

Air tamponade and without heavy liquid usage in pars plana vitrectomy for rhegmatogenous retinal detachment repair

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Abstract

• **AIM:** To report the results of rhegmatogenous retinal detachment (RRD) repair after pars plana vitrectomy (PPV) without operative use of heavy liquid, and utilizing air tamponade in selected cases.

• **METHODS:** RRD patients without severity of proliferative vitreoretinopathy C₂ or more underwent PPV without operative use of heavy liquid, and utilizing air tamponade were consecutively enrolled. Alternative postoperative facedown position or lateral position was required for 3-5d.

• **RESULTS:** Totally 36 eyes of 36 patients (24 males, 66.7%) aged 53.8±10.9y underwent this modified surgery. The mean number of retinal break was 2.1±1.3. Most of the eyes (29, 80.6%) had retinal detachment involving more than one quadrant. Twenty-two (61.1%) eyes with cataract had combined phacoemulsification and intraocular lens implantation. The mean follow up time was 4.6±1.8mo. Two eyes with retinal redetachment underwent a second retinal repair surgery with silicone oil tamponade, yielding the primary reattachment rate to 94.4% (34/36). Six (16.7%) eyes had intraocular pressure higher than 25 mm Hg. The visual acuity (logMAR) improved from 0.98±0.74 preoperatively to 0.52±0.31 postoperatively (*P*<0.001).

• **CONCLUSION:** The success rate of this modified retinal repair surgery is comparable with traditional surgery. This technique can be considered for certain retinal detachment patients, since its apparent advantages included lower surgical complications, reduced surgery expenditure, shorter time for postoperative facedown position, and avoiding silicone oil removal surgery.

• **KEYWORDS:** air; heavy liquid; rhegmatogenous retinal detachment; pars plana vitrectomy

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INTRODUCTION

Rhegmatogenous retinal detachment (RRD) is a common vitreoretinal disease which would cause sudden and painless loss of vision. It is characterized by the sign of separation of the neurosensory retina from the retinal pigment epithelium layer due to the presence of retinal breaks and vitreous synchysis. Usually, these breaks are caused by vitreous traction on the retina and allow the accumulation of fluid beneath the retina. At the present, pars plana vitrectomy (PPV) with different types of vitreous tamponade, including long-term gas or silicone oil, followed by facedown positioning for various durations, is considered as the most common and effective treatment for RRD^[1-3]. The procedure of PPV has undergone significant modifications since its original conception and has evolved along with advances in materials, instrumentation, and surgical techniques. Nowadays, the primary success rate of the PPV is up to 90%^[3-5].

At the end of the surgery, long-term gas or silicone oil is alternatively used for vitreous tamponade to provide a sustained pressure to achieve retinal reattachment. However, 11%-42% of the eyes with silicone oil tamponade would have elevated intraocular pressure (IOP)^[6-9]. Besides, it was reported that facedown position may have some potential complications, including acute angle closure of contralateral eye, ulnar neuropathy and decubitus^[10-13]. Additionally, long-term gas tamponade may delay air travel due to the air expand and consequent high IOP when travel to high altitude^[14]. Moreover, postoperative facedown position per se for one to several weeks seems an ordeal for almost all patients, especially for elder patients, young children, pregnant women, or patients with cervical spondylosis, coronary heart disease, pulmonary or bronchial disease, or obesity. In the past decade, several studies have reported a satisfying efficacy of air tamponade for RRD with superior or inferior retinal breaks after PPV^[15-20]. However, heavy liquid (perfluorodecalin C₁₀F₁₈, or perfluorooctane C₈F₁₈) was usually used operatively.

Heavy liquid, characterized by its higher density than water, transparent appearance, close refractive index compared to the vitreous, and certain surface tension, is usually temporarily used operatively to facilitate the subretinal fluid drainage out from the retinal break, and flatten the retina. However, this procedure has the risk of residual heavy liquid entering the subretinal from the retinal break. It has been reported that the residual heavy liquid in the vitreous chamber could cause retinal damage, including loss of outer and inner segments, retinal necrosis, and vacuole formation in the retinal layers of rabbits^[21-22]. To our knowledge, no clinical studies have specifically reported the surgical outcomes of RRD after PPV without operative use of heavy liquid, utilizing only air tamponade. Hence, we conducted a prospective clinical observational study to report the outcomes of this surgery.

