AIR VERSUS GAS TAMPONADE IN RHEGMATOGENOUS RETINAL DETACHMENT WITH INFERIOR BREAKS AFTER 23-GAUGE PARS PLANA VITRECTOMY

A Prospective, Randomized Comparative Interventional Study

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Purpose: To compare the efficacy of air and octafluoropropane (C_3F_8) in treating rhegmatogenous retinal detachments with inferior breaks after 23-gauge pars plana vitrectomy.

Methods: A prospective, randomized comparative interventional study. Sixty-four patients with rhegmatogenous retinal detachment with inferior breaks underwent pars plana vitrectomy with air (32 eyes) or gas (32 eyes) tamponade. Anatomical and visual outcomes of the two groups were compared.

Results: The mean follow-up period was 13.09 ± 1.90 months. Significant differences were identified regarding prone positioning period ($P < 0.01$), intraocular pressure ($P < 0.01$), and gas volume ($P = 0.03$) on the first postoperative day. The single-operation success rates for the air and gas groups were 84.38% and 78.13% ($P = 0.522$), and the final surgery success rates increased to 100% and 96.88% ($P = 0.313$), respectively. The single-operation success rate between the groups was not statistically significant, even after adjustment for confounding factors. Multivariate logistic regression also indicated that the number of involved retinal quadrants (odds ratio = 19.88, $P = 0.01$) was an independent predictor of surgery failure. The only postoperative complication observed was new or missed breaks, which occurred in 12 patients (18.75%).

Conclusion: Air had equivalent tamponade effects to C_3F_8, with a shorter prone positioning period, fewer complications, and less expense, in the surgical management of rhegmatogenous retinal detachment with inferior breaks.

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Pars plana vitrectomy (PPV) with gas tamponade remains an important surgical technique in the modern era in treating rhegmatogenous retinal detachments (RRDs). Octafluoropropane (C_3F_8) and sulfur hexafluoride (SF_6) are the most widely used tamponade materials.[1,2] However, C_3F_8 and SF_6 demand good compliance of patients for long periods of postoperative prone positioning. Compared with expansile gas, room air stays for a shorter time; therefore, the prone positioning period and visual recovery can also be shortened. In addition, the greater half-life of expansile gas promotes vitreous disturbance and can delay air or mountain travel.[1] Moreover, the expansile gases are expensive, especially in developing countries or remote areas; therefore, air would be a reasonable alternative for the tamponade in patients with RRD.

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Recent studies have reported favorable results with air tamponade. Sinawat et al[3] conducted a double-blinded, randomized controlled study of 126 patients with RRD and demonstrated that the reattachment rate and visual outcomes of pneumatic retinopexy with air tamponade were comparable with those using C_3F_8. In a subsequent report, Hasegawa et al[4] noted that air tamponade could have an equivalent effect to that of SF_6 in the macular hole surgery.

The healing procedure of RRDs relies on the expanding and buoyancy features of gas that effectively closes the causative breaks and impedes the intraocular currents to the subretinal space, thus facilitating expedient healing of RRDs. However, PPV with gas tamponade is generally indicated for RRDs with retinal breaks involving the superior 8 clock hours of the fundus.[1] Therefore, inferior breaks present a surgical challenge for gas tamponade.[5,6] Several studies have explored the effects of air tamponade in treating RRD with inferior breaks; however, their conclusions have varied. Martínez-Castillo et al[7,8] conducted 2 prospective noncomparative studies that included 15 and 40 patients, respectively. They demonstrated that air tamponade was effective in the management of pseudophakic RRDs with inferior breaks. In contrast, in another retrospective study of 523 patients, Tan et al[9] found that gas tamponade was superior to air tamponade in retinal detachments (RDs) cases with the involvement of the lower quadrants, and they suggested that air tamponade should only be recommended for superior RDs.

To our knowledge, no clinical studies have specifically compared air and expansile gas tamponades for treating RRDs with inferior breaks. Therefore, we conducted a prospective, randomized controlled study to assess whether air was as effective as C_3F_8 gas in the surgical management of RRDs with inferior breaks. Provided that air tamponade had an equivalent effect to that of expansile gas, the visual rehabilitation would be much more rapid and would result in fewer complications. In addition, the medical cost of treating this disease would be significantly reduced.

