

Air tamponade in retinal detachment surgery followed by ultra-widefield fundus imaging system

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Abstract

• **AIM:** To report the surgical result of pars plana vitrectomy (PPV) with air tamponade for rhegmatogenous retinal detachment (RRD) by ultra-widefield fundus imaging system.

• **METHODS:** Of 25 consecutive patients (25 eyes) with fresh primary RRD and causative retinal break and vitreous traction were presented. All the patients underwent PPV with air tamponade. Visual acuity (VA) was examined postoperatively and images were captured by ultra-widefield scanning laser ophthalmoscope system (Optos).

• **RESULTS:** Initial reattachment was achieved in 25 cases (100%). The air volume was >60% on the postoperative day (POD) 1. The ultra-widefield images showed that the retina was reattached in all air-filled eyes postoperatively. The retinal break and laser burns in the superior were detected in 22 of 25 eyes (88%). A missed retinal hole was found under intravitreal air bubble in 1 case (4%). The air volume was range from 40% to 60% on POD 3. A double-layered image was seen in 25 of 25 eyes with intravitreal gas. Retinal breaks and laser burns around were seen in the intravitreal air. On POD 7, small bubble without effect was seen in 6 cases (24%) and bubble was completely disappeared in 4 cases (16%). Small oval bubble in the superior area was observed in 15 cases (60%). There were no missed and new retinal breaks and no retinal detachment in all cases on the POD 14 and 1mo and last follow-up. Air disappeared completely on a mean of 9.84d postoperatively. The mean final postoperative best-corrected visual acuity (BCVA) was 0.35 logMAR. Mean final postoperative BCVA improved significantly relative to mean preoperative ($P<0.05$). Final VA of 0.3 logMAR or better was seen in 13 eyes.

• **CONCLUSION:** PPV with air tamponade is an effective management for fresh RRD with superior retinal breaks. The ultra-widefield fundus imaging can detect postoperative retinal breaks in air-filled eyes. It would be a useful facility for follow-up after PPV with air tamponade. Facedown position and acquired visual rehabilitation may be shorten.

• **KEYWORDS:** rhegmatogenous retinal detachment; air tamponade; ultra-widefield fundus imaging system

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INTRODUCTION

Rhegmatogenous retinal detachment (RRD) is commonly treated by scleral buckling, pars plana vitrectomy (PPV), pneumatic retinopexy or a combination techniques^[1-2]. In the modern era, PPV has been a trend towards an important management of RRDs with identification of retinal breaks and removal of vitreous traction. Once the PPV is chosen, intraocular tamponade agents are used. Gases and silicone oils are the most commonly used types of tamponade agents^[3-4]. In China, perfluoropropane (C₃F₈) is the unique long-acting gas can be used for RRDs except when silicon oil is preferred. Since July 2015, the company has a full cessation production and sale C₃F₈. At present, there is no long-acting gas with China Food and Drug Administration certification in China, then silicone oil is used for RRDs management frequently. However, the use of silicone oil is associated with several common complications, including elevated intraocular pressure (IOP), cataract and corneal opacity. In addition, patients need to take reoperation with silicone oil removal. They will face anxiety of surgery and extra medical expense. Therefore, air would be another reasonable tamponade for treatment of RRDs.

Air filled in the vitreous cavity after the PPV is performed. The series of studies reported varies of results and the initial reattachment rate from 69.6% to 100%^[5-11]. One of the main causes of retinal redetached was missed or new retinal breaks.

Intravitreal air would decrease the visibility of the retina due to strong reflections from the air bubble in the early postoperative period. Clinicians usually detect the missed or new retinal breaks until the air bubble getting smaller or disappeared. With the development of fundus photography, the Optos ultra-widefield imaging system makes retinal visualization and documenting in the gas-filled eyes^[12-13]. It is useful in evaluating postoperative retinal breaks and retinal reattachment in gas-filled eyes^[14-15].

The study was conducted to determine the efficiency of management of RRDs with PPV combined air tamponade and to detect the retinal break after PPV air tamponade by ultra-widefield fundus imaging. According to volume of air and the position of the bubble, the prone positioning may be briefest.

SUBJECTS AND METHODS

Patients Twenty-five consecutive patients (25 eyes) with fresh primary RRD and causative retinal break were included from December 2016 to July 2017. The fresh RRD was considered as retinal detachment (RD) in 1mo without subretinal fibrosis and greater proliferative vitreoretinopathy (PVR). The retinal break was defined as a horseshoe tear and a hole on 8-4 o'clock presented. The exclusion criteria were: 1) RRDs with giant tears; 2) inferior breaks (5-7 o'clock); 3) retinal dialysis; 4) acquired or secondary retinoschisis, pediatric RRDs; 5) PVR grade C or greater.

All patients were examined by slit-lamp biomicroscopy with a non-contact or contact wide angle lens to detect all retinal breaks preoperatively. The number, position (anterior, equatorial, and posterior to the equator), type (horseshoe tear or atrophic hole), size of retinal breaks and significant vitreous traction was determined. The study conducts followed the principles of the Declaration of Helsinki. Additionally, the study was conducted with approval from the Ethics Committee of Guangzhou Aier Eye Hospital.

