Retinal Vein Occlusion		1
Intraocular Foreign Body	1	1
Lens Status		
Phakia	74	72.5
Pseudophakia	13	12.8
Aphakia	15	14.7

n=Numbers, %=Percentage, <=Less than, >=More than

Table 1 displays the clinical characteristics of patients diagnosed with secondary glaucoma following PPV. Majority of the patients in this study were male, comprised of 74 patients (72.5%). The mean age in this study was 49.54 ±12.35.

Table2: Characteristics of Vitrectomies Performed

Characteristics	Frequency (N=102)	(%)
Tamponade Agents		
C_3F_8	9	8.8
SF_6	7	6.9
SO 1300 cSt	48	47.1
SO 5000 cSt	18	17.6
SO 5500 cSt	2	2
Heavy fluid	1	1
Oxane HD	7	6.8
Cairan	9	8.8
Udara	1	1
Prior History of PPV		
No Prior History	84	82.4
Prior History	18	17.6
SO Duration (weeks)		
< 4	1	1.3
4-11	7	6.8
12-24	41	40.2
25-48	17	16.7
>48	4	3.9
Emulsification	17	16.7
SO Evacuation	70	68.6

PPV: Pars Plana Vitrectomy, SO: Silicone Oil, C_3F_8: Octofluoropropane, SF_6: Sulfur hexafluoride, cSt: Centistokes, HD: High Density, n=numbers, %=Percentage

Table 2 presents the characteristics of PPV

procedures. PPV with SO was the most common, done in 76 patients (74.5%). In this study, 84 patients (82%) underwent vitrectomy for the first time, while 18 patients (18%) had a prior history of vitrectomy. SO with a viscosity of 1300 cSt is the most frequently employed type of tamponade. SO evacuation was performed in 70 patients (68.6%), whereas 6 patients (5.8%) had not undergone SO evacuation at the last visit. The average duration of SO use in this study is 23.21 ± 11.35 weeks.

Table 3. Types and Onset of Secondary Glaucoma

Characteristics	Frequency (N=102)	(%)
Types of Secondary Glaucoma Open-Angle	90	88.2
Closed-Angle Onset of Secondary Glaucoma	12	11.8
1st day	0	0
>1 day - ≤1 week	21	20.6
>1 week - ≤ 3 months	66	64.7
>3 months - ≤6 months	10	9.8
>6 months - ≤12 months	5	4.9

n=Numbers, %=Percentage, >More than, =less than, ≤ less than or equal

As shown in Table 3, the predominant type of secondary glaucoma was open-angle secondary glaucoma, seen in 90 patients (88.2%). Secondary glaucoma onset was observed between 5 days and 8 months following vitrectomy

The IOP data from the first and last visits to the glaucoma unit were noted. Mean IOP at the first visit was 38.13 10.72 mmHg, while the mean intraocular pressure at the last visit was 19.33 ±8.42mmHg.

DISCUSSION

In this study, we observed a 5.7% occurrence rate of secondary glaucoma following PPV. Our result is lower compared to a 2010 study by Idrus, *et al* that reported an occurrence rate of 6.3%.[11] Demographic data indicates that majority of the subjects in this study were male. This finding aligns with a study by Gadia, *et al* that also reported that secondary glaucoma after PPV is more frequently observed in males.[8]

The predominant age range in this study is 41-60 years, with a mean age of 49.54 ± 12.35 years. The findings in this study demonstrate that the productive age group of 41-60 years is the most prevalent age range for the occurrence of secondary glaucoma after PPV. In addition to the productive age that increases risk of ocular trauma, inflammatory response is hypothesized to contribute to this phenomenon. This aligns with results of a study by Pillai, *et al* which explains that patients under 50 years of age demonstrate elevated risks of secondary glaucoma following PPV due to more significant inflammatory response.[12,13]

Retinal detachment is the most prevalent preoperative diagnosis, occurring in 74.5% of patients. This finding demonstrates a high prevalence of secondary glaucoma post-vitrectomy in patients diagnosed with retinal detachment. Idrus, *et al* reported a similar finding, indicating that 89% of patients with secondary glaucoma following PPV had retinal detachment as their preoperative diagnosis.[11]

The pathophysiology of glaucoma following PPV can be directly linked to the procedure itself and/or the employment of tamponade agents. The removal of vitreous humor via PPV may facilitate diffusion of oxygen from the vitreous cavity to the anterior chamber, potentially causing oxidative stress in the trabecular meshwork causing disturbance in outflow of aqueous humor leading to elevation of intraocular pressure.[9,14] The rise of IOP due to the employment of SO can occur in the early and late postoperative period. In the early postoperative period, high IOP may be due to overfilling of the SO, pupillary block, SO migration, inflammation, and/or ocular hypertension induced by steroid. On the other hand, Secondary glaucoma associated with SO in the late postoperative period can be attributed to pupillary block, synechia angle closure, rubeosis iridis, and SO migration.[15]

Secondary glaucoma linked to the use of intraocular gases as tamponade agents can be attributed to the concentration used. Expansive gases induce open-

angle secondary glaucoma if the rate of expansion exceeds the outflow rate of aqueous humor or if the expanded volume is bigger than the capacity of the vitreous cavity. Secondary open-angle glaucoma can also occur with the use of non-expansive gases, resulting from the shift of the iris lens diaphragm or due to iridocorneal apposition with or without pupillary block. The concentration of gas tamponade used in vitrectomy depends on the consideration of the retinal surgeon. In clinical practice, incorrect usage of gas concentrations may occur, resulting in the application of high concentrations that can elevate post-operative IOP.[10]

