Evaluation of Vitreous Substitutes in Managing Complicated Vitreo-retinal Surgeries

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Abstract

Background: Vitreous substitutes presently in use for intraoperative tamponade are perfluorocarbon liquids (PFCL) and for post operative tamponade are silicon oil (SO), sulphur hexafluoride (SF₆) and perfluorocarbon gas (PFC). Several factors are important for a thorough understanding of each of these vitreous substitutes. The absorption or necessity for removal, indications for use (including clinical studies and special surgical methods), additives and complications of use have to be considered.

Methods: Three port standard pars plana vitrectomy was performed in 60 consecutive cases requiring intra-vitreous intervention. PFCL was used intra-operatively in 30 cases (PFCL group and X group). The eyes were implanted with SO (silicon oil subgroup), PFC (C₃F₈ sub-group) and SF₆ (SF₆ sub-group) in twenty cases each. Apart from best corrected visual acuity (BCVA), the retinal status and the longevity of gas when used, changes and reaction in both the anterior and posterior segments were noted.

Result: The difference of postoperative BCVA in the PFCL and non-PFCL groups was statistically significant with $p < 0.001$. In both the PFCL and non-PFCL groups the difference between preoperative and postoperative BCVA was statistically significant with $p < 0.0001$. All three vitreous substitutes studied are effective given the case where they had been utilised.

Conclusion: PFCL is invaluable in the management of complicated retinal detachment (RD). Where a vitreous microsurgery is indicated, the visual outcome is good. SF₆ is useful for short-term tamponade. Silicon oil and C₃F₈ are useful for longer tamponade.

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Key Words : Tamponade; Perfluorocarbon liquids; Silicon oil; Sulphur hexafluoride; Perfluorocarbon gas; Retinal detachment

Introduction

Complicated vitreo-retinal surgical disorders like complicated rhegmatogenous retinal detachments (RRD), tractional retinal detachments due to various disorders notably proliferative diabetic retinopathy, post-traumatic vitreous haemorrhage and retained intra-ocular foreign bodies with or without retinal detachment pose a great surgical problem. The aim of surgery is not only to relieve the tractions but also to keep the retina in a continuous state of attachment from inside. Various vitreous substitutes have been used for assistance in surgeries as additional instruments for re-establishing vitreous volume, in separating membranes attached to the retina and to mechanically flatten the retina. Agents have also been developed for the maintenance of the attached retina in the postoperative period for sufficient time so as to achieve natural attachment.

The perfect vitreous substitute would be re-growth of the human vitreous with all of its hyaluronic acid (sodium hyaluronate), collagen fibrils, and electrolytes.

This seems an unlikely achievement even in the distant future. The presently available vitreous substitutes, based on their physical mechanism, are divided into aqueous miscible vitreous substitutes such as balanced salt solution and aqueous immiscible substances such as fluorinated silicon oils, perfluorocarbon liquids (PFCL), air and other gases. The immiscible substances depend on their surface tension to seal retinal breaks either temporarily or on a long term basis. These vitreous substitutes are also broadly divided into intraoperative and postoperative agents. Of the agents available, those presently in use are perfluorocarbon liquid PFCL for intraoperative tamponade, silicon oil (SO), sulphur hexafluoride (SF₆) and perfluorocarbon gas (PFC) for postoperative tamponade. Several factors are important for a thorough understanding of each of these vitreous substitutes. The mode of action and physical properties such as surface tension and viscosity must be considered. Biocompatibility, including direct toxicity, immune response, inflammatory response and in some cases, foreign body response is important. The

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absorption or necessity for removal, indications for use (including clinical studies and special surgical methods), additives and complications of use have also to be considered [1]. There is paucity in literature of a single study that has evaluated all these agents. A study was therefore conducted at a tertiary care eye centre to study the efficacy and utility of these common vitreous substitutes, specifically for the following:

- To evaluate use of special tamponades in the vitreous cavity such as expanding gases like SF_6 , perfluorocarbon octane (C_3F_8) and silicon oil after completion of vitreo-retinal surgery.
- To evaluate intraoperative use of perfluorocarbon liquids PFCL in cases of vitreoretinal surgery.

Material and Methods

Consecutive cases requiring vitreo-retinal surgery were taken for consideration of the study.

Cases of nuclear drop or drop of nuclear fragment wherein PFCL would have been used for the floatation of the same were excluded. Cases of posterior dislocation of intraocular lenses, cases of macular hole and cases that did not settle after the second surgery (after silicon oil injection) were not taken up for study.

Under local/general anaesthesia standard three port pars plana vitrectomy was performed. The intraoperative surgical technique was planned as per the case. During the procedure for which pars plana vitrectomy had been employed, if there was any difficulty encountered, PFCL was used and the same was removed on settling of the retina and completion of the endolaser.

