Taiwan J Ophthalmol 2020;10:284-288

Access this article online

Quick Response Code:

Website:
www.e-tjo.org

DOI:
10.4103/tjo.tjo_1_19

Factors impacting gas fill after microincision vitrectomy surgery combined with fluid–gas exchange

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Submission: 06-01-2019
Accepted: 30-11-2019
Published: 31-03-2020

Abstract:

PURPOSE: The objective of the study was to investigate possible factors influencing gas fill after microincision vitrectomy surgery (MIVS) combined with fluid–gas exchange.

MATERIALS AND METHODS: This was a retrospective chart review of patients who underwent MIVS combined with fluid–gas exchange (20% C_3F_8) from February 2017 to December 2017.

RESULTS: Sixty-one eyes of 58 patients were identified. The mean age was 59.97 ± 9.65 years. The mean gas fill percentage was 76.28% ± 14.29% on day 1, 65.49% ±13.65% on day 3, 60.03% ± 14.53% on day 4, and 43.9% ± 20.88% on day 7 postoperatively. Compared to phakic eyes, eyes that were pseudophakic prior to surgery had a lower gas fill on days 1–3, but the difference did not reach significance on day 3. Eyes that underwent phacovitrectomy had a significantly lower gas fill on days 1–3 than eyes that did not.

CONCLUSION: Postoperative pseudophakic status is associated with lower gas fill after MIVS. Adjusted gas fill should be considered in these cases.

Keywords:

Fluid–gas exchange, gas fill, microincision vitrectomy surgery

Introduction

Fluid–gas exchange is the standard adjunctive procedure with pars plana vitrectomy for macular hole and retinal detachment.[1,2] Although facedown positioning after vitrectomy was encouraged by early studies, newer research has increasingly shown that outcomes of nonsupine positioning are noninferior if the gas fill is adequate for sufficient gas-macula contact. However, postoperative gas fill percentage and gas components vary among patients, likely due to poor initial gas fill and/or sclerotomy leakage. The purpose of this study was to investigate possible factors influencing gas fill after microincision vitrectomy surgery (MIVS) combined with fluid–gas exchange.

Materials and Methods

We conducted a retrospective review of medical records of patients who underwent MIVS combined with fluid–gas exchange from February 2017 to December 2017. This study was approved by the Institutional Review Board and Ethics Committee of the Kaohsiung Veterans General hospital (Approval No. VGHKS17-CT4-06) and adhered to the tenets of the Declaration of Helsinki. Due to the retrospective nature of this research which utilized preexisting information, patients' informed consent was waived. All patients were assigned a number code, and no personally identifiable information was revealed. Data variables collected included age, sex, diagnosis, presence of high myopia, presence of pseudophakia, use of general anesthesia during surgery, use of 23G or 25G needle vitrectomy,

How to cite this article: Li MS, Horng YH, Lin HS, Sheu SJ. Factors impacting gas fill after microincision vitrectomy surgery combined with fluid–gas exchange. Taiwan J Ophthalmol 2020;10:284-8.

duration of postoperative bandaging, history of the previous vitrectomy, and whether vitrectomy was combined with cataract surgery.

All surgeries were performed by a single operator Shwu-Jiuan Sheu (SJS), and 20% perfluoropropane (C_3F_8) was used in all patients. Perfluorocarbon liquid was not used in this case series.

Repeated drainage of residual subretinal fluid was done in cases of rhegmatogenous retinal detachment but not macular hole without retinal detachment. Corneal wounds are routinely sutured in combined phacovitrectomy. Patients who had infectious eye diseases underwent scleral buckling or had incomplete data were excluded from the study. On postoperative day 1 (POD1) and POD4, the patients were examined in the sitting position. The height of gas–fluid level was measured via indirect fundoscopy, and the degrees of gas fill were estimated. The height of gas–fluid level can be converted to the percentage of gas fill using a geometric model of the eye. We hypothesized that the decline of gas fill was linear. Interpolation method was used to estimate the percentage of gas fill within POD4, and extrapolation methods were used to estimate the percentage of gas fill beyond POD4 if there was no data measurement recorded. Factors associated with ≥65% gas fill on POD3, POD4, and POD7 were analyzed.

