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Pneumatic retinopexy combined with scleral buckling in the management of relatively complicated cases of rhegmatogenous retinal detachment: A multicenter, retrospective, observational consecutive case series*

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Abstract

Objective: To evaluate the efficacy of maximal pneumatic retinopexy (PR) and subretinal fluid (SRF) drainage combined with scleral buckling (SB) in the treatment of complicated rhegmatogenous retinal detachment (RRD).

Methods: Patients with RRD who underwent maximal PR and SRF drainage combined with SB from June 2007 to June 2012 were included in this multicenter retrospective study. The outcome measures were the primary and final operation success rates and best-corrected visual acuity (BCVA).

Results: In total, 159 consecutive patients were included. The mean follow-up period was 13.76 $\pm$ 1.97 months. Primary operation success was achieved in 146/159 (91.82%) eyes. After salvage

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management, the final reattachment rate increased to 98.11%. All eyes had improved BCVA, with 62/159 (38.99%) attaining BCVA of ≥20/40.

Conclusions: Maximal PR and SRF drainage combined with SB achieved satisfactory anatomical and visual recovery in relatively complicated cases of RRD. The decreased need for vitrectomy makes this surgical approach more widely available.

Keywords

Rhegmatogenous retinal detachment, pneumatic retinopexy, scleral buckling, subretinal fluid drainage, best-corrected visual acuity, case series

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Introduction

Rhegmatogenous retinal detachment (RRD) is an important cause of vision loss worldwide, with an annual incidence rate of 6.3 to 18.9 per 100,000 individuals.[1–3] The main treatment modality for RRD is surgical reattachment of the retina, which includes pneumatic retinopexy (PR), scleral buckling (SB), and vitrectomy. Generally, vitrectomy is indicated for relatively complicated RRD.[4] However, vitrectomy may be more frequently associated with cataract aggravation, secondary glaucoma, and a high economic burden to poor patients in developing countries.[5–7]

PR has long been used for the management of RRD because it is convenient and less invasive.[8–11] SB cures RRD by releasing vitreous traction, closing the retinal breaks, and bringing the retina and retinal pigment epithelium (RPE) closer to each other.[12] Both PR and SB preserve the vitreous. However, they are usually indicated for relatively simple RRD. Prior studies have indicated that low intraocular pressure (IOP), persistent intraoperative detachment at the buckle, macular-off status, and posterior retinal breaks are risk factors for surgical failure of SB.[13–15] Meanwhile, inferior breaks and visible vitreous traction on a tear often predict failure of PR.[16,17]

Nonetheless, PR and SB can complement each other. Early in 1985, Gilbert and McLeod[18] and Stanford and Chignell[19] introduced a technique involving sequential subretinal fluid (SRF) drainage (D), intravitreal injection of air (A), transscleral cryopexy (C), and episcleral explant (E) (DACE) for selected patients with bullous retinal detachment (RD). The primary operation success rates were 90%[18] and 96%,[19] respectively. However, after including more complicated cases (e.g., RRD with unseen retinal breaks, macular holes [MHs], or some degree of proliferative vitreoretinopathy [PVR]), the single-operation success rate decreased to 67%.[20] Even after reoperation, the reattachment rate was only 81%.[20] In a subsequent study, Cheng et al.[21] performed short-term external SB combined with PR in patients with RRD with inferior breaks and reported a single-operation reattachment rate of 87.9%.

Consistent with our clinical experience, a single PR with external drainage of SRF rarely achieves complete retinal reattachment in relatively complicated RRD because of the deep SRF, static vitreoretinal tractions on a tear, and deep locations of retinal breaks. The use of a small gas bubble in prior studies was largely ineffective for complete release of the vitreoretinal traction. In the past few years, maximal PR has been developed in our practice. Maximal PR involves injection of an adequately large non-expansile gas bubble into the vitreous to achieve thorough release of the vitreoretinal traction. We have performed maximal PR and SRF drainage combined with SB for treatment of relatively complicated RRD, such as those involving tractional tears, vitreous hemorrhage, unseen retinal breaks, and posterior holes (including MHs) with combined peripheral retinal breaks, and favorable results were achieved. The purpose of the present study was to introduce and evaluate the efficacy of maximal PR and SRF drainage together with SB for the management of relatively complicated RRD.

