A Comparative Study of Vitrectomy Combined with Internal Limiting Membrane Peeling for Idiopathic Macular Hole of different hole diameters with Air or C3F8 Intraocular Tamponade

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Research article

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Abstract

Background—Vitreotomy and membrane peeling followed by gas filling technique has become a standard procedure of macular hole surgery, the outcomes are affected by many factors, and which kind of intraocular tamponade is the best choice still has some conflicts. The purpose of this study is to investigate whether air filling can achieve comparable effects to long-acting inert gases when different macular hole sizes are enrolled.

Methods—116 patients with idiopathic macular hole were enrolled in this retrospective study, 44 received C3F8 tamponade and 72 received sterile air tamponade. Before and after vitrectomy surgery, the best corrected visual acuity, slit lamp examination, fundus examination and intraocular pressure were analyzed.

Results—No statistically significant difference was found in age, gender, axial length, intraocular pressure, or preoperative visual acuity between groups. After the surgery, the closure rates of air group and C3F8 group with macular hole diameter ≤ 400 microns were 94.4% and 100.0%, with no significant difference between the two groups ($P = 0.701$). The closure rates of macular hole diameters larger than 400 microns are 66.7% and 91.3%, $P = 0.029$. The total closure rates of the two groups are 80% and 95.6%, $P = 0.018$.

Conclusions—In idiopathic macular hole surgery, the effect of air as an intraocular tamponade material is similar to that of C3F8 in macular hole with diameters less than 400 microns. In patients with larger macular hole (diameter over 400 microns) performed therapeutic surgery with air filling, internal limiting membrane insertion or flap inversion may be recommended get better outcomes.

Background

Idiopathic macular hole (IMH) with the prevalence approximately 4/1000 in people over 40 years of age is more commonly seen in woman, and leads to loss of central vision, distortion of vision, and central scotoma [1]. Although the exact etiology of IMH remains to be further explored, optic coherence tomography (OCT) studies have demonstrated that the vitreofoveal traction plays an important role in the formation of IMH [2, 3]. Thus, the vitreoretinal surgery becomes the mainstream of intervention of IMH. In recent years, the procedure for treating IMH is pars plana vitrectomy (PPV) with peeling of the internal limiting membrane (ILM) and intraocular gas tamponade followed by a prone position for several days [4].

Gas tamponade, such as perfluoropropane (C3F8), perfluoroethane (C2F6), and sulfur hexafluoride (SF6), has been used in macular hole surgery. Studies showed that the gas tamponade can cause cataracts, elevated intraocular pressure, secondary glaucoma, and other complications [5]. Sterile room air is used as another intraocular tamponade has been proved with shorter absorption time, fewer prone position days. Many studies have done on comparison between gas tamponade [6, 7]. However, there are fewer reports about the use of air for intraocular tamponade. Hideaki et al found that room air filling may provide equally prompt functional and morphological recovery as well as a comparable rate of MH

closure compared with SF₆ gas tamponade, especially for smaller macular hole [8, 9]. Chen et al demonstrated that the effect of air as an intraocular tamponade material can be similar to that of C₃F₈ with fewer complications [10]. However, Gesser et al found that the air tamponade effectiveness is poor [11].

IMH is conventionally staged using the classification devised by Gass [12]. And the stage, minimum and basal diameter of the IMH, and preoperative visual acuity have been reported as preoperative factors of favorable IMH surgery outcomes [13, 14]. Therefore, this study retrospectively analyzed patients with IMH of different macular hole diameter underwent vitrectomy to investigate whether the room air has the same efficiency as the gas tamponade.

Patients And Methods

Study Design and Patients

This was a retrospective and nonrandomized study about the evaluation of closure rate of patients with IMH. Patients with idiopathic macular hole were included who consulted the Eye Hospital of Wenzhou Medical University between October 2014 and October 2018, who underwent transconjunctival 23-gauge pars plana vitrectomy for treatment and were followed up for 1 months or longer (till the macular hole healed). A total of 120 eyes from 116 patients (32 men and 84 women) aged 37–85 years (average age of 64.3 years) were identified. This study was approved by the Ethics Committee of Eye hospital of Wenzhou medical university.