Statistical analysis was performed using SPSS version 20 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were expressed as mean ± standard deviation. The Fisher's exact test and Pearson's Chi-square test were used to compare the proportions in the 2 × 2 groups and contingency tables, respectively. The means of normally distributed variables were compared with the *t*-test. Odds ratios were also calculated. Generalized estimating equation was used to analyze the association between the variables and gas fill. The *P* value or 95th percentile confidence interval is shown, as appropriate. Variables not showing a normal distribution were compared using the nonparametric Mann–Whitney U-test.

Results

Sixty-one eyes of 58 patients (22 males and 36 females) were identified. The mean age was 59.97 ± 9.65 years. Eyes were bandaged for 4 h postoperatively with the exception of 8 eyes from which the patch was removed prematurely due to negligence of a resident physician and were bandaged for 1 h postoperatively. One eye had intraocular pressure (IOP) ≤5 mmHg and none had IOP ≥30 mmHg on POD1. The mean gas fill percentage was 76.28% ± 14.29% on POD1, 65.49% ± 13.65% on POD3, 60.03% ± 14.53% on POD4, and 43.9% ± 20.88% on POD7. In 37 patients diagnosed with macular hole, only 3 patients did not achieve hole closure. The gas fill in one patient was more than 65% in 1 patient (73%) and <65% in 2 patients (34% and 64%) on POD3. The outcome of the macular hole did not have a statistical difference in the patients with high or low gas fill. Strict prone position was requested if the gas fill is relatively low. Elevated IOP was noted in 23 eyes. Except four eyes with previous glaucoma history, the rest could be controlled by short-time antiglaucomatous medications. Those with low gas fill did not show significantly different course.

Compared with eyes that were phakic before surgery, eyes that were preoperatively pseudophakic had a lower gas fill on POD1–POD3, but the difference did not reach statistical significance on POD3. Eyes that received MIVS combined with cataract surgery had a significantly lower gas fill on POD1 to POD3 ($P < 0.05$) compared to eyes that did not receive combined cataract surgery. Other factors including age, sex, presence of high myopia, use of general anesthesia during surgery, use of 23G or 25G vitrectomy, and duration of postoperative bandaging were not associated with significantly different gas fill percentage from POD1 to POD4 [Table 1]. Eyes with pseudophakic status after the surgery were significantly less likely to maintain ≥65% gas fill on POD3 ($P = 0.003$), and the difference was nearly significant on POD4 ($P = 0.054$). Eyes with previous vitrectomy had higher gas fill from POD1 to POD4 and were significantly more likely to have ≥65% remaining gas fill on POD3 and POD4 [Tables 1-3]. Diagnosis of macular hole, rhegmatogenous retinal detachment, or proliferative diabetic retinopathy with tractional retinal detachment was not associated with significantly different gas fill percentage at any studied time point.

Discussion

Vitreous substitutes as surgical adjuncts were described as early as 1911 when Ohm injected air into the vitreous cavity to treat retinal detachment.[3] The high surface tension between gas and fluid enables the formation of an effective seal around a retinal break, thus allowing the retinal pigment epithelium to absorb any remaining subretinal fluid to facilitate reattachment of the retina. As such, facedown positioning was thought to be crucial for the success of macular hole closure after vitrectomy with fluid–gas exchange by increasing gas-macula contact. However, poor compliance with this positioning has been reported.[4,5] Furthermore, the optimal duration of gas tamponade for macular hole closure has come under debate in recent years.

