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The Efficacy of Fluid-Gas Exchange for the Treatment of Postvitrectomy Retinal Detachment

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Purpose: This study was designed to evaluate the efficacy of fluid-gas exchange for the treatment of postvitrectomy retinal detachment.

Methods: We retrospectively reviewed the records of 33 consecutive patients (35 eyes) who underwent fluid-gas exchange treatment for postvitrectomy retinal detachment using the two-needle pars plana approach technique.

Results: The retinal reattachment rate was 80.0% after complete intravitreal gas disappearance following the fluid-gas exchange; the overall success rate was 65.7%. Visual acuity was improved or stable in 80.0% of cases; a two-line or greater vision improvement or a best-corrected visual acuity of 0.4 or better occurred in 62.9% of cases. The success rates for superior retinal detachments and posterior pole retinal detachments were 76.5% and 85.7%, respectively.

Conclusions: Fluid-gas exchange represents a simple and cost-effective alternative outpatient procedure for retinal reattachment without reoperation for the treatment of superior and posterior pole retinal detachments.

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Key Words: Fluid-gas exchange, Postvitrectomy retinal detachment, Two-needle pars plana approach technique

Since Machemer[1,2] reported the use of the vitreous infusion suction cutter in 1971, the evolution of pars plana vitrectomy has caused it to become one of the most widely used operations for retinal vascular disease and retinal detachment treatments. Although Custodis' segmental scleral buckle was widely used for the treatment of retinal detachment with breaks,[3] a surgical approach to the vitreous in retinal detachment has gained tremendous popularity in recent years due to the development of instruments such as the vitreous cutters, intraocular illumination sources, endolaser delivery devices, vitreous scissors, and forceps.

The major advantages of this type of vitrectomy are the direct relief of vitreo-retinal traction and the removal of vitreous opacities, if present, in order to gain access to the detached retina and to easily identify retinal breaks.[4] However, the incomplete removal of the peripheral vitreous and additional retinal holes adjacent to the points of the sclerotomies are associated with an increased risk of vitreous incarceration and retinal detachment.

In postvitrectomized eyes, many problems can develop, such as vitreous hemorrhage, retinal detachment with retinal breaks, as well as uncontrolled fibrous proliferation. These complications require repeat surgical interventions. Several reports have described outpatient fluid-gas exchange (F-G exchange) technique as an alternate approach.[5-8] However, to date, there have been no reported studies on the two-needle pars plana approach technique for F-G exchange treatment of retinal detachments in postvitrectomized eyes. Therefore, we reviewed the recto d of 35 such F-G exchange treatments to assess the value of outpatient F-G exchange for the treatment of postvitrectomy retinal detachment using the two-needle technique.

Materials and Methods

Subjects

We retrospectively reviewed the records of 35 eyes with 33 postvitrectomy retinal detachments that underwent outpatient F-G exchange treatment at our hospital between June 2000 and April 2008. All patients were followed-up for at least three months after this procedure.

The medical records were reviewed in regard to patient characteristics, diagnosis at the time of the primary vitrectomy, interval between the most recent vitrectomy and the F-G exchange, other ophthalmologic history, and duration of follow-up. Every patient with a retinal detachment initially received a complete ophthalmologic examination including best-corrected visual acuity (BCVA), slit lamp examination,