Methods

Patients

Patients were recruited from the wards of the First People's Hospital of Shanghai from January 2010 to June 2013. The inclusion criteria were patients having RRDs with inferior breaks (between 4- and 8-o'clock). This disease was diagnosed based on indirect ophthalmoscopy of the RRD and was confirmed by B-ultrasonography. The exclusion criteria were: 1) a history of vitreoretinal surgery; 2) RRDs with giant retinal tears; 3) cases with proliferative vitreoretinopathy worse than grade C_1; 4) inability to cooperate with postoperative prone positioning; and 5) other severe vision-impaired eye diseases (e.g., advanced glaucoma or macular hole).

Data Collection

All the patients were fully informed of all the aspects of this procedure, and they participated in this study voluntarily without any additional compensation. The recruited patients were allocated to two groups by block randomization with varying block sizes. The patients were treated with 23-gauge PPV with either filtered air or C_3F_8 tamponade. All the participants underwent comprehensive ophthalmic examinations before and after surgery, which included the following: 1) slit-lamp examination with direct and indirect ophthalmoscopy; 2) best-corrected visual acuity using the Snellen visual acuity chart; 3) intraocular pressure (IOP), obtained using a noncontact tonometer; and 4) ocular B-ultrasonography.

Informed consent was obtained from all the patients. This study adhered to the tenets of the Declaration of Helsinki and was approved by the Shanghai Jiaotong University Research Ethics Committee.

Surgical Procedures

All the procedures were performed under retrobulbar anesthesia by the same surgeon (Q.Q.). Three-port PPV was performed using the Alcon Accurus system (Alcon Laboratories, Inc, Forth Worth, TX). After central and peripheral vitreous removal with 23-gauge incision, all the eyes underwent 360° scleral indentation to shave the vitreous base up to ora serrata, followed by the removal of all vitreous traction from retinal tears. The vitreous base shaving was going on while the scleral indentation was partially decreased. Complete fluid–air exchange was performed, and subretinal fluid (SRF) was aspirated with a flute needle. If the breaks were in the most peripheral part of the retina (located within 2 optic disk diameters to the ora serrata), and direct visualization of fluid drainage was extremely difficult, the flute needle was not used. In this condition, perfluorodecalin was used to flatten the retina first, then perfluorodecalin–air exchange was performed. The patients underwent either transscleral cryopexy (peripheral retina) or endolaser (posterior retina) to achieve retinopexy. The sclerotomy was closed by a preset figure-of-eight stitch to avoid gas leakage. At the end of the procedure in expansile gas group, 0.5 mL to 0.8 mL C_3F_8 was injected into the vitreous cavity through a tuberculin syringe with a short 27-gauge needle at

3 mm to 4 mm posterior to the limbus (in phakic eyes, 3.8 mm from limbus; in pseudophakic and aphakic eyes, 3.5 mm from limbus). The needle tip was visualized directly to ensure the formation of a single large bubble with a moderately slow speed. After introvitreal injection, a gentle pressure was maintained on the injection site with a 75% alcohol rinsed cotton-tip applicator for at least 5 minutes until the injection site was definitely closed. After injection, C_3F_8 was in an isovolemic mixture of ~12%[9] and the IOP was controlled to around 24 mmHg, slightly higher than the normal level, thus avoiding postoperative hemorrhage. All the patients were asked to maintain a tilt head posture for 3 days to 14 days.

Anatomically, a successful surgery was defined as the complete disappearance of SRF and flattening of the entire circumference of the retinal breaks.

Statistical Analysis

The data were analyzed using SAS software (version 9.2; SAS Institute, Inc, Cary, NC) and were reported as the mean ± SD or n (%). Firstly, demographic and preoperative clinical indicators of the air and gas groups were compared using either Student's *t*-test (continuous factors) or the chi-square test (categorical factors). Significant variates were considered confounders of the effect of tamponade type on surgery success. After controlling for these potential confounders, the single-operation success rate between the groups was compared using multivariate logistic regression analyses. All the tests were two-sided, and a $P < 0.05$ was considered statistically significant.

