PNEUMATIC RETINOPEXY USING ONLY AIR

J. SEBAG, MD,* M. TANG†

Abstract: Pneumatic retinopexy was performed using only air in an attempt to minimize vitreous disturbance and lower the incidence of postoperative proliferative vitreoretinopathy (PVR) and premacular membranes (PMM). Retinal cryopexy or laser treatment (in 2 cases) and intravitreal injection of 0.8 cc filtered air were performed on 45 rhegmatogenous retinal detachments with superior breaks and no preoperative vitreous hemorrhage or PVR. Reattachment was achieved in 39 (86.7%) eyes. The remaining 6 eyes were secondarily treated with scleral buckle surgery, which was successful in all cases. The average length of follow-up was 17.1 +/- 8.6 months, at which time visual acuity was the same or better in 44 (97.8%) eyes. In 1 case (2.2%) PVR developed, a PMM formed in 1 case (2.2%), and new or missed retinal breaks were found in 4 cases (8.8%). This technique achieves a high rate of reattachment, good visual outcome, and low incidence of PVR, PMM, and new or missed breaks, perhaps due to the short-acting, nonexpansile nature of air.
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Pneumatic retinopexy is a nonincisional operation used to treat rhegmatogenous retinal detachment. As currently practiced, this procedure most often involves intravitreal injection of an expanding, long-acting gas. Studies have found that this technique achieves a success rate comparable to that of scleral buckle surgery with less postoperative morbidity, as evidenced by better final visual acuity.[1–3] However, in four of the largest studies performed to date,[3–6] postoperative proliferative vitreoretinopathy (PVR) developed in 4% to 10% of cases, and premacular membranes (PMM) developed in 2% to 4.0% of all cases. New or missed retinal breaks were found in 12% to 23% of eyes treated with long-acting expanding gases.[3–6] Hilton and Tornambe[7] have recently grouped together 18 reported series totalling 1274 eyes. Although it is not clear that this is a homogenous group, given certain methodologic differences from center to center, the overall reattachment rate (after one operation) was 80%, new or missed retinal breaks were found in 13%, and PVR developed in 4%.

The injection of gas into vitreous is an injection into a complex tissue possessing an intricate macromolecular structure.[8] Studies have shown that when injected into vitreous, expanding gases can remain in the eye for as long as 3 to 4 weeks[9] and induce biochemical[10] and structural[11,12] alterations. A recent study[12] has found that complete fill of the rabbit vitreous resulted in permanent alterations of vitreous biochemistry and structure, whereas a partial fill induced temporary alterations that resolved by the sixteenth day after surgery. In a clinical setting where management includes maneuvers such as a cryopexy, these temporary alterations could be sufficient to facilitate cell migration and proliferation predisposing the eye to PVR and PMM formation. Similarly, vitreous disturbances could lead to formation of new retinal breaks or opening of missed retinal breaks, resulting in recurrent retinal detachment.

In an attempt to minimize vitreous disturbance and possibly decrease the incidence of these postoperative complications, pneumatic retinopexy was performed using a nonexpanding gas of short duration: air. The results demonstrate a high success rate with a low incidence of

From *the Department of Ophthalmology, University of Southern California School of Medicine, Los Angeles, California, and †the Diabetes Research Program, the University of California, Irvine, California.

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Reprint requests: J. Sebag, MD, 11th Floor, Pacifica Tower, 18800 Delaware Street, Huntington Beach, CA 92648.

PVR, PMM, and new or missed retinal breaks after surgery.

Materials and Methods

Patient Population

The study group included a consecutive series of 45 eyes of 44 adults (22 men, 22 women) seen between August 1988 and July 1990 with superior rhegmatogenous retinal detachment (defined as detachments with retinal breaks between 8:00 and 4:00 in the superior periphery) and no preoperative vitreous hemorrhage or PVR. There were no cases of retinal tears with only a rim of elevated retina, and all cases had subretinal fluid elevating the retina enough so that laser photocoagulation, cryopexy, or both would not be sufficient to manage the case. The clinical findings in these eyes are given in Table 1. The mean age of this population was 65.4 ± 12.2 years. Of the 45 eyes, 22 (48.8%) were phakic. Of the 23 nonphakic eyes all but 3 (cases 13,27,28) had intraocular lens implants (17 posterior chamber, 3 anterior chamber) and all but 3 (cases 10,16,44) of these had open posterior capsules. Axial myopia in excess of 6 diopters was found in 4 eyes (8.9%; cases 3,12,25,26). More than half of the cases (24/44, 54.5%) had a single retinal tear. In eyes with multiple retinal tears, all were within three clock hours of each other. Only two cases had tears that were one clock hour in size at their base; most cases (30/44; 68.2%) had tears smaller than approximately one-half clock hour. In 4 eyes inferior breaks were present in attached retina before surgery and were treated prophylactically at the time of pneumatic retinopexy (cases 8,21,28,38).

