Comparison of Primary Gas Tamponade and a Vitrectomy for Repair of Macular Holes with Retinal Detachment in Highly Myopic Eyes

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Background: A preference for the primary use of standard gas tamponade or a vitrectomy combined with other adjuvant measures to treat myopic eyes with macular holes (MHs) and retinal detachment (RD) has not been established. This article evaluates postoperative outcomes of both surgeries, and recommends a surgical method based on the findings.

Methods: We reviewed the records of 61 patients (62 eyes) with high myopia (> -6.0 diopter, > 26 mm of axial length, or visible posterior staphyloma) and MHs with secondary RD (no peripheral retinal break) who were treated between April 1986 and September 2002 in southern Taiwan. Descriptive statistics of baseline examinations and results of the operations were retrospectively analyzed.

Results: Baseline clinical data of the primary gas tamponade and vitrectomy groups did not significantly differ, except for the mean preoperative log (minimum angle of resolution) visual acuity (VA) ($p = 0.016$) and extent of RD ($p = 0.001$, located in the posterior staphyloma only). None of the results (including success rate, cause of failure, number of operations until stability was achieved, and mean duration of postoperative follow-up) of the operations in the 2 groups significantly differed, except for the improved VA at the final status ($p = 0.03$).

Conclusion: Among highly myopic eyes with MHs, we suggest a vitrectomy for those with poorer VA and a greater extent of RD. However, gas tamponade is strongly recommended for those with RD with posterior staphyloma (PS) only because this procedure is safer and requires no sophisticated instruments.
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Key words: **macular hole, retinal detachment, high myopia, posterior staphyloma, gas tamponade, vitrectomy.**

The prevalence of myopia is growing in Taiwan. The increased severity and prevalence of high myopia may be due to an earlier onset of myopia.[1] Highly myopic eyes often have macular holes (MHs)

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with secondary retinal detachment (RD), especially when associated with posterior staphyloma (PS). Unfortunately, we do not have a good understanding of the pathogenesis of myopic MHs with RD. Various surgical techniques have been used to treat RD from MHs in myopic eyes. These techniques include posterior scleral buckling and intraocular gas tamponade with or without a pars plana vitrectomy, which sometimes is combined with macular photocoagulation or diathermy.[2-7]

Idiopathic MHs, possibly caused by tangential traction from the posterior cortical vitreous,[8-10] have been successfully treated by vitrectomies for the last decade.[11,12] The vitreous in highly myopic eyes is extensively liquefied, and the increased amount of fluid, which can move in the enlarged vitreous pocket, can cause added traction to the fovea and contribute to RD.[4] With these modern techniques, most myopic eyes with MHs and RD can be successfully treated, although multiple procedures are often needed. Currently, intraocular gas tamponade with or without pars plana vitrectomy is commonly used for treatment of non-myopic MHs with RD.[13,14] We evaluated the postoperative outcomes of patients with myopic eyes treated with either gas tamponade or a vitrectomy combined with other adjuvant procedures for MHs with secondary RD in southern Taiwan.

METHODS

Between April 1986 and September 2002, 62 eyes in 61 patients with high myopia (> -6.0 diopter, 26 mm of axial length, or visible PS) and RD resulting from a MH (without peripheral retinal break) were treated at Kaohsiung Chang Gung Memorial Hospital by primary gas tamponade or primary vitrectomy, combined with other procedures (including a lensectomy, scleral buckling, membrane peeling, gas tamponade, silicone oil tamponade, etc.).

A diagnosis was established clinically by a detailed ocular examination that included slit-lamp biomicroscopy of the anterior and posterior segments and indirect ophthalmoscopy. The presence of staphyloma and the extent of RD were determined by a fundus examination or B-mode echography. The posterior vitrous detachment (PVD), the presence of which was determined by the appearance of a glial ring, and the epiretinal membrane (ERM) were examined using a slit-lamp biomicroscope with a 90-diopter lens.

Preoperative data recorded included gender, age, refraction error, axial length, logarithm of the minimum angle of resolution (logMAR),[15] duration of symptoms, lens status, and the extent of RD. Biomicroscopic assessment of the retina and vitreous in highly myopic eyes is indeed difficult, even with appropriate contact lenses, so some data of the PVD and ERM were not completely recorded. All patients had a history of progressively decreasing visual acuity for several years with sudden loss of vision from macular detachment ranging from 1 week to 24 months (mean$\pm$SD, 2.3$\pm$4.1 months). Of the 62 eyes, 19 were treated by primary gas tamponade with or without an equatorial encircling scleral buckle (SB). All 19 eyes showed RD with PS and no other retinal breaks. Of the 62 eyes, 43 were treated by a primary vitrectomy combined with other adjuvant procedures.

