

# Comparison of two techniques for the decrease of perfluoropropane gas volume in the management of retinal detachment in Thammasat hospital

Kittichai Akrapipatkul<sup>1</sup>, Grobgarn Wichitnark<sup>1</sup>

<sup>1</sup>*Department of Ophthalmology, Thammasat University, Thailand*

**Purpose:** To compare the residual gas volume of perfluoropropane C<sub>3</sub>F<sub>8</sub> after two different methods of air gas exchange procedures, namely fixed-concentration and fixed-volume, used in rhegmatogenous retinal detachment surgery.

**Methods:** A prospective, randomized clinical trial in 56 patients whose eyes were diagnosed as rhegmatogenous retinal detachment and underwent 23-gauge pars plana vitrectomy combined with laser endophotocoagulation and air-perfluoropropane gas exchange. In 28 patients whose eyes were in fixed-concentration group, air-perfluoropropane gas exchange were performed using 20% C<sub>3</sub>F<sub>8</sub> 50cc. replacing air within eye globe and the 28 eyes in fixed-volume group, 0.8 cc. of 100% C<sub>3</sub>F<sub>8</sub> was injected into the eyes. We followed up at 1 day, 1 week, and 1 month postoperatively to measure outcomes including postoperative intraocular gas volume (in percent), anatomical retinal reattachment rate and post-operative complications such as ocular hypertension and endophthalmitis.

**Results:** A total of 56 eyes (56 patients) with 23-gauge pars plana vitrectomy combined with laser endophotocoagulation and air-perfluoropropane gas exchange were performed in this study. The patients consisted of 34 men (60.7%) and 22 women (39.3%). Patient ages were between 33-84 years with a mean of 59.84 ± 10.4 years. The mean postoperative residual intraocular gas volume for the fixed-volume method after 1 day, 1 week, and 1 month were 81.25 ± 8.57%, 62.14 ± 12.87%, and 31.25 ± 11.52% respectively. And the mean postoperative residual intraocular gas volume for the fixed-concentration method after 1 day, 1 week, and 1 month were also 85.36 ± 10.71%, 70.36 ± 17.74% and 38.93 ± 16.18% respectively. There was no significant difference in residual intraocular gas volume between the two groups in 1 day and 1 week postoperatively. After 1 month, there was a difference of mean postoperative residual intraocular gas volume between 2 groups; 31.25 ± 11.52% for the fixed-volume method and 38.93 ± 16.18% for the fixed-concentration method (p<0.05). The anatomical retinal reattachment rates were 85.7% and 89.3% for the fixed-volume method and fixed concentration method respectively. There was no significant difference in the rates of ocular hypertension between two groups, and none of the patients developed postoperative endophthalmitis.

**Conclusions:** Both techniques of air-perfluoropropane gas exchange in 23-gauge pars plana vitrectomy combined with laser endophotocoagulation were comparable when considering the anatomical retinal reattachment rate, though there was a smaller intraocular gas volume in fixed-volume technique when compared to fixed-concentration technique.

**Conflicts of interest:** The authors report no conflicts of interest.

**Keywords:** Perfluoropropane gas, C<sub>3</sub>F<sub>8</sub>, Residual gas volume, Air-gas exchange procedure, Rhegmatogenous retinal detachment surgery

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**Correspondence to:**

Kittichai Akrapipatkul, Department of Ophthalmology,  
Thammasat University, Thailand  
E-mail: ktcoph@yahoo.com