Some surgeons advocate nonsupine positioning postoperatively as patients are more likely to be adherent and because it has shown noninferiority in the hole closure rate compared with the facedown

Table 1: Characteristics of patients with gas fill on postoperative day 1, 2, 3, 4, and 7

	n	Day 1		Day 2		Day 3		Day 4		Day 7	
		Mean gas fill (%)	*P*	Mean gas fill (%)	*P*	Mean gas fill (%)	*P*	Mean gas fill (%)	*P*	Mean gas fill (%)	*P*
Age			0.100		0.070		0.069		0.088		0.189
Sex											
Male	22	0.76	0.567	0.70	0.539	0.65	0.510	0.59	0.543	0.42	0.618
Female	36	0.76		0.71		0.66		0.61		0.45	
High myopia											
Yes	14	0.81	0.364	0.74	0.757	0.67	0.781	0.60	0.416	0.39	0.105
No	47	0.76		0.71		0.66		0.60		0.45	
Pseudophakia before surgery											
Yes	25	0.75	0.008	0.70	0.027	0.65	0.096	0.60	0.313	0.46	0.847
No	36	0.78		0.72		0.66		0.60		0.43	
Surgery under general anesthesia											
Yes	50	0.73	0.468	0.68	0.640	0.63	0.924	0.58	0.892	0.44	0.500
No	11	0.77		0.71		0.66		0.60		0.43	
23/25 gauge PPV											
23	24	0.78	0.968	0.73	0.989	0.67	0.990	0.62	0.994	0.46	0.988
25	37	0.75		0.70		0.64		0.59		0.43	
Previous PPV											
Yes	9	0.89	<0.001	083	<0.001	0.78	<0.001	0.73	<0.001	0.57	0.047
No	52	0.74		0.69		0.58		0.53		0.42	
PPV combined phacoemulsification											
Yes	4	0.72	0.006	0.67	0.011	0.62	0.037	0.58	0.115	0.44	0.645
No	57	0.77		0.71		0.66		0.60		0.44	
Postoperative 1 h bandage											
Yes	8	0.76	0.301	0.70	0.618	0.64	0.900	0.58	0.530	0.39	0.141
No	53	0.76		0.71		0.66		0.60		0.45	
Diagnosis											
Macular hole*											
Yes	39	0.77	0.387	0.72	0.656	0.67	0.972	0.62	0.732	0.46	0.335
No	22	0.75		0.69		0.63		0.57		0.39	
Presence of subretinal fluid†											
Yes	24	0.76	0.335	0.70	0.711	0.64	0.809	0.57	0.447	0.39	0.112
No	37	0.77		0.72		0.67		0.62		0.47	

*Lamellar and full-thickness macular hole, †Rhegmatogenous retinal detachment, proliferative diabetic retinopathy with tractional retinal detachment, and macular hole with retinal detachment. PPV=Pars plana vitrectomy

Table 2: Characteristics of patients with gas fill more or<65% on postoperative day 3

	Total (*n*)	Gas fill <65%	Percentage	Gas fill ≥65%	Percentage	*P*
Age (years±SD)		60.12±11.555		59.89±8.084		0.617
Sex (male/female)	24/37	11/14	45.80/37.80	13/23	54.20/62.20	1
High myopia	14	5	35.70	9	64.30	0.537
Pseudophakia after surgery	29	16	55.17	13	44.83	0.003
Surgery under general anesthesia	50	20	40.00	30	60.00	0.823
23/25 gauge PPV	24/37	9/16	37.50/43.20	15/21	62.50/56.80	0.928
Previous PPV	9	1	11.10	8	88.90	0.007
Postoperative 1 h bandage	8	5	62.50	3	37.50	0.188
Diagnosis						
Macular hole*	39	15	38.50	24	61.50	0.707
Presence of subretinal fluid†	24	11	45.80	13	54.20	0.683

*Lamellar and full-thickness macular hole, †Rhegmatogenous retinal detachment, proliferative diabetic retinopathy with tractional retinal detachment, and macular hole with retinal detachment. PPV=Pars plana vitrectomy, SD=Standard deviation

position.[6-9] However, success outcomes of nonsupine positioning depend on an adequate amount of gas fill after vitrectomy. Alberti and la Cour[6] reported that gas fill of at least 65% on postoperative day 4 reduces the risk of poor gas-macula contact and surgical failure. Our study showed that gas fill level after MIVS combined with 20% C_3F_8 fluid–gas exchange gradually decreased from 65.49% ± 13.65% on day 3 to 43.9% ±

Table 3: Characteristics of patients with gas fill more or<65% on postoperative day 4