The inclusion criteria were patients with IMH receiving vitrectomy combined with internal limiting membrane peeling followed by air or gas filling. Patients with other ocular diseases, such as an epiretinal membrane (ERM), ocular trauma, macular edema, retinal detachment, glaucoma, previous vitreoretinal surgery, diabetic retinopathy, and high pathological myopia (axial length exceeding 26.0 mm and/or > 6 diopters) were excluded.

Methods

All surgeries were performed under retrobulbar anesthesia and carried out by a single surgeon. Phacoemulsification with posterior chamber intraocular lens implantation was performed simultaneously in 118 of 120 eyes (98.3%). The surgery consisted of a standard 3-port transconjunctival 23-gauge pars plana vitrectomy, and core vitrectomy was performed after the creation of a posterior vitreous detachment (PVD). After visualization using indocyanine green, the ILM was grasped at the temporal raphe to avoid damaging the retinal nerve fiber layer. It was then peeled off for 2- to 4-disc areas around the macular hole. Finally, a fluid-air exchange was performed. Intraocular tamponade with sterile room air or 15%-20% C₃F₈ was applied at the end of the surgery. The patients were instructed to remain in a prone position for at least 7 days with C₃F₈ as tamponade and at most 7 days with sterile air in vitreous cavity.

Patients underwent secondary surgery by the same surgeon when the macular hole did not anatomically close or caused retinal detachment. IML in peri-macular area was peeled and inserted into the macular hole. A fluid- air exchange was performed and intraocular tamponade with sterile air was applied. A prone position was suggested for 3–7 days.

Main Outcome Measures

The basic parameters of patients, such as age, sex, involved eye, axial length, were noted. All patients underwent preoperative and postoperative ophthalmic examinations. The anterior segment was examined by slit-lamp, and evaluation of the posterior pole was performed by indirect ophthalmoscopy. Axial length was measured preoperatively by the IOL-Master 500 (Carl Zeiss, Dublin, CA, USA). The BCVA and intraocular pressure (IOP) were measured before surgery and at 1 day, 1 week and 1 month after the operation. At each follow-up visit, BCVA, IOP, and optical coherence tomography (OCT) images were recorded. The BCVA was converted to the logarithm of the minimum angle of resolution (logMAR) scale for statistical analysis. Measurements of IOP were carried out using non-contact tonometry (cannon TX20).

On the basis of OCT scans, anatomic closure of macular hole was defined as the flattening of the hole with resolution of subretinal cuff fluid. The macular hole was anatomically unclosed if the neurosensory retina (NSR) did not attach to the underlying RPE, and “intraretinal cysts” were present at the edges of the macular hole [14].

Statistical Analysis

The BCVA results were converted to logMAR equivalents. Statistical analysis was performed using independent-samples t test, paired-samples t test, Pearson Chi-Square, Fisher's exact test, and Pearson Correlation. A P value ≤ 0.05 was considered statistically significant. The statistical analyses were performed with SPSS, software version 16.0 (SPSS Inc., Chicago, IL).

Results

A total of 120 eyes of 116 consecutive patients with IMH were enrolled in this study, and 118 of 120 eyes (98.3%) underwent phacoemulsification with intraocular lens implantation. The room air group had 72 patients (75 eyes), and the C3F8 group had 44 patients (45 eyes). The average age of room air group was 63.36 ± 7.93 years, and that of the C3F8 group was 64.74 ± 12.29 years, $P = 0.465$. The gender ratios (male/female) of room air group and C3F8 group were 18/57 and 15/30 separately, $P = 0.268$. The eye differs (OD/OS) were 34/41 and 21/24, $P = 0.887$. The mean axial lengths were 23.45 ± 0.80 and 23.49 ± 0.78 microns, $P = 0.774$. The mean preoperative logMAR visual acuities were 1.02 ± 0.44 and 1.00 ± 0.41 , $P = 0.748$ (Table 1).

Table 1
Patient characteristics

Group (n)	Age (SD)	Sex, M/F	OD/OS	Axial length, mm (SD)	Preoperative LogMAR VA (SD)
Air (75)	63.36(7.93)	18/57	34/41	23.45 (0.80)	1.02 (0.44)
C3F8 (45)	64.71(12.29)	15/30	21/24	23.49 (0.78)	1.00 (0.41)
P	0.465	0.268	0.887	0.774	0.748
M, male; F, female; LogMAR, logarithm of minimal angle resolution; VA, visual acuity; SD, standard deviation.					