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## Introduction

Intraocular gas was first used by Ohm since 1911<sup>1</sup>. He injected air into the vitreous cavity to treat rhegmatogenous retinal detachment. Perfluoropropane gas ( $C_3F_8$ ) was introduced in retinal detachment surgery by Lincoff et al. since 1980<sup>2,3</sup>. Perfluorocarbon gas is the most commonly used in retinal detachment surgery<sup>4</sup>. It was used to provide long-term internal retinal surface tamponade until chorioretinal adhesion from laser photocoagulation could be achieved. The 100%  $C_3F_8$  bubble can expand to about 4 times of its original volume within 72 to 96 hours and persist in the vitreous cavity approximately 6 to 8 weeks<sup>5,6</sup>. Although the non-expandible concentration of  $C_3F_8$  was theoretically 14% using in vitreo-retinal surgery, but Han DP. et al. found that the nonexpandible concentration of perfluoropropane could be between 12% and 20%. They found no significant difference in mean intraocular volume of  $C_3F_8$  at 36 to 48 hours among these varieties of gas concentration<sup>7,8</sup>. A long-acting intraocular gas bubble is necessary in certain circumstances, but it should not be used indiscriminately because of the need for long period of head positioning and the possible chance of complications<sup>9,10</sup> such as ocular hypertension<sup>11</sup>, cataract formation, corneal endothelial damage in aphakic eyes, intraocular inflammation and still include patient's activity such as restriction on air travel<sup>12</sup> and prolonged visual rehabilitation<sup>13</sup>. The standard technique to fill  $C_3F_8$  into vitreous cavity after fluid-air exchange is air-gas exchange. First, we use a 50-ml. syringe connected with sterile 0.22  $\mu$ m millipore filter and then infuse 100%  $C_3F_8$  10 cc. into the syringe. Thereafter, we add filtered room air continually until the total volume is 50 ml. reaching a total of 20% concentration. The last step is the infusion of mixed gas into the air-filled vitreous cavity as exchange. This is called a fixed-concentration technique<sup>14</sup>. The other technique in this study is called a fixed-volume technique. Firstly, 100%  $C_3F_8$  0.8 cc. is injected into the air-filled vitreous cavity. Then the pure gas will be mixed with the air in vitreous cavity to reach 20% concentration same as the previous technique. According to the advantages of the fixed-volume technique which include time saving for preparing gas and secondary less gas volume consumption, we would like to study whether the fixed-volume

technique differs from the fixed-concentration technique in the aspects of postoperative residual gas volume, anatomical reattachment rate and postoperative complication including ocular hypertension and endophthalmitis.

## Patients and Methods

This study was approved for ethical research in human with the human research ethics committee of Thammasat university, Thailand (Research ID: MTU-EC-OP-0-244/61).

From June 2018 to August 2019, we recruited 56 eyes from 56 patients who were diagnosed with rhegmatogenous retinal detachment in the retina clinic, at the department of ophthalmology, Thammasat university hospital.

## Patient selection

### Inclusion criteria

1. Eyes diagnosed with rhegmatogenous retinal detachment and underwent 23-gauge pars plana vitrectomy combined with laser endophotocoagulation and air-gas exchange procedure.
2. Patients who are informed and consented to surgery.
3. Patients who are able to attend a follow-up of at least 1 month postoperatively.

### Exclusion criteria

1. Patients with complicated rhegmatogenous retinal detachment such as proliferative vitreoretinopathy grade C, traumatic retinal detachment and pediatric retinal detachment.
2. Eyes with a history of prior retinal surgery.
3. Eyes with a history of pre-existing uveitis, cloudy ocular media or ocular hypertension.
4. Patients who are unable to adequately remain in prone position postoperatively.
5. Patients who are unable to consent for following the study protocol.

## Surgical technique

All patients underwent 23-gauge pars plana vitrectomy combined with laser endophotocoagulation and air-gas exchange with 20%  $C_3F_8$  under retrobulbar

anesthesia. After these operations were done, the patients were randomized into 2 groups: fixed-concentration group and fixed-volume group.

In the fixed-concentration group, the various steps were shown as follows

1. One of the sclerotomy ports was first closed without suture after pars plana vitrectomy combined with endophotocoagulation and air-fluid exchange.

2. A 50-ml syringe containing 20% C<sub>3</sub>F<sub>8</sub> was prepared by mixing 10 ml. of 100% C<sub>3</sub>F<sub>8</sub> with 40 ml. of filtered room air.