The surgical techniques employed included primary gas tamponade and a trans pars plana vitrectomy which are described below.

1. Primary gas tamponade (19 of 62 eyes)

(A) Primary gas tamponade without SB (17 of 19 eyes): Primary injection of a gas bubble was performed in patients under retrobulbar or peribulbar anesthesia. A 1-ml syringe with a 27-gauge needle was partially filled with gas (7 eyes used 100% sulfer hexafluoride (SF_6), and 12 eyes used 100% perfluopropane (C_3F_8). The C_3F_8 (mean, 0.38 ml) or SF_6 (mean, 0.45 ml) was injected into the vitreous cavity, and a small amount of liquid vitreous, or aqueous humor, in the anterior chamber was aspirated using a syringe for intraocular pressure control.

(B) Primary gas tamponade with equatorial encircling SB (2 of 19 eyes)

Primary injection of a gas bubble was performed under general anesthesia after an equatorial encircling SB was sutured using a sterile technique.

2. Primary trans pars plana vitrectomy (43 of 62 eyes)

A standard pars plana vitrectomy was performed, and a lensectomy was also performed in 5 eyes that had a cataract obscuring fundus visibility. If present, vitreoretinal adhesion to the posterior pole was separated from the retinal layer. Fluid-air

exchange was then performed, and a longstanding gas (either 20%-30% SF_6 or 15%-20% C_3F_8) was injected. Two patients received a vitrectomy, equatorial encircling SB, and silicone oil tamponade.

The intraocular pressure was measured, and the eye was reexamined to ensure that complications had not occurred. If a high intraocular pressure was noted, antiglaucoma agents were given. The patients remained in a facedown position to maximize the contact of the expanding intravitreal gas bubble with the MH.

Postoperative variables recorded included the initial, secondary, and final anatomic results, improved logMAR VA, failure cause, number of operations until stability was achieved, and duration of follow-up.

Clinical data of patients were analyzed using the *t* and Pearson's X^2 tests, and categorical variables were analyzed using SPSS for Windows (vers. 10.0). If there was a potential confounder, the Hantel-Haenszel test was used to investigate the success rate between the 2 groups. A p value of < 0.05 was considered statistically significant.

RESULTS

There were 62 eyes (33 right and 29 left; 40 phakic, 17 pseudophakic, and 5 aphakic) in 61 patients (46 women and 15 men; age 42-79 [mean±SD, 60.0±8.7] years). Because not all eyes had undergone routine refractive and B-scan examinations, the refractive data for only 31 eyes (range, -6.0 to -19.75 diopters; mean±SD, -12.9±5.0 diopters) and the axial lengths for only 24 eyes (range, 26.4 to 36.0 mm; mean±SD, 28.9±2.3 mm) were known. There was no statistically significant difference between groups with respect to gender, age, mean refractive error, mean axial length, or mean duration of preoperative symptoms (follow-up period of from 0.25 to 24 months; mean±SD, 2.3±4.1 months). The mean preoperative logMAR VA of the gas tamponade group was significantly lower than that of the vitrectomy group ($p=0.016$). The number of RDs associated with only PS in the gas tamponade group was significantly higher than that in the vitrectomy group ($p=0.001$). Conversely, the number of RDs associated with PS + 3 or 4 quadrants (Q) in the vitrectomy group was significantly higher than that in the gas tamponade group (Table 1).

Initial outcomes of gas tamponade vs. a vitrectomy are shown in Table 2. Anatomic success was defined as reattachment of the RD (no recurrence of RD during the follow-up period). The initial success rate of the gas tamponade group was 13/19 (68.4%), and that of the vitrectomy group was 23/43 (53.5%). There was no significant difference in success rates between groups.

Total outcomes are shown in Table 3. No sig-

Table 1. Descriptive Statistics of Baseline Examinations of the Gas Tamponade vs. Vitrectomy Approaches