In this study, patients of the room air group and C3F8 group were classified according to the minimal macular hole diameter and were divided into 2 groups. The MH diameters of 2 groups were ≤ 400 microns and > 400 microns. No significant difference was found in the constituent ratios between the 2 groups, and the P values were 0.925 and 0.925 (Table 2).

Table 2
The diameter of macular hole of air group and C3F8 group.

Diameter of MH, μm	Air group	C3F8 group	P
≤ 400	36/75	22/45	0.925
> 400	39/75	23/45	0.925
MH, macular hole.			

The follow up time was at 1 week and 1 month separately. BCVA, OCT and other ocular factors were measured at each follow up visit. The BCVA was converted to the logarithm of the minimum angle of resolution (logMAR) scale for statistical analysis. The postoperative BCVA of both air group and C3F8 group were improved significantly, and the P-values were 0 separately (Table 3). The postoperative logMAR visual acuity scores for the two groups were 1.08 and 1.08 at 1 week, 0.79 and 0.66 at 1 month after the surgery, no statistical difference was found with $P = 0.703$ and $P = 0.144$ (Table 3).

Table 3
Comparison of preoperative and postoperative logMAR visual acuity

Group(n)	Preoperative logMAR VA, (SD)	Postoperative, logMAR VA, (SD)	
		1 week	1 month
Air (75)	1.02 (0.44)	1.08 (0.40)	0.79 (0.43) ^a
C3F8 (45)	1.00 (0.41)	1.08(0.58)	0.66 (0.47) ^b
P	0.748	0.703	0.144
Comparison of logMAR visual acuity before surgery and 1 month after surgery: air group, a: P = 0; C3F8 group, b: P = 0. VA, visual acuity; SD, standard deviation.			

The structure of the macular area was examined by OCT preoperatively and at every follow up visit after the surgery. These results suggest that the closure rates of air group and C3F8 group with macular hole diameter ≤ 400 microns were 94.4% and 100.0%, with no significant difference between the two groups ($P = 0.701$). While significant difference of closure rate is found between groups when macular hole diameter was larger than 400 microns, with closure rate 66.7% and 91.3%, $P = 0.029$. The total closure rates of the two groups are 80% and 95.6%, $P = 0.018$ (Table 4). 2 patients in C3F8 group and 15 patients of air group undergo secondary surgery 1 month after the first surgery, and all macular hole was anatomically closed.

Table 4
The closure rates of air group and C3F8 group of different MH diameters.

Diameter of MH, um	Closure rates		
	Air group	C3F8 group	P
≤ 400	94.4% (34/36)	100.0% (22/22)	0.701
> 400	66.7% (26/39)	91.3% (21/23)	0.029
All	80.0% (60/75)	95.6% (43/45)	0.018
MH, macular hole.			

Discussions

Macular hole was first described by Henry Noyes in 1871[16]. Since then many studies had been carried out in order to illustrate the formation and pathogenesis of macular holes. OCT studies have demonstrated that the vitreofoveal traction plays an important role in the formation of idiopathic macular hole. However, it was not until 1991, when Kelly and Wendell reported the first successful closure of a

series of macular holes by pars plana vitrectomy and membrane peeling, macular hole was described as an incurable disease. Kelly and Wendel used room air to fill the vitreous cavity and required that the patients stay prone position for one week [17]. Intraocular gas may form a surface tension which exclude subretinal fluid from the macular hole and provides a scaffold for glial proliferation, and those may promote the closure of macular hole [18, 19]. To maximize the effects of gas and improve the closure rate of macular hole, long-lasting gas tamponades, such as SF₆, C₂F₆, and C₃F₈, are used as standard practice in macular hole surgery [20]. Recently, some studies have demonstrated that room air can have similar outcomes to long-lasting gas, but the conclusions of these studies are limited because they only macular holes with small diameters were included [8, 9, 10]. Gesseret al. reported that the initial closure rate for air as a tamponade for MH surgery was only 79%, about 10% lower than that reported in other studies with long-acting gas tamponades [11]. The conclusions of those studies are somewhat controversial.