Operative Procedure

After informed consent was obtained, a Honan balloon was applied for 30 minutes. Retrobulbar anesthesia was achieved using 4% Xylocaine (Astra Pharmaceutical, Westborough, MA) injected via an inferior orbital approach. The Honan balloon was then reapplied for 15 minutes. Indirect ophthalmoscopy was performed with 360° of scleral depression in the peripheral fundus. Cryopexy (Frigitronics, Shelton, CT) was applied about the retinal breaks(s) in 43 (95.5%) eyes. In the remaining 2 eyes, peripheral retinal laser photocoagulation (Opthalas Argon/Dye Laser with indirect Ophthalmoscope delivery system; Alcon Laboratories, Ft. Worth, TX) was administered 1 to 2 days after air injection. The external globe and fornices were sterilized with full-strength Betadine solution (Medical Chemical, Santa Monica, CA) and irrigated with balanced salt solution. A 30-gauge needle was used to inject 0.8 cc of filtered (0.45-μm pore size; Millipore, Bedford, MA) air via a stab incision through the pars plana (3.5–4.0 mm posterior to the limbus) inferotemporally or inferonsally. The needle tip was viewed with the indirect ophthalmoscope during moderately slow injection of air, and a single large bubble was usually achieved.[13]

In all cases, a paracentesis of the anterior chamber was performed with a 30-gauge needle inserted at the limbus. In patients with open or no posterior capsules, paracentesis was performed before intravitreal air injection. Indirect ophthalmoscopic examination was performed in all cases. In 20 (44.4%) cases pulsations of the central retinal artery were noted as late as 10 minutes after intravitreal air injection and a second paracentesis was performed at the limbus 180° from the first paracentesis site. Good perfusion at the optic nerve head was achieved in all patients before discharge. Patients were instructed to position their heads so that the retinal breaks were uppermost in location. In cases with multiple breaks, none were farther apart than 3 clock hours and the bubble thus covered the break(s) in all cases. Patients were asked to maintain that position all day and night except for meals and toiletry, for a minimum of 3 days, and if tolerated, until the bubble was noted to disappear.

Results

Follow-up evaluation lasted for at least 6 months in 44 (97.8%) of the 45 cases. One patient (case 15) died 2 months after surgery, shortly after his most recent eye examination. Duration of the follow-up period ranged from 6 months to 33 months (mean = 17.1; standard deviation = 8.6 months). Postoperative intraocular inflammation was minimal and the intravitreal air bubble dissipated within 5 days in all cases. There were no cases of postoperative vitritis or endophthalmitis.

Retinal reattachment was achieved by a single pneumatic retinopexy procedure in 38 (84.4%) cases. This occurred within 2 to 3 days in all cases. Repeat cryopexy and air injection were necessary in one case (case 30) because of a new retinal tear with superior retinal detachment temporal to the original retinal break and detachment. The second pneumatic retinopexy procedure was successful. The patient developed a PMM 13 months after surgery. This was the only PMM that developed in this series of cases (incidence = 2.2%), and after vitrectomy with membrane peeling, final visual acuity was 20/60. Proliferative vitreoretinopathy developed in one case (incidence = 2.2%) of high myopia with lattice degeneration (case 26), and vitrectomy with scleral buckle surgery was performed; the retina was successfully reattached after surgery. This was the only other case in this study in which vitrectomy was necessary. Thus, clinically significant abnormal cell migration and proliferation occurred after surgery in 2 of 45 cases (4.4%). In 4 (8.8%) eyes there were inferior retinal tears