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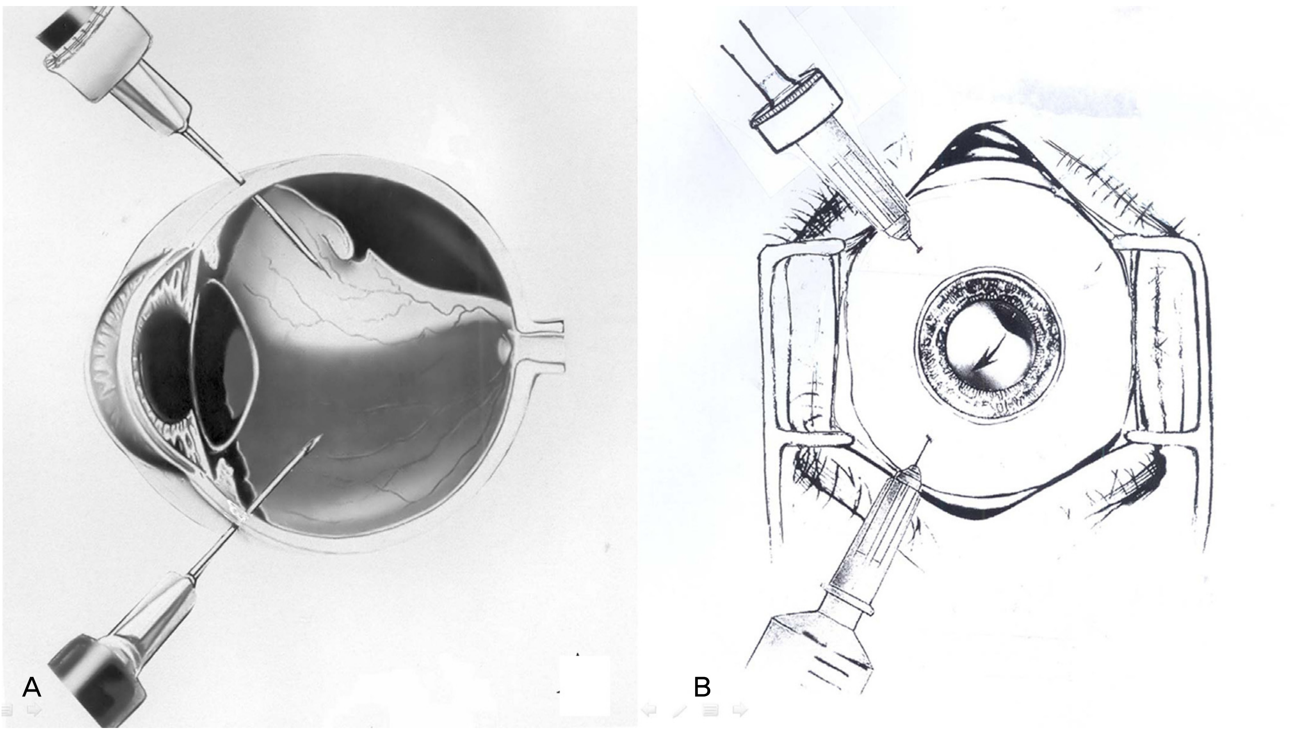

Fig. 1. (A) Technique for the pars plana approach to fluid-gas exchange using two 1 mL syringes for retinal detachment in a vitrectomized eye. (B) The gas infusion syringe is inserted in the superotemporal pars plana while the second 1 mL syringe, without a plunger, is inserted in the inferotemporal pars plana.

evaluation of lens status, and a fundus examination using a +90 D lens or a Goldmann- three mirror lens. Data on the range of retinal detachments, location and number of retinal tears, as well as retinal holes were recorded.

The range of retinal detachments was subdivided into a superior retinal detachment, an inferior retinal detachment, and a posterior pole retinal detachment. A superior retinal detachment was defined as a primary retinal break located above the horizontal meridian, or a retinal detachment with the likely location of the retinal break within the superior retina. An inferior retinal detachment was defined as a break located in the inferotemporal or inferonasal quadrant, or a shallow inferior detachment in which the subretinal fluid lay below the optic disc, without breaks. A posterior pole retinal detachment was defined as macular hole or retinal break located at the foveal or parafoveal areas.

Follow-up examinations consisted of evaluation of lens status, retinal attachment status, number of repeated F-G exchanges, and the final visual and anatomic results. The follow-up examinations were performed at 24 hours, within one week, two weeks, and one month postoperatively as well as at the patient's final visit.

Anatomic success of the retinal reattachment was defined as the absence of any retinal detachment or the presence of subretinal fluid not exceeding two clock-hours of retinal surface area and not involving the macula at more than one month after the intraocular gas disappeared completely. Functional success was defined as either visual improvement of two lines or greater or a BCVA of 0.4 or better.

Procedures

Our modified technique for outpatient F-G exchange is shown in Fig. 1. The F-G exchange procedure was performed through the pars plana in all patients and required two additional operative assistants.

After retrobulbar anesthesia (in cooperative patients, topical anesthesia with 0.5% proparacaine hydrochloride can also provide adequate anesthesia) using 3 mL of 2% lidocaine, the eyelids, the periocular regions, and the conjunctiva were prepared with a 10% povidone iodine solution. A lid speculum was then inserted between the lids. The patient was placed in the lateral decubitus position with the temporal pars plana in the dependent position. A 26-gauge needle attached to a 50 mL syringe partially filled with sterile gas (14% perfluorpropane or 18% sulfur hexafluoride) *via* a filtered air infusion line, connected with a three-way stopcock, was inserted 3.5 mm (3.0 mm in nonpahkic eyes) posterior to the limbus through the nasal pars plana into the vitreous cavity. Another 26-gauge needle was attached to a 1 mL syringe without a plunger and was then inserted 3.5 mm (3.0 mm in nonpahkic eyes) posterior to the limbus through the temporal approach. As the gas was injected into the vitreous cavity through one needle, an equal amount of vitreous fluid was concurrently drained into the other syringe. After the exchange was completed, the