Results

A total of 64 patients participated in this study. The mean follow-up period was 13.09 ± 1.90 months. Of the 64 cases, 32 were treated with air tamponade and the other 32 were treated with C_3F_8 gas tamponade. The demographic and preoperative clinical data for both groups are shown in Table 1. No statistical significance was noted regarding age, gender, duration of symptoms, grade of proliferative vitreoretinopathy, number of patients with lattice degeneration, and lens status at surgery. However, the gas group had more retinal breaks and detached retinal quadrants and enrolled higher number of myopic eyes than the air group.

The postoperative clinical characteristics for the air and gas groups are summarized in Table 2. All the eyes achieved improved best-corrected visual acuity postoperatively. The two groups did not significantly differ in final IOP, primary and final reattachment rate. However, on the first postoperative day, the IOP of the gas group (16.41 mmHg) was much higher than that of the air group (11.47 mmHg). The gas volume of C_3F_8 (86.90%) was significantly greater than the air volume (75.30%). The prone positioning period for the air group was 4.20 ± 0.51 days, which was notably shorter than that of the gas group (13.51 ± 0.72 days). The single-operation success rates for the air and gas groups were 84.38% and 78.13%, and the final-operation

Table 1. Demographic and Preoperative Clinical Characteristics of Patients

	Total	C_3F_8	Air	*P*
Gender				0.606
Male	40	19	21	
Female	24	13	11	
Age, years	55.55	53.91	57.19	0.241
Duration of symptoms, days	20.89	19.84	21.94	0.356
Number of retinal breaks	2.11	2.59	1.63	0.002
Number of quadrants involved	3.13	3.5	2.75	<0.01
PVR				1.00
B	62	31	31	
C1	2	1	1	
With high myopia	10	9	1	0.013
With lattice degeneration	26	15	11	0.309
Lens status at operation				0.356
Phakic	62	30	32	
Pseudophakic	1	1	0	
Aphakic	1	1	0	

PVR, proliferative vitreoretinopathy.

Table 2. Postoperative Clinical Characteristics of Patients

	Total	C_3F_8	Air	*P*
Follow-up period (months)	13.09	13.34	12.84	0.30
IOP on the first postoperative day (mmHg)	13.94	16.41	11.47	<0.01
IOP at the last visit (mmHg)	16.94	16.84	17.03	0.58
Gas volume on the first postoperative day (%)	80.10	86.90	75.30	<0.01
Prone position period (days)	8.85	13.51	4.20	<0.01
Lens status at the last follow-up				0.781
Phakic	42	20	22	
Pseudophakic	10	6	4	
Aphakic	12	6	6	
Primary reattachment rate (%)	81.25	78.13	84.38	0.522
Final reattachment rate (%)	98.44	96.88	100	1.000
New or missed breaks	12	7	5	0.522

Table 3. Potential Risk Factors Predicting Surgery Success

	Success	Failure	*P*
Number of retinal breaks	2.02	2.50	0.25
Highly myopia			0.08
Yes	6	4	
No	46	8	
PVR			0.34
B	51	11	
C1	1	1	
Lattice degeneration			0.04
Yes	18	8	
No	34	4	
Number of quadrants involved	2.96	3.83	<0.01
Lens status at operation			0.79
Phakic	50	12	
Pseudophakic	1	0	
Aphakic	1	0	

PVR, proliferative vitreoretinopathy.

success rates increased to 100% and 96.88%, respectively. Obviously, the single-operation and final-operation success rates in the air group compared favorably with those in the gas group; however, neither of them reached statistical significance.

Table 3 shows that the number of involved retinal quadrants (odds ratio = 6.75, $P = 0.01$) and lattice degeneration (odds ratio = 3.78, $P = 0.05$) were potential confounding factors of the effect of tamponade type on surgery success. The odds ratios and their 95% confidence intervals are shown in Table 4. However, the difference in success rate between the groups was not statistically significant, and this trend was not weakened after adjustment for confounding factors (Table 5). The results in Table 5 also indicate that the number of involved retinal quadrants was an independent risk factor for surgery success (odds ratio = 19.88, $P = 0.01$). The only complication observed after surgery was new or missed breaks, which occurred in 12 patients (18.75%). Air–fluid exchange and cryopexy were carried out under indirect ophathalmoscopy in nine patients, and two patients received vitrectomy with silicone oil tamponade as salvage treatment, and no one had recurrent RD until the last follow-up. The other one patient gave up further treatment for economic reasons. No one received scleral buckle as the primary or salvage management in our study.