3. This prepared gas was slowly injected through the infusion cannula into the eye while intraocular air was expelled through the other unclosed sclerotomy. This allowed for exchange between intraocular air and 20% C<sub>3</sub>F<sub>8</sub>.

In the fixed-volume group, the various steps were shown as follows

1. All of the sclerotomy ports were closed after 23-gauge pars plana vitrectomy combined with endophotocoagulation and air-fluid exchange.

2. A bolus 0.8 ml. of 100% C<sub>3</sub>F<sub>8</sub> was injected intravitreally.

### Post-operative care and follow-up

The intraocular pressure was measured and recorded at 6 hours postoperatively. All eyes were prescribed both steroid and antibiotic eye drops for at least 4 weeks and all patients were followed up on the first day, first week, and first month postoperatively. In each visit of follow up, all eyes received complete eye examination and intraocular gas volume measurement were performed with slit-lamp biomicroscopy using diffuse illumination technique in the primary position of the patient's head. We estimated the intraocular gas volume by measuring the height of the gas-fluid interface level seen through the dilated pupil with the plane of the cornea perpendicular to the ground. Gas-fluid level in the eye could indicate gas volume. We reported the intraocular gas volume in percentage as shown in figure 1. Intraocular pressure was also measured by applanation tonometry in each visit. Also, all postoperative complications were recorded if detected.

### Statistical analysis

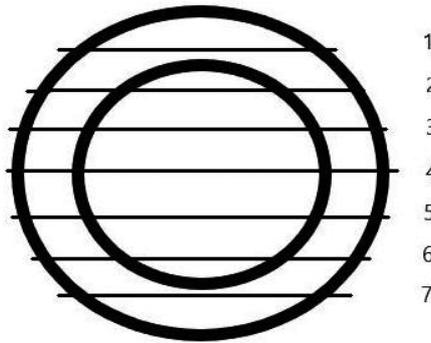
SPSS version 14.0 was used for statistical analysis in this study. The data were collected and analyzed by using mean, standard deviation and percentage. Independent t-test and Chi-square test were used for comparing the data between two groups. P-value less than 0.05 was statistically significant.

### Results

All of the demographic data of the patients were shown in table 1. There were 56 eyes of 56 patients including 34 men (60.7%) and 22 women (39.3%). The average age of patients was 59.84 ± 10.4 years old (between 33-84 years old). The site of affected eyes occurred was 31 (55.40%) on the right and 25 (44.60%) on the left. No significant difference of demographic data was found between two groups.

The mean residual intraocular gas volume and the mean difference between two techniques in 1 day, 1 week and 1 month postoperatively were shown in table 2. At 1 day postoperatively, the mean intraocular gas volume of fixed-volume group was 81.25 ± 8.57% (range, 70%-95%) and the mean intraocular gas volume of fixed-concentration group was 85.36 ± 10.71% (range, 70%-100%). At 1 week postoperatively, the mean intraocular gas volume of fixed-volume group was 62.14 ± 12.87% (range, 50%-90%) and the mean intraocular gas volume of fixed-concentration group was 70.36 ± 17.74% (range, 40%-100%). At 1 month postoperatively, the mean intraocular gas volume of fixed-volume group was 31.25 ± 11.52% (range, 20%-50%) and the mean intraocular gas volume of fixed-concentration group was 38.93 ± 16.18% (range, 10%-60%). The mean differences of post-operative intraocular gas volume between two groups in 1 day, 1 week, and 1 month postoperatively were 4.11% (95% CI, -1.09-9.30, p-value = 0.119), 8.21% (95% CI, -0.09-16.52, p-value = 0.052) and 7.68% (95% CI, 0.15-15.20, p-value = 0.046) respectively.

There were 24 eyes (85.7%) in the fixed-volume group reached successful anatomical retinal reattachment and there were also 25 eyes (89.3%) in the fixed-concentration group that reached the same result. In contrast, there were 4 eyes (14.3%) in the fixed-volume group and 3 eyes (10.7%) in the fixed-concentration group developed unsuccessful retinal attachment and



**Figure 1.** The intraocular gas volume was estimated clinically as the percentage by measuring the height of the gas-fluid interface seen through the dilated pupil with the plane of cornea perpendicular to the ground. There were 7 reference lines with the percentage of gas volume as below.