Table 1. Patient demographics and clinical characteristics

Variables		
Age (yr)	Mean	50.31
	Range	16-87
Gender (Male : Female)	No. of patients	21 : 12
	No. of eyes	23 : 12
Laterality (No. of eyes)	OD : OS	15 : 20
Lens state at initial F-G exchange (No. of eyes)	Aphakic state	6
	Phakic state	14
	Pseudophakic state	15
Interval between vitrectomy and F-G exchange (No. of eyes)	$<$ 1 wk	7
	1 wk to 1 mon	11
	1 mon to 3 mon	10
	$>$3 mon	7
Duration of follow-up after final procedure (mon)	Mean	21.1
	Range	3-87
Number of repeated F-G exchanges (No. of eyes)	Once	25
	SF_6	11
	C_3F_8	14
	Twice	10
	SF_6+SF_6	7
	$SF_6+C_3F_8$	2
	$C_3F_8+C_3F_8$	1

F-G exchange=fluid-gas exchange; SF_6=sulfur hexafluoride; C_3F_8=perfluoropropane.

intraocular pressure was estimated with a cotton-tip applicator and the needles were withdrawn. To prevent loss of gas, the needle tract was immediately covered with a cotton-tipped applicator.

The patient was maintained in the head-prone position for 30 minutes and was positioned with a head tilt such that the axis of the retinal break was pointed toward the ceiling. The appropriate position, with the retinal break uppermost, was maintained until the intravitreal gas bubble achieved an size that would not tamponade the retinal break.

A topical antibiotic, Cravit® (0.5% Levofloxacin; Santen Pharmaceutical Co. Ltd., Osaka, Japan), was administered as ophthalmic drops four times a day following the intraocular gas injection. Intraocular pressure was checked on the day following the exchange. If a rise of more than 30 mmHg in intraocular pressure was detected, a topical glaucoma medication was added to the medication regimen.

Photocoagulation was applied to the retinal break or the localized retinal detachment area in all cases when the anatomy of the eye allowed for easy visualization of the peripheral retina or break. Argon laser photocoagulation with a slit-lamp delivery system and contact lens was performed to surround the retinal break or focally detached retina with three to five rows of laser.

Results

Table 1 presents the patient demographics and clinical characteristics. Among 33 patients with retinal detachments, 21 were male and 12 were female. The average age was 50.3 years (range, 16 to 87 years). The mean duration of follow-up was 21.1 months (range, 3 to 87 months); all patients were followed-up for at least three months.

Seven eyes had F-G exchange within one week of their most recent vitrectomy; for 11 eyes, the interval was between one week and one month; for ten eyes, the interval was between one and three months; and for seven eyes, the interval was more than three months. Twenty-five eyes underwent one F-G exchange while the remaining ten eyes underwent the procedure twice (Table 1).

The vitreoretinal disease diagnoses that required the primary vitrectomy were rhegmatogenous retinal detachment (nine eyes), followed by proliferative diabetic retinopathy (eight eyes), endophthalmitis (four eyes), retinal detachment with a macular hole (three eyes), an intraocular foreign body (three eyes), proliferative vitreoretinopathy (PVR, two eyes), subretinal hemorrhage due to age-related macular degeneration (two eyes), intraocular lens dislocation (one eye), traumatic retinal dialysis (one eye), and total retinal detachment due to acute retinal necrosis (one eye) (Table 2).

The retinal status at the time of the first procedure was divided into a superior retinal detachment, an inferior retinal detachment, and a posterior pole retinal detachment (Table 2). Among the patients, 48.6% had superior retinal detachments, 31.4% had inferior retinal detachments, and 20.0% had posterior pole retinal detachments. Retinal breaks were identified in 65.7% of the eyes. Nineteen eyes had a new retinal break or breaks, while three eyes had a reopened macular hole; only one eye developed a retinal detachment due to a reopened retinotomy site (Table 3).