SUBJECTS AND METHODS

RRD patients who underwent PPV surgery without operative use of heavy liquid, and utilizing only air tamponade from January 2017 to August 2017 at the Eye Hospital of Wenzhou Medical University were consecutively enrolled. The inclusion criteria for this surgery were: 1) patients older than 18y; 2) RRD; 3) retinal break ≤ 6 papilla diameter. The exclusion criteria were: 1) ocular penetrating trauma history or traumatic RRD; 2) proliferative vitreous retinopathy (PVR) grade C2 or greater; 3) retinal detachment (RD) caused by proliferative diabetic retinopathy (PDR); 4) RD caused by macular hole. Postoperative follow up shorter than 3mo was also excluded for this study.

The study followed the tenets of the Declaration of Helsinki and was approved by the Ethics Committee of the Eye Hospital of Wenzhou Medical University. All participants signed a written and informed consent.

Surgical Techniques and Steps All patients underwent similar surgical procedure by the same surgeon (Wu RH). PPV was performed using a 23-gauge system (Constellation Vitrectomy System; Alcon, Fort Worth, Texas, USA) after retrobulbar anesthesia with a 50% mixture of 2% lidocaine and 0.75% bupivacaine. The main steps of the surgery are described below.

1) Three cannulae were established 3.5 to 4.0 mm from the limbus. Phacoemulsification would be performed for patients with cataract; 2) a core vitrectomy was performed, followed by peripheral vitrectomy, using a wide-angle viewing system. The retinal break flap(s) as well as the vitreous around the retinal breaks was removed completely to make sure no more traction; 3) the vitrectomy probe was placed close to the retinal break to gradually aspirate the subretinal fluid with great care until the detached retina became flat. If the break was larger than the vitrectomy probe, the vitrectomy probe was placed beneath the retinal break and then moved outwards gradually with great care to aspirate the subretinal fluid. No drainage retinotomy was performed; 4) the peripheral retina was

inspected to determine whether there were any retinal breaks or degenerative areas; 5) a complete fluid-air exchange was performed. Confluent photocoagulation (at least two rows) or cryotherapy (cryotherapy spot was approximately 1 mm wider than the break area) was performed to seal the retinal breaks; 6) the intraocular lens (IOL) was implanted, if needed. Finally, the cannulae were removed.

Alternative postoperative facedown position or lateral position, except for meals or short breaks, was required for 3-5d. The patients were required to stay in hospital for at least 3d. During the admittance, patients were frequently visited and the postoperative position was confirmed. Only tobradex (*qid*) and tropicamide (*qn*) were instilled post operation.

Complete ocular examinations were performed in each patient, including slit lamp, uncorrected visual acuity, best-corrected vision acuity (BCVA), IOP, and fundus examination, before and after surgery. The number, location, type, and size of RD and retinal breaks were recorded. The patients were routinely followed up at 1wk, 1, 3mo, and then followed up as necessary. All Snellen visual acuity values were converted to the logarithm of the minimum angle of resolution (logMAR) for statistical analysis. Visual acuity of counting fingers was assigned 2.3, hand movements 2.6, and light perception 2.9^[21]. Primary retinal reattachment rate, visual acuity, operative and postoperative complications were presented. A *P* of <0.05 was considered statistically significant. All statistical analysis was performed with Statistical Analysis System for Windows version 9.1.3 (SAS Inc., Cary, NC, USA).

RESULTS

Thirty-six eyes of 36 patients (24 males, 66.7%) aged 53.8 ± 10.9 y were enrolled for this study. The median (lower and upper quartiles) duration of the symptoms was 13 (7, 30)d. The mean number of retinal break was 2.1 ± 1.3 . Majority of the eyes ($n=31$, 83.8%) with breaks located in equator or posterior, while rest located in peripheral or ora serrata. There were 10 (27.8%) eyes had at least one break 3 papilla diameter or larger, 20 (55.6%) eyes had multiple (2 to 6) breaks, 8 (22.2%) eyes had dispersive multiple breaks (located ≥ 3 clock hours apart), and 14 (38.9%) eyes had at least one break between 4 and 8 o'clock. The mean RD extent was 4.6 ± 2.7 clock hours. Most of the eyes (29, 80.6%) had RD involving more than one quadrant. Three (8.3%) eyes had a whole RD. The macula was detached preoperatively in 20 eyes (55.6%). The detailed information of these eyes was presented in Table 1.