- Line 1 represented 12.5% of gas volume, an approximate value as 10% was recorded.
- Line 2 represented 25% of gas volume, an approximate value as 25% was recorded.
- Line 3 represented 37.5% of gas volume, an approximate value as 35% was recorded.
- Line 4 represented 50% of gas volume, an approximate value as 50% was recorded.
- Line 5 represented 62.5% of gas volume, an approximate value as 60% was recorded.
- Line 6 represented 75% of gas volume, an approximate value as 75% was recorded.
- Line 7 represented 87.5% of gas volume, an approximate value as 85% was recorded.

**Table 1.** Descriptive statistics in demographic data of patients in this study.

	Fixed volume (n=28)	Fixed concentration (n=28)	p-value*
<b>Age</b>	60 ± 7.88	59.68 ± 12.91	0.911
<b>Sex</b>			
Female	9 (32.1%)	13 (46.4%)	0.274
Male	19 (67.9%)	15 (53.6%)	
<b>Laterality</b>			
LE	12 (42.9%)	13 (46.4%)	0.788
RE	16 (57.1%)	15 (53.6%)	

**\*Independent t-test and Chi-square test**

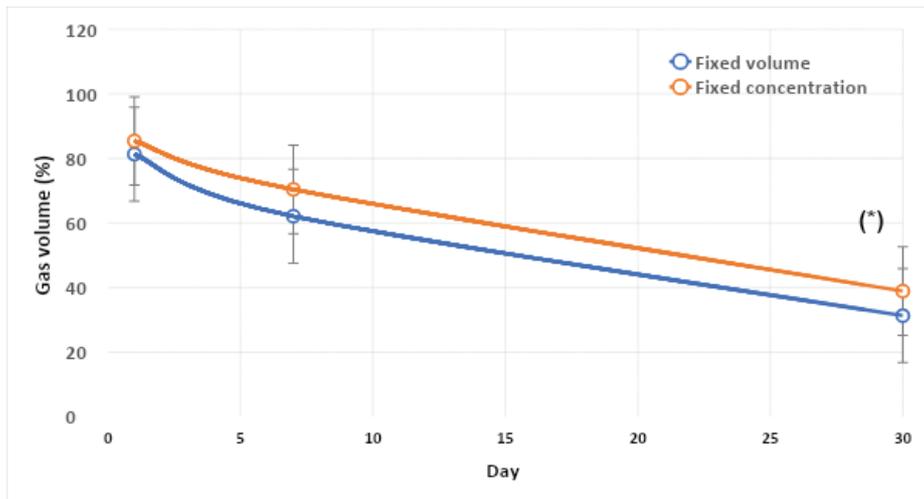
**Table 2.** Postoperative mean intraocular gas volume over time (%) and mean difference between fixed-volume group and fixed-concentration group.

	Fixed volume (n=28)	Fixed concentration (n=28)	Mean difference	95%CI	p-value*
<b>Day 1</b>	81.25 ± 8.57	85.36 ± 10.71	4.11	-1.09 to 9.30	0.119
<b>Week 1</b>	62.14 ± 12.87	70.36 ± 17.74	8.21	-0.09 to 16.52	0.052
<b>Month 1</b>	31.25 ± 11.52	38.93 ± 16.18	7.68	0.15 to 15.20	0.046

**\*Independent t-test**

underwent additional retinal surgery later. There were 12 eyes (42.9%) in the fixed-volume group and 8 eyes (28.6%) in the fixed-concentration group developed ocular hypertension after the

surgery and which required anti-glaucoma drugs for controlling intraocular pressure. None of the eyes in both groups developed postoperative endophthalmitis.