Table 1. Clinical Findings

Case No.	Age (yrs)	Sex	Eye	Lens	Duration of Detachment (wks)	Extent (hours)	No. of Tears	Location of Tears (hours)	Macula	Scleral Buckle	VA Before Surgery	VA After Surgery	Length of Follow-up (mos)
1	71	F	OD	pc/open	2	8	1	12:00	off	yes	CF	20/40	28
2	74	M	OD	phakic	8	1	1	9:00	on		20/40	20/30	24
3	42	F	OD	phakic	1	4.5	1	1:00	on		20/30	20/30	32
4	72	F	OS	ac/open	1	6.5	2	12,1:00	off		HM	20/50	12
5	81	F	OS	ac/open	1	8	4	1,2,3,4:00	off		HM	20/50	11
6	75	F	OS	pc/open	1	7	1	1:30	off		HM	20/40	17
7	65	M	OS	ac/open	12	3	1	3:00	off		20/200	20/25	33
8	44	M	OS	phakic	12	3.5	4	2,3,4:00	off		20/200	20/40	22
9	49	F	OS	phakic	52	1	1	11:00	on		20/30	20/20	14
10	76	F	OS	pc/intact	1	6	1	11:00	off		CF	20/100	12
11	69	M	OS	phakic	1	5	1	12:30	off		20/100	20/100	10
12	58	M	OS	phakic	1	4	1	11:00	on		20/30	20/25	28
13	60	F	OD	aphakic	40	3.5	1	9:00	off		CF	20/40	31
14	67	F	OD	phakic	3	6	1	11:00	off	yes	CF	20/200	30
15	74	M	OD	pc/open	40	3.5	3	11,12:00	off		20/400	20/40	2
16	70	F	OD	pc/intact	1	6	1	1:00	on		20/60	20/40	7
17	68	M	OS	pc/open	1	6	2	11,12:00	off		20/400	20/30	30
18	76	F	OS	pc/open	1	6	2	10 to 12	on		20/40	20/25	28
19	56	M	OS	ac/open	1	5	1	11:00	on		20/50	20/20	17
20	56	M	OD	pc/open	1	4	3	12,1,2:00	off	yes	CF	20/30	8
21	61	M	OS	phakic	5	5.5	2	12,1:00	off		CF	20/200	9
22	74	F	OS	phakic	1	3.5	5	12,1:00	on		20/60	20/30	26
23	53	F	OD	phakic	4	8	1	10:30	off		CF	20/100	26
24	65	M	OD	pc/open	4	7	1	10:00	off		CF	20/40	13
25	36	M	OD	phakic	2	3	1	11:00	off	yes	20/200	20/60	23
26	40	M	OS	phakic	2	5	2	1:30	off	yes	20/200	20/200	19
27	35	M	OD	aphakic	1	3	3	2,3:00	on		20/200	20/30	23
28	70	M	OS	aphakic	1	4	1	2:00	off		HM	20/30	22
29	70	M	OS	phakic	1	4	1	3:00	on		20/30	20/40	21
30	76	M	OD	phakic	1	4.5	4	9,10:00	on		20/40	20/60	21
31	90	F	OS	pc/open	1	3	1	10:00	on		20/25	20/25	20
32	53	F	OS	phakic	12	3	4	2,2:30	on	yes	20/25	20/20	16
33	67	M	OD	phakic	2	2.5	2	10,11:00	off		HM	20/50	6
34	73	M	OS	phakic	1	1.5	2	1,2:00	on		20/40	20/25	18
35	82	F	OD	pc/open	1	4	3	10 to 12	off		20/400	20/25	12
36	67	F	OS	phakic	3	1	1	3:00	on		20/25	20/30	12
37	72	M	OD	pc/open	1	3	1	2:30	on		20/50	20/40	10
38	60	F	OD	phakic	1	1	2	11:30	on		20/30	20/30	8
39	72	M	OD	pc/open	1	2	1	1:30	on		20/20	20/20	10
40	78	F	OD	pc/open	1	2.5	2	10 to 12	on		20/40	20/40	9
41	72	M	OS	phakic	1	5	3	12,1:00	on		20/40	20/40	7
42	71	F	OD	pc/open	2	6.5	2	9:30,11:00	off		20/60	20/25	6
43	71	F	OD	phakic	3	6	1	12:00	off		HM	20/60	6
44	63	F	OS	pc/intact	2	9	1	1:00	off		HM	20/60	6
45	69	M	OD	phakic	1	3.5	1	10:00	off		HM	20/25	23

VA = visual acuity; pc = posterior chamber intraocular lens; open = open posterior capsule; CF = counting fingers; ac = anterior chamber intraocular lens; HM = hand motions; intact = intact posterior capsule.

in attached retina before surgery. Cryopexy was applied at the time of pneumatic retinopexy, and none developed recurrent retinal detachments.