Methods

Patients

This study involved a retrospective chart review of consecutive patients who underwent maximal PR and SRF drainage together with SB at three large hospitals in Eastern China (First People's Hospital of Shanghai, Fourth People's Hospital of Taizhou, and People's Hospital of Xinghua) from June 2007 to June 2012. The inclusion criteria were an RD with tractional tears, vitreous hemorrhage, and posterior holes combined with peripheral retinal breaks or unseen retinal breaks. The tractional tears often had a fish-mouth appearance and were defined as the inability of the circumference of the retinal breaks to touch the RPE under scleral indentation. Vitreous hemorrhage was caused by retinal breaks and did not impair adequate examination of the peripheral retina under scleral indentation. Unseen retinal breaks included retinal tears that were undetectable both preoperatively and intraoperatively. The diagnoses were based on indirect ophthalmoscopy examinations and confirmed by B-mode ultrasonography and optical coherence tomography. The exclusion criteria were as follows: a history of vitreoretinal surgery, giant retinal tears, posterior retinal breaks spanning more than one quadrant, PVR greater than grade C_1, inability to cooperate in postoperative prone positioning, severe lens opacity compromising visualization of the fundus, and a follow-up period of <12 months.

Data collection

The following data were collected by a chart review: age; sex; refractive status; number, location, and types of breaks; extent of RD; macula and lens status; preoperative and postoperative best-corrected visual acuity (BCVA); IOP; and complications. Informed consent was obtained from all patients. The patients were fully informed of the nature and the treatment of the disease, alternative managements, and the importance of postoperative prone positioning. This study adhered to the tenets of the Declaration of Helsinki and was approved by the institutional review board of First People's Hospital of Shanghai, Ninth People's Hospital of Shanghai, Fourth People's Hospital of Taizhou, and People's Hospital of Xinghua.

Surgical procedures

All procedures were performed under retrobulbar anesthesia and standard sterilization. Indirect ophthalmoscopic observation was performed with 360° scleral depression of the peripheral fundus. Initially, a customized SB was performed. After the circling band had been tightened, the SRF was drained through a syringe with a 30-gauge needle. In patients with involvement of a large RD area, PR was performed first to increase the IOP, thus facilitating SRF drainage. In PR, non-expansile gas (cumulative volume of 0.6–3.0 ml of filtered air or diluted perfluoropropane [C_3F_8] [12%–20% C_3F_8 in air]) was injected into the vitreous cavity through a syringe with a 30-gauge needle at a location 3 to 4 mm posterior to the limbus (in phakic eyes, 3.8 mm from the limbus; in pseudophakic eyes, 3.5 mm from the limbus). The needle tip was directly visualized to ensure the formation of a single large bubble at a moderately slow speed. After intravitreal injection, gentle pressure was maintained on the injection site with a 75% alcohol-rinsed cotton-tip applicator for at least 5 minutes until the injection site was definitely closed. Indirect ophthalmoscopy was then repeated to determine whether the retina was attached and whether the breaks were located on the buckle indentation. If needed, repeated intravitreal gas injection and SRF drainage were alternatively performed several times under a stable IOP until the intravitreal gas bubble was large enough. In subsequent PR procedures, we asked the patients to assume a tilted head posture to ensure visualization of the bubble, which was located at the highest point of the globe. Once the needle tip was confirmed to be within the bubble, gas was smoothly injected into the bubble compartment, thus avoiding a "fish-egg" formation. After injection, the patient's head was moved slightly to ensure that the needle tip was out of the bubble; the needle was then immediately withdrawn. At the end of the surgery, the IOP was controlled to approximately 24 mmHg, which is slightly higher than the normal level, to avoid postoperative hemorrhage. Transconjunctival cryopexy was applied around the retinal breaks when slight or no SRF was present. Finally, the retina was re-examined to confirm that the circumference of the retinal breaks touched the RPE and that there was no visible vitreous traction on a tear. The duration of surgery was approximately 45 to 60 minutes.

In patients with no clearly identifiable retinal breaks, transconjunctival cryopexy was applied to the suspected area of retinal breaks; e.g., in the region of lattice degeneration.

In patients with posterior RD with an MH or posterior break, intravitreal gas was injected and the patient was asked to assume a tilted head posture. Liquefied vitreous fluid was then aspirated via the pars plana through a 30-gauge syringe. SB combined with PR and vitreous fluid aspiration (if needed) were then performed sequentially.

All patients were hospitalized and frequently visited by the operating surgeon. They were instructed on how to maintain proper head positioning 8 to 10 hours daily for 3 to 14 days to enable the retinal tears to stay in the uppermost position. They were asked to continuously maintain that position except during meals and hygiene practices until the bubble dissipated. Any movement was required to be performed in slow and stable motions to avoid violent displacement of the intravitreal gas bubble, which could possibly cause new breaks and reopen the causative break. Supplementary laser photocoagulation around the breaks was performed in some patients after the retina had reattached. The postoperative IOP was monitored and maintained at $<$25 mmHg. Patients were discharged 2 to 3 days postoperatively and visited the operating surgeon's clinic at 1 week, 2 weeks, and 1 month and then bimonthly for at least 12 months.