Twenty-two (61.1%) eyes with cataract had combined phacoemulsification and IOL implantation. No intraoperative complication was observed. One eye had phacoemulsification and IOL implantation 4mo after initial PPV. The mean follow up time was 4.6 ± 1.8 mo. Until the last follow up, 2 eyes had retinal redetachment, yielding 94.4% of the primary reattachment rate. A second retina repair surgery with silicone

Table 1 Patients preoperative characteristics

Variable	Data
Age (mean±SD, y)	53.8±10.9
Gender (male/female)	24/12
Right/left eye	19/17
Duration of symptoms, d (median, lower and upper quartiles)	13 (7, 30)
BCVA, logMAR (mean±SD)	0.98±0.74
IOP (mean±SD, mm Hg)	12.1±3.0
Lens status (phakic/pseudophakic)	34/2
Macula involved (on/off)	20/16
Number of breaks (mean±SD)	2.1±1.3
Number of breaks (single/multiple)	16/20
Dispersive breaks (n, %)	8, 22.2
Size of breaks (mean±SD, PD)	1.8±1.6
Detachment extent (mean±SD, clock hour)	4.6±2.7
Detachment quadrant (single/multiple)	7/29
Axial length (mean±SD, mm)	25.14±2.78

SD: Standard deviation; BCVA: Best-corrected visual acuity; IOP: Intraocular pressure; PD: Papilla diameter. Dispersive breaks were defined as retinal breaks located ≥ 3 clock hours apart.

oil tamponade was then performed for both eyes. Until the last follow up (9.3mo and 7.3mo respectively), the retina of both eyes were reattached with silicone oil tamponade in one eye and removed in another eye.

Until the last follow up, the overall BCVA (logMAR) improved from 0.98±0.74 preoperatively to 0.52±0.31 postoperatively ($P<0.001$), from 1.12±0.57 to 0.45±0.40 ($P<0.001$) for macula on eyes, and from 0.79±0.89 to 0.39±0.36 ($P=0.08$) for macula off eyes. Thirty (83.3%) eyes had BCVA improved 0.1 or better. No significant difference between the preoperative IOP and IOP at last follow up (12.1±3.0 vs 12.3±2.8 mm Hg, $P=0.56$). Six (16.7%) eyes had IOP higher than 25 mm Hg in the postoperative follow up, ranging from 26 to 50 mm Hg, five of them occurred at 9-11d post operation. After anti-glaucoma medication, all the eyes had normal IOP (<21 mm Hg) within 2d.

DISCUSSION

The retinal toxicity of heavy liquid and long-term gas (especially C_3F_8) have been reported in rabbits^[21-23]. However, no evident damage caused by air tamponade was found^[23]. Extensive periods of postoperative facedown position, and numerous possible postoperative complications after long-term gas or silicone oil tamponade are considered to be disadvantages for patients with RRD repair. The long-term gas tamponade will also hinder the patient from air travel before its absorption since a decrease in atmospheric pressure to high altitude can cause intraocular gas expansion, and further retinal

ischemia^[14]. Hence, avoiding the use of heavy liquid and long-term gas or silicone oil tamponade would have definite advantages and tangible benefits.

Previous studies have shown the safety and efficacy of air tamponade for RRD repair with superior or inferior retinal breaks after PPV^[15-20]. In the past decade, Martinez-Castillo *et al*^[15,19-20] have conducted 3 prospective studies successively, and demonstrated that air tamponade even without facedown position was effective in the management of pseudophakic RRDs with inferior breaks. Recently, in a randomized comparative study, Zhou *et al*^[16] also suggested that air tamponade had equivalent effects to C_3F_8 . Although one study suggested that air tamponade should only be recommended for superior RDs. This study further demonstrated its efficacy on postoperative tamponade for primary RRD. The primary retinal reattachment rate of air tamponade is high (96.6%) and comparable with previous studies with air tamponade (81%-97%)^[16-20,24-25]. Two eyes had recurrent RD in this study. The first patient was a 38-year-old male with a break located in 7:30 o'clock, who had phacoemulsification and IOL implantation 4mo after initial PPV because of the post-vitrectomy cataract. However, he had developed choroidal RD and PVR 3wk after the phacoemulsification surgery. This yielded the primary retinal reattachment rate to 92.9% to the eyes with inferior break, similar as previous studies^[19-20]. A second retinal repair surgery with silicone oil tamponade was then performed. The original break was sealed but a macular hole was found during the surgery. The second patient was a 52-year-old male with pathologic myopia, who underwent phacoemulsification plus IOL implantation and scleral buckling 11 and 5y ago in the same eye, respectively. A new retinal break (at 9 o'clock, close the edge of original cryotherapy spot) caused recurrent RD after primary scleral buckling. The retina was flat at day 6 post this PPV operation. At day 13 post-operation when the patient came to visit, he reported an apparent visual acuity decrease for 5d. After the fundus examination, we found the break redetached and enlarged. A second retina repair surgery with silicone oil tamponade was then performed. The retina was still attached after the silicone oil was removed 6mo later. We believe the key factor in recurrence may due to poor compliance (poor postoperative position), since one of the patients reported that he had even driven at day 5 post operation.