SO is the most common endotamponade utilized in cases of retinal detachment, including cases enrolled in this study. So as a tamponade agent presents few advantages. The transparent and viscous properties enable the patient to see through the SO bubble. SO can also be left within the vitreous cavity for an extended duration, allowing for increased time for retinal reattachment.[16,17]

In this study, we observed 11.8% incidence rate of emulsification in the 1300 cSt SO, which is higher than that in high viscosity silicone oils such as the 5000 cSt or the Oxane HD. This finding corresponds with multiple studies that indicate lower rate of emulsification in SO with higher viscosity.[15] The process of emulsification is directly associated with two physical properties of SO: molecular weight and viscosity. SO with higher viscosity and heavier molecular weight exhibits stronger molecular bonds, resulting in reduced propensity for dispersion and emulsification of the molecules.[18,19]

The mean duration of SO use was observed to be 23.21 ± 11.35 weeks. Extended duration of SO use is linked with an increased incidence of secondary glaucoma, as extended duration correlates with emulsification of SO.[18] Emulsified SO will be phagocytosed by macrophages. Macrophages may accumulate in the trabecular meshwork, leading to obstruction as a result of trabeculitis. Longer duration of SO use also facilitates prolonged interaction between the trabecular meshwork and SO. Prolonged interaction between the two may result in structural changes in the trabecular meshwork, leading to ineffective drainage.[20]

Our study found a reduction of IOP in 94.3% of patients who underwent SO removal. Our finding is consistent with a study by Daniel, *et al* which demonstrated that SO removal effectively reduced IOP in 90% of patients who had elevated IOP associated with SO.[21] SO removal is routine procedure performed when adequate retinal reattachment is confirmed or when complications arise, such as emulsification or secondary glaucoma.[22] There is no exact consensus on when a SO evacuation should be performed, but it is most often removed at around three to six months postoperatively. The timing of SO removal differs between patients, with the objective of optimizing retinal reattachment while mitigating complications associated with prolonged SO durations, particularly emulsification.[21]

Secondary glaucoma manifested earlier in individuals with intraocular gases than in those with SO, with a mean onset of 43.12 ± 8.67 days. The earlier onset of secondary glaucoma associated with the use of intraocular gases is linked with the gas' rapid volume expansion. The volume of SF_6 will double within 24-48 hours and persist for 10-14 days, while the volume of C_3F_8 will quadruple within 48-72 hours and last for 48-72 hours.[9,23] At maximum volume expansion, the rate of expansion will exceed the drainage rate of the eye, leading to elevation of IOP. Elevated IOP subsequent to gas endotamponade is transient and typically resolves spontaneously within a week after post-surgery.[10,24]

Secondary glaucoma following PPV with SO occurred earlier in pseudophakic and aphakic eyes, compared to phakic eyes. This finding corresponds with the results of Chang, *et al* which indicated that secondary glaucoma associated with SO demonstrated a delayed onset in phakic patients relative to pseudophakic patients. The lens is thought

to play a role in mitigating the risk of secondary glaucoma following PPV by serving as physical barrier that inhibits SO migration into the anterior chamber. The lens also acts as a protective mechanism against oxidative stress that may arise from vitrectomy, potentially damage to the trabecular meshwork.[19]

In this study, Secondary open-angle glaucoma constituted 88.2% of all secondary glaucoma diagnoses, making it the most prevalent form. This finding indicates that the pathophysiology of secondary glaucoma following PPV, resulting either directly from oxidative damage or indirectly from the employment of tamponade agents, generally presents as an open-angle mechanism. A study by Han, *et al* reported similar findings, demonstrating that secondary open-angle glaucoma was diagnosed in 80% of secondary glaucoma cases post-PPV.[25]

Total 18% of patients in this study had a previous history of PPV. History of multiple PPV is linked to a progressive optic disc damage, as it increases incidence rate of postoperative ocular hypertension. This may progressively result in optic disc enlargement, ultimately leading to retinal ganglion cell death and subsequent visual field defects.[7]

We acknowledge our notable limitations present in this study, including short follow-up period and its retrospective, non-comparative character. Future studies should implement a longer follow-up duration to enhance the understanding of secondary glaucoma following PPV. A comparative study between different tamponade agents would provide valuable insights regarding into their safety and efficacy. Further studies with these implementations would yield crucial information for clinicians and researchers, facilitating for an improved treatment decisions and potentially decreasing the incidence of secondary glaucoma following PPV.

CONCLUSION

Secondary glaucoma is a frequently reported complication following PPV, generally presenting as an open-angle type. IOP may increase in both the early and late postoperative periods, typically linked to the type of tamponade agents used. Intraocular gases pose challenges related to high postoperative IOP. The natural crystalline lens serves as a protective mechanism against the development of secondary glaucoma.

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Ethical Approval:

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Author(s) Contributions

AMAY: Writing of the original draft, Data curation and Formal analysis.

MRD: - Supervision and guidance during the research process, Provided revision to the original draft, Validation of theory written in the original draft and Provided final approval for publishing

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