The Gass stage, minimal and basal diameter of the MH, and preoperative visual acuity have been reported as preoperative factors of MH surgery outcomes [13, 14]. One study indicated that when the diameters of MHs were less than 400 μ m, the closure rates were approximately 92–97%, while MHs with diameters greater than 500 μ m showed a closure rate of just 50% [21]. Thus, MH diameters, especially the minimal and basal diameters, are important issues in macular hole closure. Our study has shown that the closure rates of air group and C₃F₈ group with small macular hole (diameter less than 400 microns) are 94.4% and 100.0%, the closure rates of macular hole diameters over 400 microns are 66.7% and 91.3%, and the total closure rates of the two groups are 80% and 95.6%. The closure rate of air group is dramatical reduced as the minimal MH diameter increases, and is lower than that of C₃F₈ group with the same MH diameter. The closure rates of groups were statistically significant, but the lager the minimal MH diameter was, the lesser closure rate of air group got, which indicated that we should take minimal diameter as important factor in choosing the surgical procedures.

2 patients in C₃F₈ group and 15 patients of air group undergo secondary surgery 1 month after the first surgery, and all macular hole closed. The minimal MH diameter of patient with unclosed MH in C₃F₈ group was over 900 microns, and patients were diagnosed with MH derived retinal detachment 1 month after the primary macular hole surgery, silicon oil is employed in the secondary surgery. 6 patients with unclosed MH of air group undergo fluid-gas exchange and vitreous cavity insufflation, and the rest 9 patients are treated with IML peeling, insertion of IML flap, fluid-gas exchange and gas injection, prone position for at 3–7 days is suggested. All the patients underwent secondary surgery received anatomical closure, larger macular hole with ILM flap insertion should be applied.

Postoperative visual acuity of MH is known to differ depending on the preoperative visual acuity, the minimal diameter and basal diameter of MH, HFF, MHI, and the ellipsoid zone deficit. Guber et al. [22] reported that patients with large MHs (diameter > 400 μ m) showed BCVA improvements of 1 to 2 lines following surgery using the inverted flap technique. Khodani et al. [23] reported that visual acuity was improved in patients with very large MHs (diameter > 1000 μ m) from a baseline visual acuity of 20/120 to a final visual acuity of 20/80 following surgery using the inverted flap technique. In our study,

postoperative BCVA of both air group and C3F8 group were improved significantly compared with the preoperative base line, and the P-values were both 0. The postoperative logMAR visual acuity scores for the two groups were 1.08 and 1.08 at 1week, 0.79 and 0.66 at 1month after the surgery, and no statistical difference was found.

Lens opacification was another complication of intraocular gas filling, Chen et al. found a higher rate of transient lens opacity in the C3F8 group than that of air group after the surgery [10]. Studies showed that cataract surgery performed after macular hole repair could cause complications due to intraoperative difficulties during phacoemulsification, which arise from the absence of vitreous support in a vitrectomized eye and the increased risk of zonular and/or posterior capsular insult [24]. Moreover, cataract surgery following macular hole repair may lead to postoperative reopening of the macular hole in about 20% of patients, especially if there are complications involving cystoid macular edema. Thus, we performed phacovitrectomy in 118 of 120 eyes, and one patient aged at 38 had vitrectomy surgery only. Complications, such as an iris/intraocular lens capture, were not observed during the follow up visit.

Conclusions

The study was limited by a lack of randomization and the short follow-up period. In conclusion, we revealed that air filling had the same therapeutic effect as C3F8 in patient with smaller macular hole (diameter less than 400 microns), patients with larger macular hole (diameter more than 400 microns) might get better surgery results via C3F8 filling. Thus, for patients with macular hole diameter less than 400 microns, air can be a good intraocular tamponade in macular hole surgery with stable postoperative IOP. Air filling combined with inter limit membrane peeling or flap insertion may get better results in larger macular hole operations.

Abbreviations

IMH:Idiopathic macular hole; OCT:Optical coherence tomography; PPV:pars plana vitrectomy;ILM:internal limiting membrane

Declarations

Ethics approval and consent to participate

Written consent was obtained from all individual participants included in the study. This study was approved by the Ethics Committee of Eye hospital of Wenzhou medical university.

Consent to publish

Not Applicable.

Availability of data and materials

I can confirm I have included a statement regarding data and material availability in the declaration section of my manuscript

Competing interests

All authors declare that there is no conflict of interest regarding this publication of this paper.

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Authors' contributions

Design of the study (Ronghan Wu); conduct of the study (Yongping Tang); data collection (Beilei Wu); analysis of data (Yongping Tang, Zhong Lin); preparation of manuscript (Yongping Tang); critical review and final approval of the manuscript (Ronghan Wu).

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