In 3 cases (6.7%) poor patient compliance resulted in persistent retinal detachment and scleral buckle surgery was performed (cases 1,14,32). In 3 cases (6.7%) new retinal tears developed inferiorly and caused a new retinal detachment requiring scleral buckle surgery (cases 20,25,26). Five of these six cases with persistent or new retinal detachments were successfully treated by one scleral buckle procedure; scleral buckle was supplemented with vitrectomy for PVR (see above) in the sixth case. The success rate of pneumatic retinopexy in phakic cases or those with intact posterior capsules (21/25;84%)

was equivalent to that in aphakic cases, and pseudophakic cases with open posterior capsules (18/20;90%). The overall retinal reattachment rate in all 45 eyes was 39 out of 45 (86.7%) for pneumatic retinopexy and 45 out of 45 (100%) for pneumatic retinopexy and scleral buckle, with vitrectomy in one case.

Visual acuity improved by at least 2 Snellen lines in 30 eyes (66.7%), and remained the same (within 2 Snellen lines) in 14 eyes (31.1%; Figure 1). In one eye (case 30; pneumatic retinopexy twice followed by vitrectomy for PMM) visual acuity worsened from 20/40 before surgery to 20/60 after surgery.

Discussion

Pneumatic retinopexy has been shown to be an effective method of treating rhegmatogenous retinal detachment,[1–7] purportedly with less morbidity than scleral buckling.[3] However, the use of expanding, long-acting gases in pneumatic retinopexy has been associated with clinically significant abnormal cell migration and proliferation in 8% to 13% of cases.[3–7] In the only randomized prospective trial performed to date,[3] the use of expanding, long-acting gases was associated with a higher incidence of postoperative "new or missed" retinal breaks (23%) compared to scleral buckling (13%). The study

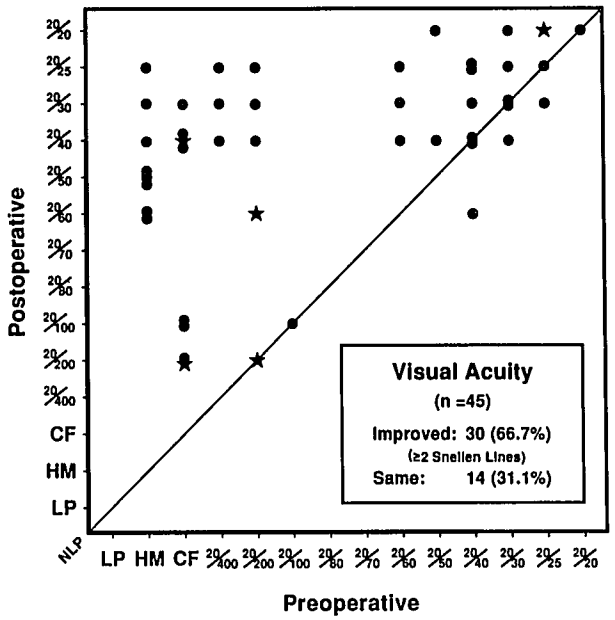

Fig. 1. Scattergram of visual acuity results before and after surgery. Points above the diagonal line represent improvements; points on or within 1 Snellen unit represent no change; and the one point 2 Snellen units below the line represents worsened visual acuity. The stars indicate those cases that required scleral buckle surgery. Points clustered in the upper right hand corner represent cases with attached maculae before surgery. Those in the upper left likely represent cases with "overhang" of detached retina in front of an attached macula and cases of recently detached maculae. Points in the lower left represent cases with detached maculae before surgery. NLP = no light perception; HM = hand motion; CF = count fingers.

reported herein demonstrates that pneumatic retinopexy using air alone without expanding, long-acting gases achieves a high rate of retinal reattachment (86.7%). Visual acuity was stable or improved in 44 of 45 (97.8%) cases. The incidence of postoperative PVR, PMM, and new or missed retinal breaks was lower using air alone than in some previous studies using expanding, long-acting gases (Table 2).