Anatomically successful surgery was defined as the complete disappearance of SRF and flattening of the entire circumference of the retinal breaks. Primary operation success was defined as retinal reattachment at 12 months after the initial operation without additional vitreoretinal surgery. Final operation success was defined as retinal reattachment at the last follow-up.

Statistical analysis

BCVA was converted to the logarithm of the minimum angle of resolution (logMAR) for statistical analyses. Visual acuities of counting fingers, hand movement, and light perception were assigned logMAR values of 2.1, 2.4, and 2.7, respectively. All data were analyzed using SAS software (version 9.2; SAS Institute, Inc., Cary, NC) and are reported as mean ± standard deviation or n (%). Continuous and categorical variables were compared using Student's t test and the chi-square test, respectively. Spearman's rank correlation test was used to identify the relationship between the baseline and final BCVA. All tests were two-sided, and a p value of <0.05 was considered statistically significant.

Results

A minimum 12-month follow-up evaluation was obtained in 159 eyes of 159 patients. The mean follow-up period was 13.76 ± 1.97 months (range, 12–24 months). The mean age of the patients was 49.51 ± 14.91 years (range, 15–77 years).

Most patients had RRD with tractional tears (58.49%), followed by RD with a posterior hole (19.50%), RD with unseen retinal breaks (11.32%), and RD with vitreous hemorrhage (10.69%). Horseshoe tears were found in 112 patients (70.44%), followed by atrophy holes (20.13%), posterior holes (19.50%), and dialysis of the ora serrata (3.15%). Eighteen patients (11.32%) had no clearly identifiable retinal breaks either preoperatively or intraoperatively. Macular detachment was observed in 155 eyes (97.48%). Thirty-three patients (20.75%) had RRDs with inferior retinal breaks. The patients' preoperative clinical characteristics are shown in Table 1.

Sixty-eight patients received an intravitreal injection of pure air, while the other 91 patients (57.23%) received diluted C_3F_8. During the drainage of SRF, localized subretinal hemorrhage was observed in six patients (3.77%), and iatrogenic retinal breaks were noted in two patients (1.26%). All adverse events were tolerable.

The prone positioning period for the pure air group was 3 to 5 days, and that of the C_3F_8 group was 10 to 15 days. On the first postoperative day, the mean IOP was 16.82 ± 4.56 mmHg. IOP-lowering agents were administered to 13 patients (8.18%) whose IOPs were >25 mmHg. Primary operation success was obtained in 146 eyes (91.82%). Postoperative complications were observed in 13 eyes and included new or missed breaks (10 eyes, 6.29%) and PVR (3 eyes, 1.89%). Repeated PR and cryopexy were performed in the 10 patients with new or missed breaks. Two patients with fixed retinal folds underwent vitrectomy and silicone oil tamponade, and the remaining patient with failed PVR discontinued further treatment for economic reasons. These salvage therapies increased the final reattachment rate to 98.11%. The patients' postoperative clinical characteristics are summarized in Table 2.

All 159 eyes achieved improved BCVA postoperatively ($p < 0.01$). A total of 157 of 159 eyes (98.74%) gained ≥0.30 logMAR units (approximately 2 Snellen lines), and 62 of 159 eyes (38.99%) attained BCVA of ≥20/40. The final BCVA was significantly correlated with the baseline BCVA ($r = 0.43$, $p < 0.01$).

The primary operation success rate in the C_3F_8 group (93.41%) compared favorably with that in the pure air group (89.71%) but did not reach statistical significance. Among the different types of RRDs, patients with a posterior hole had the highest primary operation success rate (100.00%), followed by patients with RD with tractional tears (92.47%), RD with vitreous hemorrhage (88.24%), and RD with unseen retinal breaks (77.78%). In addition, no significant difference in the primary operation success rate was found between patients with and without inferior retinal breaks (93.94% vs. 91.27%, respectively). These details are shown in Table 3.