Variable (N1 vs. N2)	Gas tamponade approach (N1)	Vitrectomy approach (N2)	*p*
Gender			
Male (19 vs. 43)	4 (21.1%)	11 (25.6%)	0.701
Age, year (mean±SD) (19 vs. 43)	59.5±9.5	60.2±8.4	0.792
Refractive error (diopters) (13 vs.18)	-13.0±4.74	-12.0±5.3	0.592
Axial length (mm) (4 vs. 20)	29.3±1.3	28.8±2.5	0.841
Mean preop. logMAR VA (19 vs. 43)	2.4±0.8	2.8±0.4	0.016*
Lens status (19 vs. 43)			
Phakia	13 (68.4%)	27 (62.8%)	0.772
Pseudophakia	4 (21.1%)	13 (30.2%)	
Aphakia	2 (10.5%)	3 (7.0%)	
Extent of RD (19 vs. 43)			
PS only	15 (78.9%)	15 (34.9%)	0.001†
PS + 1 or 2 Q	2 (10.5%)	4 (9.3%)	
PS + 3 or 4 Q	2 (10.5%)	24 (55.8%)	
Mean duration of preoperative symptoms (week) (19 vs. 43)	3.1±5.4	2.1±3.3	0.470

Number data were compared between groups using the *t*-test (*) and Pearson Xtest (†).

Abbreviations: LogMAR: logarithm of the minimum angle of resolution; VA: visual acuity; RD: retinal detachment; PS: retinal detachment confined to posterior staphyloma; 1 Q: retinal detachment confined to 1 quadrant.

Table 2. Initial Reattachment Rates

Surgical technique	No. of eyes	No. (%) of reattachments
Gas tamponade approach		
Gas tamponade only	17	13 (76.5%)
Gas tamponade + equatorial encircling scleral buckle	2	0 (0 %)
Subtotal	19	13 (68.4%)
Vitrectomy approach		
Vitrectomy combined with other adjuvant maneuvers	41	21 (51.2%)
Vitrectomy combined with other adjuvant maneuvers + silicone oil tamponade	2	2 (100 %)
Subtotal	43	23 (53.5%)
Total numbers	62	36 (58.1%)

*Analyzed by Mantel-Haenszel while controlling for the extent of RD.

Table 3. Outcomes of the Gas Tamponade (19 eyes) vs. Vitrectomy (43 eyes) Approach

Variable (N1 vs. N2)	Gas tamponade approach (N1)	Vitrectomy approach (N2)	*p*
Improved logMAR VA (N1 vs. N2)			
Initial operation minus pre-operation value (mean±SD) (19 vs. 43)	-0.06±0.68	-0.34±0.61	0.12*
Final status minus pre-operation value (19 vs. 43)	0.10±1.00	-0.41±0.75	0.03
Success rate			
Anatomic attachment as the initial operation (19 vs. 43)	13 (68.4%)	23 (53.5%)	0.52†
Anatomic attachment as the secondary operation (5 vs. 15)	1 (20.0%)	6 (40.0%)	0.12
Anatomic attachment as the final status (19 vs. 43)	14 (73.7%)	31 (72.1%)	0.52

* Improved logMAR VA was analyzed using *t*-test.
† Analyzed by Mantel-Haenszel while controlling for the extent of RD.

Table 4. Outcomes of the Gas Tamponade (15 eyes) vs. Vitrectomy (15 eyes) Approach in Cases of RD with PS

Variable (N1 vs. N2)	Gas tamponade approach (N1)	Vitrectomy approach (N2)	*p**
Preoperative logMAR VA (15 vs. 15)	2.2±0.7	2.7±0.6	0.305
Improved logMAR VA			
Initial operation minus pre-operation value (mean ± SD) (15 vs. 15)	-0.07±0.55	-0.43±0.97	0.113
Final status minus pre-operation value (15 vs. 15)	0.12±0.97	-0.28±0.87	0.244
Success rate			
Anatomic attachment as the initial operation (15 vs. 15)	11 (73.3%)	9 (60.0%)	0.539
Anatomic attachment as the secondary operation (3 vs. 6)	0 (0.0%)	3 (50.0%)	0.464
Anatomic attachment as the final status (15 vs. 15)	11 (73.3%)	13 (86.7%)	0.539
Cause of failure (4 vs. 6)			
PVR	2 (50.0%)	3 (50.0%)	1.000
Other causes	2 (50.0%)	3 (50.0%)	
Number of operations until stability was achieved (11 vs. 12)	1.0±0.0	1.3±0.5	0.316
Mean duration of postoperative follow-up (month) (12 vs. 15)	35.5±42.9	30.7±28.5	0.741

*: Number data were compared between groups using *t*-test; Other causes, including epiretinal membrane and unknown factors
Abbreviation: PVR: proliferative vitreoretinopathy.