Agent for long term tamponade was decided by the preoperative status and the retinal condition on intraoperative retinal settlement. If the retina showed no subretinal bands and if it settled without PFCL then SF_6 was used. In all other situations either C_3F_8 or SO was used. If the retina did not settle with SF_6 or with C_3F_8 , the eye was taken up for injection of SO. *In all cases where SO/ C_3F_8 / SF_6 were to be injected, it was done so after a fluid-air/ PFCL-air exchange. The gas mixture used was 20% [2].*

Whenever silicon oil was injected, an inferior peripheral iridotomy (Ando's Iridotomy) was performed either on the table or by YAG laser iridotomy in the postoperative period in aphakic/ pseudophakic eyes. Silicon oil was removed when the complications of the oil were seen to set in. Prior to the removal, 360° laser delimitation was done at the posterior edge of the buckle.

Postoperatively all patients were examined daily for first three days and subsequently on day 7, 10, 4, 21, 28, 35 and thereafter every four weeks. These patients were followed up postoperatively for a further period of eight weeks. On each postoperative visit the best corrected visual acuity (BCVA) was estimated. Detailed anterior segment examination was done by slit lamp biomicroscopy for the status of the cornea and lens and for signs of any intraocular inflammation.

Intraocular pressure was measured with applanation tonometer where possible and by non-contact tonometer otherwise. Decongestive measures were instituted as per the case. Fundus examination was done by binocular indirect ophthalmoscope. The main criteria on fundus evaluation were (i) status of retinal settlement, (ii) amount of gas mixture in the vitreous cavity where gas was used and (iii) any untoward effect of the gas when used. The data was then tabulated and the results were analysed.

A total of 60 cases were taken up for the study. In 30 cases retina was settled with the use of PFCL group. In the remaining 30 cases retina was settled without the use of non PFCL group. The comparison between these two groups was taken up for study. For long term tamponade the entire study was divided into three sub groups of 20 each and were grouped silicon oil sub-group (SO), SF_6 sub-group (SF_6) and C_3F_8 sub-group (PFC).

Results

The age of the study group ranged from four years to 72 years but half the patients were between 51 to 70 years. Fifty (83.33%) patients were male. There was no statistically significant difference between the two main groups as regards age and sex distribution.

The commonest condition treated was retinal detachment accounting for 32 (53.34%) cases. PFCL was mainly used in cases of retinal detachment followed by cases of trauma. Other cases which required intravitreal intervention could be managed without the use of PFCL (Table 1).

In the non PFCL group, which consisted of eyes wherein PFCL was not used in the procedure, 24 (80%) cases were of etiologies other than retinal detachment. The BCVA preoperatively was < hand movement close to the face (HMCF) in all cases which improved to > 6/36 in 19 (63.33%) eyes (Table 2).

In the PFCL group, 26 (86.66%) cases were of retinal detachment. The BCVA preoperatively was < HMCF in all cases of this group also. In 27 eyes the post-operative BCVA was between 5/60 to 6/36 with the improvement of BCVA > 6/36 seen in five (16.66%) eyes only (Table 3).

The difference between the three postoperative subgroups is not statistically significant. The statistical analyses of BCVA preoperatively with BCVA postoperatively in the three subgroups did not show any significance.

Half the cases where SO was used were cases of retinal detachment and 30% of the remaining cases were cases of trauma (Tables 4 a, b).

In the 20 cases wherein PFC was used 19 (95%) cases were of RD. The longevity of the gas was about 35 days (Tables 5a, b).

Half the cases were eyes with vitreous haemorrhage wherein the gas was injected at the end of the procedure for any iatrogenic break or suspicion of the same (Tables 6a, b). The longevity of the gas was 10-14 days.

Table 1**Various conditions treated**

Diagnosis	No of cases (%)	Non PFCL (%)	PFCL used (%)	SO (%)	PFC (%)	SF ₆ (%)
Retinal detachment	32 (53.34)	06 (20)	26 (86.67)	10 (50)	19 (95)	03 (15)
Trauma	13 (21.67)	09 (30)	04 (13.33)	06 (30)	01 (05)	06 (30)
Vitreous haemorrhage	11 (18.33)	11 (36.67)	-	01 (05)	-	10 (50)
Endophthalmitis	40 (6.66)	04 (13.33)	-	03 (15)	-	01 (05)
Total	60 (100)	30 (100)	30 (100)	20 (100)	20 (100)	20 (100)

Table 2**Pre and postoperative BCVA in non PFCL group**

BCVA	Non PFCL (%)	
	Preoperative	Postoperative
6/6	0 (0)	1 (03.33)
6/9 – 6/18	0 (0)	14 (46.67)
6/24 – 6/36	0 (0)	4 (13.33)
6/60 – 5/60	0 (0)	9 (30)
HMCF*	17 (56.67)	2 (06.67)
PL+	13 (43.33)	0 (0)
Total	30	30

* Hand movement close to face

Table 3**Pre and postoperative BCVA in PFCL group**

BCVA	PFCL (%)	
	Preoperative	Postoperative
6/6	0 (0)	0 (0)
6/9 – 6/18	0 (0)	0 (0)
6/24 – 6/36	0 (0)	5 (16.66)
6/60 – 5/60	0 (0)	22 (73.34)
HMCF	18 (60)	3 (10)
PL+	12 (40)	0 (0)
Total	30	30

Discussion

Vitreo-retinal disorders that require intravitreal intervention can range from cases which improve with simple and minimal intervention to cases which require complicated intravitreal manoeuvre. Cases of retinal detachment which require intravitreal surgery are those complicated by severe proliferative vitreo-retinopathy (PVR) and in these cases apart from peroperative tamponade there is a requirement of prolonged postoperative tamponade which can be delivered either by SO or PFC. This study corroborates these facts with half the study group consisting of cases of retinal detachment and 29 (90.62%) of these cases requiring long-acting tamponade like SO/PFC.