Discussion

In PR, the healing process of RRD relies on the expanding and buoyancy characteristics

Table 1. Demographic and preoperative clinical characteristics of patients who underwent maximal pneumatic retinopexy and subretinal fluid drainage combined with scleral buckling

Sex	
Male	79 (49.69)
Female	80 (50.31)
Age (years)	49.51 ± 14.91
Number of retinal breaks	1.43 ± 0.62
Number of quadrants involved	3.01 ± 0.79
Preoperative logMAR BCVA	2.19 ± 0.41
RD types	
RD with tractional tear	93 (58.49)
RD with posterior hole (including macular hole)	31 (19.50)
RD with unseen retinal break	18 (11.32)
RD with vitreous hemorrhage caused by retinal breaks	17 (10.69)
Type of retinal breaks	
Horseshoe tear only	75 (47.17)
Horseshoe and atrophy hole	30 (18.87)
Posterior hole only	24 (15.09)
Posterior hole and horseshoe tear	5 (3.14)
Posterior hole and atrophy hole	2 (1.26)
Dialysis of ora serrata only	3 (1.89)
Dialysis of ora serrata and horseshoe tear	2 (1.26)
Proliferative vitreoretinopathy	
Class A	18 (11.32)
Class B	139 (87.42)
Class C_1	2 (1.26)
With high myopia	68 (42.77)
With lattice degeneration	40 (25.16)
Lens status at operation	
Phakic	141 (88.68)
Pseudophakic	18 (11.32)
Macular status	
On	4 (2.52)
Off	155 (97.48)
Inferior quadrants involved	131 (82.39)
With inferior retinal breaks	33 (20.75)

Data are presented as n (%) or mean ± standard deviation.
logMAR: logarithm of the minimum angle of resolution, BCVA: best-corrected visual acuity, RD: retinal detachment.

of gas, which allow the gas to effectively close the causative breaks and impede the intraocular currents into the subretinal space; additional cryopexy or laser photocoagulation is used to induce chorioretinal adhesion.[11] Supplementary SB increases the effect of gas tamponade on the detached retina by bringing the choroid and retina closer, circumferentially relieving the traction on the tears, and supporting the retinal breaks. Therefore, in this study, we evaluated the surgical approach of SB combined with maximal PR and SRF drainage in the treatment of selected cases of complicated

RRD (including RD with tractional tears, vitreous hemorrhage, unseen retinal breaks, and posterior holes [including MHs] combined with peripheral retinal breaks). The primary and final operation success rates were 91.82% and 98.11%, respectively, which are comparable with those achieved by vitrectomy.[22–24]

Table 2. Postoperative clinical characteristics of patients who underwent maximal pneumatic retinopexy and subretinal fluid drainage combined with scleral buckling

Follow-up period (months)	13.76 ± 1.97
IOP on first postoperative day (mmHg)	16.82 ± 4.56
IOP at last visit (mmHg)	15.80 ± 1.76
Prone position period (days)	10.30 ± 3.32
Lens status at last follow-up	
Phakic	146 (91.82)
Pseudophakic	13 (8.18)
Final logMAR BCVA	0.49 ± 0.25
Primary reattachment rate (%)	146/159 (91.82)
Final reattachment rate (%)	156/159 (98.11)

Data are presented as n (%) or mean ± standard deviation. IOP: intraocular pressure, logMAR: logarithm of the minimum angle of resolution, BCVA: best-corrected visual acuity.

Previous studies have explored the efficacy of combined PR and SB in the treatment of RRD. The single operation success rate of DACE in treating simple bullous RD varies from 85% to 96%.[18–20] However, the primary success rate of DACE for more complicated RRD is far from satisfactory.[20] Consistent with our clinical experience, a single PR and external drainage of SRF in previous studies rarely achieved complete retinal reattachment in patients with relatively complicated RRD because of the deep SRF, static traction of tears, and deep locations of retinal breaks; maximal PR and adequate SRF drainage are necessary in such cases. To avoid large fluctuations of IOP during the procedure, PR and SRF drainage were alternatively performed several times. With this method, the deep SRF can be drained under a stable IOP. In addition, unlike previous studies using pure C_3F_8[16] or sulfur hexafluoride (SF_6),[16,18] non-expansile gas was used reduce the risk of a high postoperative IOP caused by a large gas bubble. Moreover, supplementary SB can facilitate the healing of chorioretinal adhesion around retinal tears.

Table 3. Primary Operation Success Rate in Patients underwent Maximal Pneumatic Retinopexy and Subretinal Fluid Drainage combined with Scleral Buckling

	Primary operation success rate (%)	*p*
Different gas tamponades		0.55
Pure air (n = 68)	89.71	
Diluted C_3F_8 (n = 91)	93.41	
Different RD types		0.05
RD with tractional tears (n = 93)	92.47	
RD with posterior hole (n = 31)	100	
RD with unseen retinal breaks (n = 18)	77.78	
RD with vitreous hemorrhage caused by retinal breaks (n = 17)	88.24	
Involvement of inferior retinal breaks		0.618
With inferior retinal breaks (n = 33)	93.94	
With non-inferior retinal breaks (n = 126)	91.27	

RD: retinal detachment.