It is reasonable to postulate that the use of a nonexpanding, short-acting gas (air) was to some extent the reason for this low incidence of postoperative complications. Apart from the use of air alone, the protocol employed in this study differed from that of some previous studies in the use of slow injection of air under direct visualization. Others have used this technique[13] and it is possible that the lower incidence of new or missed retinal breaks in this study is related to this maneuver. Smiddy et al[14] described that new retinal breaks occurred in 14% of cases treated with laser, cryopexy, or both for retinal breaks without intravitreal injection. Given the minimal, if any, vitreous disturbance in these cases, it is likely that some if not many of these represent "missed" retinal breaks. Consequently, we have used the term "new or missed" retinal breaks and postulate that one explanation for the low incidence of new or missed retinal breaks after surgery in this series resulted from a more careful and meticulous preoperative examination of the peripheral fundus, enabling us to identify and apply prophylactic treatment to inferior retinal tears in attached retina of 4 (8.8%) cases, thereby reducing the postoperative incidence of recurrent retinal detachment. Alternatively, it could be postulated that the nonexpanding, short-acting qualities of air did not induce changes within vitreous and upward traction on these tears of sufficient degree to result in postoperative inferior retinal detachments. This postulate, based only on the study presented here, will need testing at other centers, preferably in a randomized clinical trial.

Evidence suggests that expanding, long-acting gases induce biochemical[10] and structural[11,12] alterations of vitreous. These changes, superimposed on alterations already present in vitreous of aged,[15,16] aphakic/pseudophakic,[17,18] or myopic[19,20] eyes, may account for the observed incidence of postoperative PVR, PMM, and new or missed retinal breaks.[3–7] The alterations at the posterior vitreous cortex observed by Lincoff et al[11] would seem of particular importance as risk factors for abnormal cell migration and proliferation after treatment with long-acting expanding gases. It is therefore reasonable to hypothesize that the short duration and nonexpanding qualities of air alone induce less vitreous disturbance, thereby reducing the incidence of postoperative complications, as observed in this series.

It should be emphasized that the technique described here may not be useful in cases of rhegmatogenous ret-

Table 2. Comparative Analysis of Results

	Expanding Gas Studies*					
	3	4	5	6	7	Air
No. patients	103	58	40	51	1274	45
Retinal arc covered (°)	140	140	140	140	—	130
Reattachment rate for one procedure (%)	73	64	75	63	80	84
Proliferative vitreoretinopathy (%)	4	10	10	10	4	2.2
Preretinal membranes (%)	4	3	2.4	2	—	2.2
New or missed retinal breaks (%)	23	12	12.5	22	—	8.8

* Numbers refer to references. See references 3 through 7.

inal detachment with associated vitreous hemorrhage or PVR, as such cases were not included in this study. Furthermore, the use of air alone may only be effective in cases with small retinal tears, although 0.8 cc of air does cover 130° of retinal arc in an emmetropic eye.[2] This is comparable to the retinal arc covered by a 0.3-cc bubble of perfluoropropane that expands to 1.2 cc covering about 140° of retinal arc. The technique used in this study could be further improved by using transconjunctival diathermy or laser rather than cryopexy at the time of air injection, or by applying laser photocoagulation 1 to 2 days after intravitreal air injection. This would minimize the risk of dispersing retinal pigment epithelial cells[21] and contributing to PVR. Vitreous disturbances could also be reduced by injecting a smaller amount of air in those cases with a single, relatively small retinal tear, or by injecting twice with a smaller volume of air each time, as previously described.[22] It is not established, however, that the injection of a small volume twice is less disruptive than a single large injection. Furthermore, previous attempts using variable amounts of air (up to 1.0 cc) resulted in a reattachment rate of only 75%.[23] In that preliminary report, follow-up evaluation lasted for 6 months in only 14 (58%) of the 24 cases, and visual results were not disclosed.

In view of the high success rate and low incidence of postoperative complications after injection of air, future experimental and clinical studies should be performed to compare it with the use of expanding, long-acting gases to determine if it is the best agent for internal tamponade in treating selected rhegmatogenous retinal detachments.

Key words: retinal detachment, pneumatic retinopexy, air, proliferative vitreoretinopathy, premacular membranes, vitreous.

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