nificant difference was found in the improvement in visual ability (LogMAR VA) after the initial operation. However, the final status of visual abilities of the vitrectomy group was better than that of the gas tamponade group ($t=2.22$, $p=0.03$). After controlling for the extent of RD by the Mantel-Haenszel test, success rates did not differ between the 2 groups after the initial operation ($p=0.52$), the secondary operation ($p=0.12$), or the final status ($p=0.52$). Totally, 20 of 26 (77%) patients whose operations

initially failed accepted secondary operations. In 1 of 5 (20%) eyes in the gas tamponade group and 6 of 15 (40%) eyes in the vitrectomy group, anatomic attachment of the RD was successful. Proliferative vitreoretinopathy (PVR) was the most common cause of failure (12/26, 46.2%), and a greater number of reattachments failed for this reason in the vitrectomy group (11/20, 55%) than in the gas tamponade group (1/6, 16.7%). The number of operations needed to achieve a stable retinal reattachment (excluding 19 eyes lost to follow-up) was 1.1±0.3 (mean±SD) in the gas tamponade group and 1.2±0.5 (mean±SD) in the vitrectomy group, in a follow-up period of 1-118 months (27.8±30.2 months).

Of the 30 eyes with RD associated with only PS in this study with similar baseline conditions between groups, 15 eyes were treated with gas tamponade and 15 eyes with a vitrectomy initially; outcomes are shown in Table 4. There were no statistically significant differences between groups with respect to mean preoperative, initial, and final postoperative logMAR VA; initial, secondary, and final anatomic success rate; cause of failure; number of operations until a stable reattachment was achieved; and mean duration of postoperative follow-up.

DISCUSSION

The primary purpose of this study was to compare initial gas tamponade and vitrectomy approaches as treatment for RD secondary to MHs in highly myopic eyes. Sample sizes of similar previous work ranged from 5 to 33,[2-7] so this study had a sufficiently large sample size (N=62) for investigating the outcome of 2 operative methods among this specific population. Reattachment rates of groups treated with gas tamponade alone compared to those with a vitrectomy were 68.4% vs. 53.5% after initial surgery, 20% vs. 40% after secondary surgery, and 73.7% vs. 72.1% overall (final status), respectively. After controlling for the confounder, i.e., the extent of RD, success rates did not differ between the 2 groups at 3 time points (initial, secondary, and final statuses). Regarding these indices, this study revealed that similar outcomes were found using either gas tamponade or a vitrectomy.

A comparison with previous reports[3,7,8,13-21] on MHs with RD treatment is given as follows.

(A) The initial success rate of gas tamponade was 68.3% in our study. Others reported rates within the range of 54%-83%.[7,13,14]

(B) The initial success rate of the vitrectomy approach, which was 53.5%, was lower than that of the gas tamponade approach. In addition, the vitrectomy approach was associated with a number of problems, including a relatively low initial reattachment rate (52%-86%).[3,14,16] Two patients in our series even received a vitrectomy with equatorial encircling SB and silicone oil tamponade. Anatomic success was achieved in the first patient who presented with MHs, retinal and choroidal detachment, and grade D2 PVR and in the second patient with subtotal RD for 3 months. As indicated in a previous paper,[17] silicone oil in this particular situation had several advantages: (1) the duration of prone positioning was reduced from 24 to 48 hours; and (2) rehabilitation was fast, and the visual function of the eye operated on was rapidly restored, even in the presence of silicone oil. In fact, the hyperopic shift due to the silicone oil in phakic, aphakic, or pseudophakic eyes (with placement of an intraocular lens [IOL] having a convex posterior face) reduced the myopia, which was greatly appreciated by these patients. Wolfensberger[18] reported that a primary vitrectomy with a temporary silicone oil tamponade for treatment of RD due to MHs in highly myopic eyes appeared to provide good long-term anatomic and acceptable functional success.

(C) The final success rate of initial gas tamponade was 73.7% in our study with multiple surgical procedures (including a vitrectomy or scleral buckling). This rate was lower than the final reattachment rates (83%-100%) in eyes initially treated by gas tamponade alone.[7,13,14] High-myopia subjects with MHs seem to represent a distinct subgroup of MH subjects. Patel[19] and Sulkes[20] reported that successful retinal reattachment rates in highly myopic MH patients seem to be lower than those in idiopathic MH patients. Failure of the primary technique in eyes with very high myopia might be caused by several factors: (1) retinal adhesion might be overcome by inverse traction produced by posterior enlargement of the staphyloma; and (2) the absence of retinal pigment epithelium in areas of excessive chorioretinal atrophy might lead to reduced natural retinal adhesion, so the retina does not have sufficient elasticity to follow the posterior displacement of the scleral wall.[16] Histopathologic studies of highly

myopic eyes with PS have demonstrated thinning of the ectatic sclera, cracks in the Bruch membrane, and atrophy of the outer retina, the retinal pigment epithelium, and the choroid.[8,21]

In this study, there were no statistically significant differences between groups, except in the mean preoperative logMAR VA and the extent of RD. The mean preoperative logMAR VA of the gas tamponade group was significantly lower than that of the vitrectomy group ($p=0.016$); this is compatible with the significantly higher extent of RD in the vitrectomy group than in the gas tamponade group ($p=0.001$, RD within PS only) (Table 1). This means that a greater number of early-onset cases were selected for primary gas tamponade instead of primary vitrectomy in this study.