There were several reasons which may explain to the high success rate in this study, certainly careful case selection and operative examination of the fundus would have contributed. This study excluded young patients, eyes with ocular trauma, PVR grade C2 or greater and RD caused by PDR, factors known to predispose to recurrent RD. However, this study did not limitedly include patients with only superior retinal break or with limited RD. There were approximately 40% of the eyes

with at least one retinal break between 4 and 8 o'clock, near 30% of the eyes had break 3 papilla diameter or larger, 20% of the eyes had dispersive multiple breaks, and 80% of the eyes had RD involved more than one quadrant. Vitreoretinal surgical expertise also played a major role in the management of these cases. The complete vitreous removal, including the vitreous around the breaks and periphery at the vitreous base, and thorough aspiration of the subretinal fluid were the key techniques. Different factors influence the percentage of intravitreal air during the early postoperative period, such as the extent of peripheral vitrectomy, amount of subretinal fluid drained intraoperatively, lens status, and closure of sclerotomies. Martinez-Castillo *et al*'s^[19-20] studies indicated that the key time required for the tamponade agents to close the retinal breaks was within the early hours after surgery. After that time, once the chorioretinal adhesion develops, fluid will not enter the subretinal space through the break^[15,20]. However, generalization of these conclusions should be done with great caution, since the RD cases vary widely. Hence, after a complete removal of the vitreous and aspiration of the subretinal fluid, the maximal space seemed to be created for the air tamponade. This greatest extent of air tamponade may be beneficial for the postoperative chorioretinal adhesion. Patient compliance and monitoring (postoperative positioning) are vital to the success of the operation. Patients were carefully counseled about this surgery, and informed about the extremely high risk for secondary surgery without good postoperative position in this study. The patients were allowed to have facedown position (with inferior retinal break at 5-7 o'clock) or have alternatively facedown or lateral position (without inferior retinal break at 5-7 o'clock), according to the location of retinal breaks, when sitting, walking, lying down, or sleeping after the surgery. This adjustable postoperative position was proved to be safe and effective based on our previous work^[5]. The patients' postoperative position was monitored and instructed for at least 4d in the hospital. Another important and practical reason to use air tamponade was the unavailability of long-term gas in China from around September 2016. While no better ocular tamponade material is available at present, using silicone oil tamponade for all types of RD would definitely constitute overtreatment. Similar situation is faced for macular surgery, such as giant macular hole and macular hole RD. The visual acuity apparently improved post operation, not only because of the retinal repair, but also the combined cataract surgery performed in half of the eyes. No operative complication was found in this study, while a small portion (16.7%) of the eyes had ocular hypertension, most of which occurred at the second week post operation. The air would be absorbed completely at a mean of 10.9d after surgery^[20], the exact reason for the ocular hypertension was unclear.

Multiple breaks with large detachment extent (5 eyes) that had more severe postoperative aseptic inflammation reaction, pathological myopia (3 eyes) that was more sensitive to steroid eye drops, may be the reasons for this ocular hypertension.

Important limitations remained in this study. Firstly, the sample size was small. Secondly, the fact that all the patients were enrolled from a single tertiary institution, and underwent the operation by a single surgeon, may have certain selection bias and undermine its generalization. Thirdly, the follow up time was relatively short, hence it was difficult to draw a long-term conclusion. In addition, there was no control group and as such this work warrants further studies.

In summary, this study suggested that with proper case selection and surgical procedure, operative use of heavy liquid could be avoided; furthermore, short-term air tamponade is safe and effective for retinal reattachment, under the premise of thorough removal of vitreous traction, aspiration of subretinal fluid, and sealing the retinal breaks.

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