	Total	Gas fill <65%	Percentage	Gas fill ≥65%	Percentage	*P*
Age (years±SD)		59.77±10.172		60.27±8.879		0.990
Sex (male/female)	24/37	15/20	62.50/54.10	9/17	37.50/45.90	0.857
High myopia	14	8	57.10	6	42.90	0.952
Pseudophakia after surgery	29	18	62.07	11	37.93	0.054
Surgery under general anesthesia	50	28	56.00	22	44.00	0.802
23/25 gauge PPV	24/37	12/23	50.00/62.20	12/14	50.00/37.80	0.639
Previous PPV	9	1	11	8	88.90	0.006
Postoperative 1 h bandage	8	6	75.00	2	25.00	0.093
Diagnosis						
Macular hole*	39	19	48.70	20	51.30	0.970
Presence of subretinal fluid†	24	17	70.80	7	29.20	0.681

*Lamellar and full-thickness macular hole, †Rhegmatogenous retinal detachment, proliferative diabetic retinopathy with tractional retinal detachment, and macular hole with retinal detachment. PPV=Pars plana vitrectomy, SD=standard deviation

20.88% on day 7. Eyes with pseudophakic status before or after surgery tended to have lower gas fill after this procedure.

Increasingly, MIVS is the preferred vitrectomy procedure for a variety of vitreoretinal diseases. Although endophthalmitis was initially a major safety concern, sutureless small-gauge port sizes were not found to be associated with increased risk for endophthalmitis in recent series.[10] When the gas enters the vitreous cavity, three phases can be distinguished: expansion, equilibrium, and dissolution. Since we used a low concentration of C_3F_8(20%), the duration of the expansion and equilibrium phases were likely short. Therefore, the remaining gas fill depends mainly on the dissolution phase and possible sclerotomy leakage. The observation that eyes with only 1 h of bandaging after vitrectomy did not have significantly different gas fill level from eyes with 4 h of bandaging suggests that the sclera wound was well sealed promptly after the surgery. In addition, eyes with the previous vitrectomy had higher gas fill from POD1 to POD4, which might be due to less remaining vitreous base in these eyes. This finding also supports that sclera wounds were well sealed even in reoperative eyes. According to a study evaluating the closure of sclerotomies after 23G and 25G transconjunctival sutureless pars plana vitrectomy on optical coherence tomography, there was no difference in the incidence of wound leakage between 23G and 25G incisions, and the rate of sclera wound closure at 1 month was approximately 60%.[11] Similarly, in our series, there was also no significant difference in gas fill level between 23G and 25G MIVS. During the dissolution phase, there is a net exit of gases through absorption into the bloodstream. Absorption of intraocular gas bubbles reasonably adheres to first-order kinetics, which predicts that a constant percentage of the intraocular gas volume is absorbed over a given period of time.[12,13] In pseudophakic eyes, it is speculated that gas has an increased chance of egressing into the anterior chamber and has more contact with the iris stroma and increased access into the bloodstream. This theory may be supported by our results showing that eyes with pseudophakia and eyes that underwent MIVS combined with cataract surgery tended to have lower gas fill after MIVS combined with fluid–gas exchange. These results suggest that more concentrated gas should be used in pseudophakic eyes if adequate gas fill is needed after vitrectomy, such as in cases with macular hole. According to the previous studies, high concentrated gas has longer intraocular duration.[14] To the authors' experience, increasing the concentration of C_3F_8 to 30% prolongs the duration of gas fill.

The current study was limited by its small sample size and retrospective design. The measurement of gas fill was subjective and might not be completely accurate. However, this might be compensated by the case collection and measured by single surgeon. Additional larger series studies are needed to gain a more in-depth understanding of factors influencing gas fill after MIVS.

Conclusion

Eyes with pseudophakia and eyes that underwent MIVS combined with cataract surgery tended to have lower gas fill after MIVS combined with fluid–gas exchange. Adjusted gas fill should be considered in these cases.

Financial support and sponsorship
Nil.

Conflicts of interest
The authors declare that there are no conflicts of interests of this paper.

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