Vitreous substitutes are either used for intraoperative use or for postoperative tamponade. The only agent available for intraoperative use is PFCL. This heavy liquid helps in the surgery as the extra hand and facilitates intraoperative manoeuvres like membrane peeling,

Table 4a**Pre-operative BCVA in silicon oil subgroup**

BCVA	PFCL (%)	Non PFCL (%)	Total (%)
HMCF	3 (15)	6 (30)	9 (45)
PL+	10 (50)	1 (5)	11 (55)
Total	13 (65)	7 (35)	20 (100)

Table 4b**Postoperative BCVA in silicon oil subgroup**

BCVA	PFCL (%)	Non PFCL (%)	Total (%)
6/6	0 (0)	0 (0)	0 (0)
6/9 – 6/18	0 (0)	1 (5)	1 (5)
6/24 – 6/36	3 (15)	0 (0)	3 (15)
6/60 – 5/60	9 (45)	4 (20)	13 (65)
HMCF	1 (5)	2 (10)	3 (15)
PL+	0 (0)	0 (0)	0 (0)
Total	13 (65)	7 (35)	20 (100)

Table 5a**Preoperative BCVA in PFC subgroup**

BCVA	PFCL (%)	Non PFCL (%)	Total (%)
HMCF	8 (40)	6 (30)	14 (70)
PL+	3 (15)	3 (15)	6 (30)
Total	11 (55)	9 (45)	20 (100)

Table 5b**Postoperative BCVA in PFC subgroup**

BCVA	PFCL (%)	Non PFCL (%)	Total (%)
6/6	0 (0)	0 (0)	0 (0)
6/9 – 6/18	0 (0)	5 (25)	5 (25)
6/24 – 6/36	0 (0)	1 (5)	1 (5)
6/60 – 5/60	9 (45)	3 (15)	12 (60)
HMCF	2 (10)	0 (0)	2 (10)
PL+	0 (0)	0 (0)	0 (0)
Total	11 (55)	9 (45)	20 (100)

dissection and retinal settlement. Therefore PFCL is used more often in cases wherein these procedures become difficult and are obviously more complicated. This is corroborated by the present study as about nine-tenths of the cases of retinal detachment required intraoperative PFCL aid. The surgical outcome in many of these complex cases has improved with the free use

Table 6a**Preoperative BCVA in SF₆ subgroup**

BCVA	PFCL (%)	Non PFCL (%)	Total (%)
HMCF	1 (5)	1 (5)	2 (10)
PL+	5 (25)	13 (65)	18 (90)
Total	6 (30)	14 (70)	20 (100)

Table 6b**Postoperative BCVA in SF subgroup**

BCVA	PFCL (%)	Non PFCL (%)	Total (%)
6/6	0 (0)	1 (5)	1 (5)
6/9 – 6/18	0 (0)	8 (40)	8 (40)
6/24 – 6/36	2 (10)	3 (15)	5 (25)
6/60 – 5/60	4 (20)	2 (10)	6 (30)
HMCF	0 (0)	0 (0)	0 (0)
PL+	0 (0)	0 (0)	0 (0)
Total	6 (30)	14 (70)	20 (100)

of PFCL as reported in literature [3-5], even though the BCVA in the PFCL group has been 6/60 in comparison to 6/9 to 6/18 BCVA in the non PFCL group. These cases, where PFCL was used, had more intraretinal complications than those which were operated without PFCL aid.

Vitreous replacement surgery has improved the outcome of most cases of complicated surgical vitreo-retinal disorders. The same has also been corroborated by this study as in both the PFCL and non-PFCL groups, the difference between preoperative and postoperative BCVA is statistically significant with p value of < 0.0001.

As regards the use of various post-surgical tamponades, all the three agents were found to be effective and safe. PFC and SO have been equally useful in cases of RD. The longer duration of C₃F₈ is appealing in RD surgery but both the gases were found to be useful in other conditions as also in macular hole surgery and in pneumatic retinopathy [6-8].

PFCL, SO, C₃F₈ and SF₆ are all useful and safe vitreous substitutes. In PVR SO and C₃F₈ are useful. PFCL should be liberally used in cases of vitreous microsurgery when the need is felt and definitely in cases of PVR.

Conflicts of Interest

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Intellectual Contribution of Authors

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