Following complete intravitreal gas disappearance after F-G exchange, 28 eyes (80.0%) had retinas that were totally

Table 2. Surgical indications for the primary vitrectomies (N=35)

Primary vitrectomy indications	No. of eyes
Rhegmatogenous retinal detachment	9
Proliferative diabetic retinopathy	8
Macular hole retinal detachment	3
Proliferative vitreoretinopathy	2
Endophthalmitis	4
Subretinal hemorrhage due to age-related macular degeneration	2
Intraocular foreign body	3
Intraocular lens dislocation	1
Vitreous hemorrhage d/t central retinal vein occlusion	1
Traumatic retinal dialysis	1
Total retinal detachment due to acute retinal necrosis	1

Table 3. The retinal state at the time of first injection and the final outcomes following fluid-gas exchange (N=35)

Location of RD	No. of eyes			
	Total	Existence of retinal breaks	Final retinal reattachment (%)	Improvement in visual acuity (%)
Inferior	11	5	4 (36.4%)	5 (45.5%)
Superior	17	12	13 (76.5%)	13 (76.5%)
Posterior pole	7	6	6 (85.7%)	4 (57.1%)

RD=retinal detachment.

Table 4. The medical complications of postvitrectomy fluid-gas exchange

Complications	No. of eyes	Treatment for complications (No. of eyes)
Acute elevation of IOP	1	-
Worsening of PSCO (N=14, phakic eye)	6	Cataract surgery (4)
Persistent RD	4	Additional RD operation (3) Operation refusal (1)
PVR	6	Removal of tractional membrane and fibrosis (all eyes)
Suprachoroidal gas injection	1	Intravitreal C_3F_8 injection
Endophthalmitis	1	Intravitreal antibiotics injection

IOP=intraocular pressure; PSCO=posterior subcapsular opacity; RD=retinal detachment; PVR=proliferative vitreoretinopathy.

attached or attached with limited subretinal fluid (not involving the macula). Final reattachment success (the state of retinal attachment at the final follow-up visit) was observed in 23 eyes (65.7%), with a mean follow-up of 21.1 months. Among the 25 patients who underwent one F-G exchange, 18 eyes (72%) achieved anatomic success at the final follow-up. The remaining ten eyes, where F-G was performed twice, had final anatomic success in five eyes (50%). Eighty percent of patients had maintained or improved visual acuity following the F-G exchange procedure. Twenty-two eyes (62.9%) demonstrated functional success (visual improvement of two lines or greater or a BCVA of 0.4 or better) at the last follow-up timepoint. For cases with a superior retinal detachment, the final anatomic reattachment rate was 76.5%, the same as the functional success rate. For the eyes with posterior pole retinal detachments, the final anatomic reattachment rate was 87.5 % while the functional success rate was 57.1%. The anatomic and functional success rates for the inferior retinal detachments were the lowest at 36.4% and 45.5%, respectively.

The procedural complications that occurred following this procedure are given in Table 4. The complications that appeared to be directly related to F-G exchange included a worsening of cataracts in six of the 14 phakic eyes (for which lens extraction and intraocular lens implantation were required in four eyes), acute elevation of intraocular pressure in one eye, suprachoroidal gas injection in one eye, and endophthalmitis in one eye. Persistent retinal detachment or an extended retinal detachment occurred in four eyes. PVR was noted in six eyes. In nine cases, subsequent vitrectomies were performed.

Discussion

After Gonin's[9] report on the importance of localizing and sealing retinal breaks when treating retinal detachments, Rosengren[10] introduced the concept of internal tamponade with air. The development of external scleral buckling techniques introduced by Custodis,[3] the use of cryotherapy reported by Shea,[11] in additional to Machemer's[1,2] vitreous surgery technique, have all contributed to the surgical correction of retinal detachments.

However, we are currently confronted with new problems associated with retinal detachments in the postvitrectomized eye.[12] The postvitrectomized eye is filled with an aqueous liquid instead of vitreous gel. Once a retinal break occurs in the postoperative eye, the aqueous humor enters the subretinal snceye, *a* the retinal tear or retinal holeththe progression to retinal detachment is then very rapid. We prefer the vitreous surgical approach instead of scleral buckling surgery as superior results can be achieved in cases with complicated retinal detachments.[4,13-15]

Intraocular gases are the most commonly used material for temporary vitreous replacement. The mechanical properties of intraocular gases provide a longer internal tamponade that can successfully manage retinal detachments of postvitrectomized eyes. As the resulting gas bubble is larger than the retinal break and detachment, the surface tension of the gas prevents it from passing through the retinal break. Additionally, the buoyant forces of the gas flatten the retina by displacing the subretinal fluid into the vitreous through the retinal breaks.[16] The outpatient postvitrectomy F-G exchange technique is simple to perform and more cost-effective than the conventional vitreous operative approach.