Among the 30 eyes with RD and PS only (a smaller extent of RD), that had similar baseline conditions between groups, results of surgical repair of the RD were reanalyzed. Reattachment rates of groups treated with gas tamponade alone compared to those by a vitrectomy were 73.3% vs. 60.0% after initial surgery and 73.3% vs. 86.7% overall (final status), respectively. However, rates of the initial and final retinal reattachment showed no significant differences (Table 4). To our knowledge, no previous work has investigated this issue. From this important result, we highly recommend the method of gas tamponade as the initial treatment of choice among subjects with RD and PS only.

In addition, even though the initial gas tamponade failed in highly myopic eyes with RD, no standard surgical techniques have previously been established. In the present study, the rate of retinal reattachment with a secondary vitrectomy was higher than that with secondary gas tamponade (40% vs. 20%) (Table 3). However, even though the sample size was small, there was no statistical difference. So gas tamponade might be used alone initially; however, when recurrent RD occurs after gas tamponade, surgeons should strive to remove the epiretinal membrane as completely as possible.

Regarding the improvement in visual ability (LogMAR VA), no significant difference was found after the initial operation. However, the visual abilities of the vitrectomy group were better than those of gas tamponade group at the final status ($t=2.22$, $p=0.03$). So the authors recommend that highly myopic individuals with poorer VA and a greater extent of RD might benefit from a vitrectomy. A similar result was found by Oshima et al,[22] who used highly myopic Japanese subjects with RD; they reported a much higher success rate (92.9%) by completely removing the friable perimacular ERM. Other reports[3,18] have also suggested a role of tangential traction from the residual ERM of the vitreous in causing reopening of MHs in highly myopic eyes with RD.

In conclusion, among the highly myopic eyes with MH, we suggest a vitrectomy for those with poorer VA and a greater extent of RD. However, gas tamponade is strongly recommended for those with RD with PS only, because this procedure is safer and requires no sophisticated instruments. Regarding recurrent RD, a vitrectomy with adjuvant procedures had higher rates for retinal reattachment than gas tamponade, although no significant difference exists.

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針對高度近視合併初次黃斑部裂孔與續發性視網膜剝離，使用氣體壓迫術和玻璃體切除術的結果比較

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背 景： 在高度近視合併黃斑部裂孔與續發性視網膜剝離的病人，優先使用氣體壓迫術或玻璃體切除術作爲初次的治療，在文獻上並沒有標準的規範。本文主要探討此兩組手術方式的治療結果比較，以提供術式選擇的參考。

方 法： 從1986年至2002年，紀錄高雄長庚醫院62隻眼睛/61病人合併高度近視 (度數大於六百度以上、眼軸大於26毫米以上或者後極部葡萄腫)合併黃斑部裂孔與續發性視網膜剝離病例 (無周邊視網膜裂孔)。他們分別接受初次氣體壓迫術或玻璃體切除術合併其他輔助手術，使用統計方法分析兩種手術病人的基本資料與術後結果。

結 果： 在臨床檢查的基本資料中，除了手術前視力 ($p=0.016$) 與視網膜剝離範圍 ($p=0.001$) (侷限在後極部葡萄腫的範圍) 之外，其他在性別、年齡、屈光度數、眼軸長度、水晶體狀態、術前症狀出現時間的比較，初次氣體壓迫術與玻璃體切除術兩者並沒有統計學上的差異。比較兩組術後的結果，除了最終視力改善程度 ($p=0.003$) 之外，其餘在成功率、失敗原因、達到穩定手術次數、術後追蹤時間，兩組並無達到統計的差異。

結 論： 在高度近視合併黃斑部裂孔與續發性視網膜剝離的病人，如果手術前視力較差或視網膜剝離範圍較大，建議優先使用玻璃體切除術。相反，若剝離範圍侷限在後極部葡萄腫，在考慮安全性與便利性的因素下，可先施行氣體壓迫術。

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關鍵字： 黃斑部裂孔，視網膜剝離，高度近視，後極部葡萄腫，氣體壓迫術，玻璃體切除術。

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