**Figure 2.** Mean intraocular gas volume over time (%) in fixed-volume group and fixed-concentration group.

### Discussion

In this study, we performed two techniques of perfluoropropane injection after 23-gauge pars plana vitrectomy combined with laser endophotocoagulation in the management of rhegmatogenous retinal detachment. The first technique was fixed-concentration technique and the second technique was fixed-volume technique. The details of these techniques were mentioned in the surgical technique section. Although two techniques were different, the final gas concentrations were theoretically quite similar. There are apparent advantages and disadvantages of these two techniques. For instance, the fixed-concentration technique normally consumed more gas volume of  $C_3F_8$  and the cost was higher than the fixed-volume technique. Underfilling of the gas in fixed-concentration technique might occur if there was any leakage at the sclerotomy port. Another advantage of the fixed-concentration technique was the lower risk of postoperative intraocular pressure rising due to non-expansile properties. For the fixed-volume technique, it consumed less amount of gas volume and less time was required for preparing gas. However, the disadvantage of this technique was the higher risk of in postoperative intraocular pressure rising, especially in smaller eyes.<sup>15</sup>

The outcome of this study showed that the mean residual intraocular gas volume of the two techniques revealed no significant difference at 1 day and 1 week postoperatively. However, there

was a smaller volume of residual intraocular gas by fixed-volume technique in 1 month postoperatively, therefore there was a significant difference between the two techniques. Overall, there was a smaller intraocular gas volume in fixed-volume technique when compared with fixed-concentration technique at every point of time. To explain this difference, there might be some technical errors during gas preparation in the fixed-volume technique which could possibly underfill the gas into vitreous cavity. There was no significant difference when considered the residual gas volume between two groups. However, there were some limitations to our study. We did not define the globe size, especially in high myopia patients that are distributed among each group. Therefore, it could lead to the variation of the intraocular gas concentration in the fixed-volume group postoperatively. In the prior study, Harvey et al. found that fixed-concentration and fixed-volume technique of perfluoropropane gas exchange were comparable in terms of post-operative intraocular gas volume, intraocular pressure and anatomical retinal reattachment rates<sup>15</sup>. Our study also showed that there was no significant difference in post-operative intraocular pressure and anatomical retinal reattachment rates between both two groups. Cankurtaran et al. reported the success rate of anatomical reattachment after pars plana vitrectomy combined with gas tamponade which was approximately 81.2%<sup>16</sup>. The report was

**Table 3.** Rate of anatomical retinal reattachment, ocular hypertension and post-operative endophthalmitis in the fixed-volume group and the fixed-concentration group.

	Fixed-volume (n=28)	Fixed- concentration (n=28)	p-value*
<b>Anatomical retinal reattachment</b>	24 (85.7%)	25 (89.3%)	0.686
<b>Ocular hypertension</b>	12 (42.9%)	8 (28.6%)	0.265
<b>Post-operative endophthalmitis</b>	0 (0%)	0 (0%)	N/A

\*Chi-square test

similar to our study in the aspect of anatomical reattachment rate. The incidence of intraocular pressure rising after air-gas exchange had been estimated to range from 18% to 59%<sup>17,18</sup>. For the safety of these two techniques, there was no post-operative endophthalmitis found in both groups. The incidence of postoperative endophthalmitis had been reported in a myriad of studies. The incidence ranged between 0.03% and 0.14% for 20 G pars plana vitrectomy<sup>19</sup>.

### Conclusion

In conclusion, after comparing both techniques of air-perfluoropropane gas exchange in rhegmatogenous retinal detachment surgery, it was found that in terms of the decreased intraocular gas volume, there was some significant differences between the two groups. The intraocular gas volume in fixed-concentration technique at every point in time intended to be much more than in the fixed-volume technique. There might be a longer internal tamponade in the fixed-concentration group occasionally. However, when anatomical retinal attachment rate was considered, there was no significant difference between these two techniques. Therefore, the fixed-volume technique which consumed less amount of gas and less time consuming should be used as the standard air-gas exchange technique for rhegmatogenous retinal detachment surgery.

**Ethics:** This study was approved for ethical research in humans with the human research ethics committee of Thammasat university, Thailand (Research ID: MTU-EC-OP-0-244/61).

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