All 31 patients with posterior holes (including MHs) combined with peripheral retinal breaks achieved primary operation success in our study. In patients with a posterior hole and localized posterior RD, SRF drainage was extremely difficult due to the deep localization of the fluid. In these patients, liquefied vitreous fluid was aspirated as an alternative to SRF drainage. In patients with posterior retinal breaks, the surface tension of the intraocular gas bubble and its buoyancy were the main mechanisms of closure of the posterior retinal breaks and enhancement of SRF absorption.[25–27] However, patients with posterior retinal breaks spanning more than one quadrant may not be candidates for this procedure because one gas bubble can hardly cover such a large area.[11]

In the present study, RRD with unseen retinal breaks were associated with the lowest primary operation success rate (77.78%). Precise location of the buckles and application of the cryopexy was difficult because of the unidentifiable retinal breaks. Such patients should be monitored closely in the early postoperative period to detect any early signs of recurrence. Generally, recurrence of RD initially arises from the area in which the retinal tears are located. Therefore, for recurrent cases in the present study, special attention was paid to the initially detached area to identify the retinal tears, and PR was performed as salvage therapy. Moreover, cryopexy was applied to the initially detached area and supplementary laser photocoagulation was performed around the suspected breaks after the retina had reattached. After this management, all patients with recurrent RD with unseen retinal breaks in our study achieved final operation success until the last follow-up.

The primary operation success rate in patients with vitreous hemorrhage caused by retinal breaks was 88.24%. Because vitreous hemorrhage compromises visualization during the surgery, scleral indentation is critical in identifying the causative retinal breaks. If the hemorrhage is too dense to allow funduscopic evaluation of the retina even under scleral indentation, early vitrectomy is necessary to remove the blood and facilitate visualization.[24]

The primary operation success rate in the C_3F_8 group (93.41%) compared favorably with that in the pure air group (89.71%) but did not reach statistical significance. Our findings are consistent with those reported by Sinawat et al.[28] In their double-blind randomized controlled trial, no significant difference was observed in the reattachment rate of PR with 0.3 ml of air versus C_3F_8 gas injection (single-procedure success rate, 60.3% vs. 73.0%; final procedure success rate, 96.8% vs. 92.1%). In our study, however, the surgeon chose gas tamponade agents according to the RRD severity instead of by randomization. In patients with a large retinal break or an elevated circumference of the retinal break with static traction, C_3F_8 was chosen because of its greater half-life. However, this personal preference was a confounding factor in the comparison. Therefore, we cannot conclude that the gas tamponade effect of air is comparable with that of C_3F_8 in this surgical procedure for selected cases of complicated RRD.

Inferior breaks still present a challenge when performing PR.[16] An inferiorly placed buckle could complement PR by bringing the retina in contact with the RPE. In the present study, the primary operation success rate in patients with inferior retinal breaks was 93.94%, which was comparable with that in patients with superior retinal breaks (91.27%). Cheng et al.[21] performed short-term external SB with PR to treat RRD with inferior breaks and reported a 6-month single-operation reattachment rate of 87.9%. Instead of one injection of 0.5 to 0.7 ml of pure C_3F_8, we performed several injections of filtered air or diluted C_3F_8 to a cumulative volume of 0.6 to 3.0 ml. The non-expansile gas prevented postoperative IOP fluctuations. In addition, the large bubble was more likely to cover the inferior retinal area with postoperative prone positioning.

This study should be regarded as an initial exploration of maximal PR and SRF drainage combined with SB for the treatment of various cases of complicated RRD. Caution should be exercised when interpreting the findings because of several limitations. First, a key drawback of this study was its retrospective, noncomparative nature. Second, all patients were recruited from areas in East China. These factors may have caused selection bias, and our results cannot be generalized to the entire population of patients with RRD. Additionally, the mean follow-up period was 13.76 months, which was a relatively short time to determine the long-term prognosis. The main strength of this study is its relatively large and heterogeneous patient sample.

In conclusion, maximal PR and SRF drainage combined with SB could provide an effective, less invasive, and more economic alternative to vitrectomy for selected cases of complicated RRD. To our knowledge, this is the first study of a vitreous-preserving surgical approach to RRD with tractional tears, vitreous hemorrhage, unseen retinal breaks, and posterior holes (including MHs) combined with peripheral retinal breaks. A large series with a long-term follow-up is needed to fully validate this surgical approach.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

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