Several reports have described techniques for outpatient F-G exchange.[5-8] The F-G exchange technique can be divided into two broad groups, the one-needle and the two-needle technique. Landers et al.[5] described a procedure with a single syringe and needle which was termed the "push- pull" technique. In aphakic patients, F-G exchange can be performed at the slit lamp. The horizontal position F-G exchange in postvitectomized phakic eyes can be performed *via* the pars plana route. Kleiner[6] reported a similar technique using a single needle connected to two syringes *via* a three-way stopcock. In addition, Miller et al.[7] described a two-needle technique, using an automated air-fluid device.

Using an alternative method, a two-needle pars plana approach technique, we performed outpatient F-G exchange for the treatment of retinal detachments in 35 eyes of 33 patients. Miller et al.[7] demonstrated that the one-needle technique, alternating fluid aspiration and gas injection, made multiple small gas bubbles in more than 50% of cases. This obscured visualization of the fundus, and the formation of small gas bubbles in the vitreous often precludes the use of postoperative laser therapy and may conceal complications such as new retinal breaks, retinal incarceration, subretinal gas, and choroidal hemorrhages. However, our procedure prevents the formation of these small "fish egg" bubbles. In the two-needle technique, the gas is injected with one movement of the plunger; a single large bubble may be located in the uppermost retina as a result. While the one-needle technique causes rapid changes in the intraocular pressure or over-inflation of the eyeball with excess gases, this technique maintains a constant intraocular pressure. As the vitreous fluid is run down the barrel of the plungerless 1-mL syringe; we avoid unnecessary iatrogenic aspiration and reduce the risk of retinal incarceration in the needle entry site. We seldom face issues with a hypotonic state as leakage *via* the needle tract is very rare. This procedure is performed in a horizontal position; the entry site of the gas infusion is not at the 12 o'clock position, and using two needles, the range of needle movement is narrow, so the opening size of the needle tract is constant.

The main disadvantage of this technique is that two or more trained operators are required to position the needles inside of the eye simultaneously. Additionally, the risk of damaging the lens and causing endophthalmitis may be greater than with the single-needle technique.

Many complications can occur when using the F-G exchange technique such as elevated intraocular pressure, glaucoma, worsening of lens opacities, subretinal gas, new or enlarged retinal breaks, dislocation of intraocular lens implant, and endophthalmitis.[5,17,18] In the current study, cataract formation or worsening of lens opacity were the most common complications of the F-G exchange, occurring in six of the 14 phakic eyes (42.9%). Only one eye had a temporally increased intraocular pressure, which was controlled medically. More serious complications occurred in two eyes; a suprachoridal gas infusion in one eye and endophathalmitis in the other eye as the patient was noncompliant with the postoperative topical antibiotics. In these eyes, additional vitrectomy revisions were required to manage these complications. Subretinal or suprachoroidal gas may be complications of intraocular gas. The visualization of the needle tip during gas injection is important to avoid inadequate injection of gas.

A study reported by Blumenkranz et al.[8] using the one-needle technique in eyes with partial or total retinal detachment, demonstrated that F-G exchange resulted in attachment in 82% of cases within the first 48 hours, and the final reattachment rate was 75%. The results of the current study currconsistent with previous studies. The retinal reattachment was 80.0% following complete gas disappearance; the overall success rate was 65.7%. The anatomic successes of the superior retinal detachments and the posterior pole retinal detachments were 76.5 % and 85.7%, respectively. However, the success rate for the inferior retinal detachments was lower than the others, 36.4% had retinal reattachment.

The reasons for failure after the procedure were as follow: PVR in six eyes and persistent inferior retinal detachment or extended retinal detachment in four eyes. PVR is the most significant cause of failure in retinal detachment reported in many other studies. Proliferation of astrocytes, stimulated by retinal pigment epithelium separated into the vitreous, plays a role in the development of tractional retinal detachment. Occasionally, intraocular gas alone cannot completely remove the tractional forces. A persistent retinal detachment may be considered to reflect a new or missed retinal break or unresolved traction forces acting on retinal breaks. In inferior retinal detachments, as the meniscus of the gas bubble occupies more area than the superior retina, there is a limited capability to achieve a complete retinal attachment due to weak adhesions between the sensory retina and the retinal pigment epithelium. In these cases a surgical procedure should not be delayed.

In conclusion, in patients who have undergone vitrectomy, postoperative F-G exchange done outside of the operating room is a useful technique for retinal reattachment. Fluid-gas exchange with laser photocoagulation is a safe and cost-effective alternative to retinal reoperation in superior retinal detachments or posterior pole retinal detachments. Therefore, the location and the range of retinal detachment should be considered in the decision to perform this procedure as an alternative to repeated retinal surgery.

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