Table 4. Univariate Logistic Regression of Risk Factors for Surgery Success

	OR	95% CI	*P*
Gender (female vs. male)	1.24	0.35–4.46	0.74
Age (years)	1.05	0.98–1.13	0.19
Tamponade (air vs. gas)	0.66	0.19–2.36	0.52
Duration of symptoms (days)	0.97	0.87–1.07	0.49
Number of retinal breaks	1.30	0.83–2.03	0.26
Number of quadrants involved	6.75	1.65–27.69	<0.01
PVR (C1 vs. B)	4.63	0.27–79.94	0.29
With high myopia (yes vs. no)	3.83	0.88–16.69	0.07
With lattice degeneration (yes vs. no)	3.78	1.00–14.27	0.05

CI, confidence interval; OR, odds ratio; PVR, proliferative vitreoretinopathy.

Table 5. Multivariate Logistic Regression of Risk Factors for Surgery Success

	OR	95% CI	*P*
Tamponade (air vs. gas)	10.31	0.81–130.46	0.07
Number of retinal breaks	1.40	0.64–3.07	0.375
Number of quadrants involved	19.88	1.81–218.43	0.01
With high myopia (yes vs. no)	2.59	0.27–24.71	0.41
With lattice degeneration (yes vs. no)	1.49	0.20–11.16	0.70

CI, confidence interval; OR, odds ratio.

Discussion

The results of this prospective, randomized controlled study indicated that air tamponade had equivalent effects with C_3F_8 gas tamponade in the management of RRDs with inferior breaks. The number of quadrants involved in RD was an independent predictor of surgery failure.

Rhegmatogenous retinal detachment with inferior breaks remains a challenge to intraocular gas tamponade. According to the literature, the single-operation success rate varied from 76.9% to 93.3%,[6–8,10–13] and the final-operation success rate ranged from 95% to 100%.[7–9,11,12] Our findings (primary success rate: 81.25%, final success rates: 98.44%) were similar to previously reported results.

From our observations, the single-operation and final-operation success rates in the air group compared favorably with the gas group but neither reached statistical significance. Consistent with our findings, Sinawat et al[3] compared the reattachment rate of pneumatic retinopexy with 0.3 mL of air and C_3F_8 gas tamponade (single-procedure success rate: 60.3 vs. 73%; final-procedure success rate: 96.8 vs. 92.1%), and no significant difference was noted. However, their study population was different from ours, because they only included patients with superior retinal breaks. Hasegawa et al[4] also demonstrated that room air had equivalent tamponade effects to SF_6 in macular hole surgery (single-operation success rate: 92.3 vs. 90.1%). Less favorable results were also reported. In a retrospective study of 285 cases, Tan et al[9] demonstrated that SF_6 gas tamponade was superior to air tamponade in RD cases with the lower quadrants involved (single-operation success rate: 84.7 vs. 69.6%). Potential explanations for this discrepancy might lie in the multiple surgeons of diverse experiences, intraocular tamponade variances, dissimilar patient selection criteria, and varied sample sizes.

Previous studies have indicated that long-acting and expansile gas could cause vitreous disturbance and could thus increase the risks of elevated IOP, proliferative vitreoretinopathy, and new or missed breaks.[1,14,15] Because of the short-acting and nonexpansile nature of air, it was no surprising to see that the air group had less new or missed breaks, a shorter prone positioning period, and a lower IOP on the first postoperative day in our study. Early in 1990, Carim[16] initially described using the intravitreal injections of 0.35 mL to 0.4 mL of filtered room air to tamponade retinal breaks. Three years later, Sebag and Tang[17] reported that pneumatic retinopexy using a 0.8-mL air injection could accomplish a high rate of reattachment (86.7%), good visual outcomes, and low incidences of proliferative vitreoretinopathy, premacular membrane, and new or missed breaks. Later in a prospective case series of 15 patients, Martínez-Castillo et al[7,8] reported that PPV with air tamponade was effective in the management of pseudophakic RRDs with inferior breaks even without facedown position postoperatively (single-operation success rate: 90%,[8] 93.3%[7]; final-operation success rates: 100%[7,8]). Compared with expansile gas, the potential disadvantage of a larger volume of air was balanced by its quicker resolution. Therefore, even on the first postoperative day, the remained gas volume in the air group was notably smaller than that in the gas group. The quicker resolution of air could also result in faster visual recovery and less disturbance to the vitreous. Previous study[8] also showed that the time for the tamponade agents to close the retinal breaks was within the early hours (especially the first 24 hours) after surgery. After that time, fluid will not enter the subretinal space through the break. Regarding expense, air is far less expensive than expansile gas, consequently, using air tamponade could most likely achieve significant cost savings for medical care.

The results of our study indicated that the number of quadrants involved was a significant independent factor predicting surgery failure. A previous study[18] that included 975 patients with RD also supported this finding by demonstrating that each additional clock hour involved in RD was associated with a 13% increased risk of surgery failure. Therefore, special attention should be paid when treating patients with RD with large retinal areas involved. The average extension of RD was 3.13 quadrants in our study (Table 1). In addition, most of our patients had severe vitreous liquefaction and elevated equatorial holes with static traction, or a combination of these factors. Therefore, we did not choose scleral buckle as primary or salvage management for these patients, although a large previous study indicated that scleral buckle resulted in higher primary success rate in patients with phakic RRD compared with vitrectomy.[19]

Gas accomplishes retina reattachment by the tamponading of retinal breaks with an intraocular gas bubble, and supplementary cryopexy or laser is used to induce chorioretinal adhesion. The property of surface tension of intraocular gas bubble and its buoyancy are the main mechanism for closing retinal breaks and enhancement of SRF absorption.[20–22] In addition, vitreoretinal surgical expertise in performing the surgery is also of great importance. Firstly, remove the vitreous as completely as possible around retinal breaks and in the periphery at the vitreous base. This can be obtained by doing complete PPV and 360° vitreous base shaving under prism lens with a greater magnification. Triamcinolone was used to visualize the vitreous in young patients for their insufficient vitreous liquefaction. Secondly, a complete fluid–air exchange was essential. Subretinal fluid was drained with a flute needle until the graylike circumference of the retinal break disappeared, and then moved the flute needle to above the optic disk to drain the fluid completely. If the retinal break was in the far periphery, SRF drainage with appropriate head positioning could allow for fluid to easily come out. If direct visualization of fluid drainage was extremely difficult, perfluorodecalin was deemed necessary. With fully filled perfluorodecalin, most retinas were flattened. However, in a very few patients, the perfluorodecalin sealed the break and made SRF accumulated in the peripheral part. In this condition, partial perfluorodecalin–air exchange was performed until the fluid–gas interface was at the posterior edge of the break, and then drained peripheral SRF slowly until the retina was completely attached. These methods obviated the need for a posterior retinotomy. Furthermore, sclerotomy should be securely closed. A figure-of-eight stitch was preset around cannula, when the assistant pulled out the infusion cannula, the knot tying was made immediately, thus avoiding gas leakage.

This study should be regarded as an initial exploration regarding 23-gauge PPV with air tamponade used for RRDs with inferior retinal breaks compared with expansile gas tamponade. However, caution should be exercised when interpreting the findings because of a number of limitations. Firstly, our sample size was small, and all the patients were recruited from a single tertiary institution. These factors might have caused selection bias, and our results might not generalize to the entire RRD population. Secondly, the follow-up period was 13.09 months, which was a relatively short time to determine the long-term prognosis for a treatment. Nevertheless, it is noteworthy that the strengths of this study are its prospective, randomized, and comparative nature.

Overall, despite no significant difference in the reattachment rate between the air and gas groups, air tamponade was associated with a shorter prone positioning period, fewer complications (i.e., new or missed breaks, elevated postoperative IOP), and less expense. However, to our knowledge, this study was the first and only evaluation that compared the anatomical and visual outcomes between air and expansile gas tamponades in the management of RRDs with inferior breaks. Therefore, a large series from multiple clinical centers with a long-term follow-up is needed to fully validate this surgical approach.

Key words: rhegmatogenous retinal detachment, inferior retinal breaks, air tamponade.

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