Surgical Procedure All patients were operated on by a single surgeon (Zhang JL). The surgical method included a 23-gauge PPV performed with Accurus and Constellation Vision System (Alcon Laboratories, Inc. Fort Worth, TX, USA) and a noncontact wide viewing system (Volk Optical Inc., USA). After central and peripheral vitreous removal, all eyes underwent 360° scleral depression to shave vitreous base and removal of all vitreous traction on retinal tears. Fluid-air exchange was performed and vitreous fluid was aspirated with vitreous cutter. Perfluorodecalin would be used according to the position of the retinal breaks. Once the air bubble reached the area of the retinal breaks, subretinal fluid (SRF) under the retinal breaks were drained off by flute needle. At the end of the procedure, vitreous fluid and SRF was aspirated with a flute needle to ensure complete air-fill of the cavity, and then laser retinopexy was performed. The sclerotomy was closed carefully to avoid air loss and the IOP was about 30 mm Hg at

the end of the surgery. No complications developed during the surgical procedure.

Postoperative examinations were performed at 1, 3, 5, 7, 14d, and 1mo. Visual acuity (VA) was performed at 5, 7, 14d, and 1mo and last follow-up. Each patient was examined by slit-lamp during the follow-up period. Air volume is estimated as a percentage of vertical diameter of eye seen through the dilated pupil with the plane of the cornea perpendicular to the ground^[16]. Ultra-widefield scanning laser ophthalmoscopic images (Daytona, Optos PLC, Scotland, UK) were captured from eyes in the primary and guided position at 1, 3, 5, 7, 14d and last follow up. The investigation was detected the causative and treated retinal breaks, reattachments with intravitreal air and the volume of air bubble in the vitreous cavity. The identification of image was made by two specialists (Chen QY and He YQ). While the decision was not consisted, a third specialist (Tang YX) would detect and discuss to make the final decision

Statistical Analysis A descriptive analysis has been carried out. All statistical procedures were performed with SPSS 21.0.

RESULTS

A total of 25 patients (25 eyes) suffered fresh RRDs with superior horseshoe were included in this study. Thirteen patients were men (52%) and 12 were women (48%). Mean age was 55.52±10.28y (ranged from 37 to 69). Twenty-two phakic eyes (88%) and 3 pseudophakic eyes (12%) were presented. The mean number of quadrants affected was 2 (range, 1-4). All the retinal breaks were located between 8-4 o'clock. Twenty-two eyes (88%) had the macula detached preoperatively. All patients were underwent PPV combined with air tamponade. The preoperative clinical characteristics of patients were shown in Table 1.

Initial reattachment was achieved in 25 cases. The mean follow-up was 6.8mo (range, 2-12mo). On the postoperative day (POD) 1, the air volume was >60%. The ultra-widefield images were acquired with regardless of the volume of air in vitreous cavity. They showed that the retina was reattached in all air-filled eyes postoperatively. The retinal break and laser burns in the superior were detected in 22 of 25 eyes (88%) under the air on POD 1. On the POD 3, the air volume was range from 40% to 60%. The ultra-widefield images showed that the retina was reattached in all air-filled eyes. A double-layered image was seen in 25 of 25 eyes with intravitreal gas. Retinal breaks and laser burns around were seen in the intravitreal air, but only a missed retinal hole was found under intravitreal air bubble in 1 case (case 10). On the POD 5, the air volume was ≤30%. Air-bubble was seen in the superior area on the ultra-widefield images. On the POD 7, small bubble without effect was seen in 6 cases (24%) and bubble was completely disappeared in 4 cases (16%). Oval bubble in the

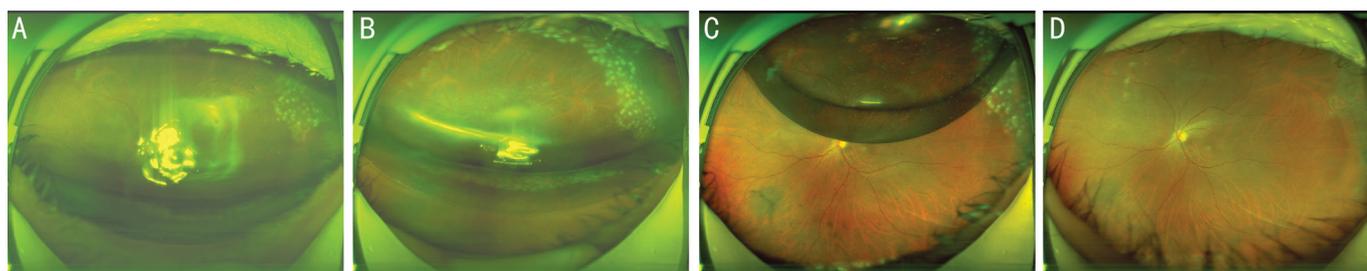


Figure 1 A 52-year-old female patient who diagnosed fresh RRD with a retinal break on 3-4 o'clock underwent PPV with air tamponade. The ultra-widefield colour fundus photographs of the left eye were shown A: On POD 1, the intravitreal air volume was about 75%. The image showed the retina was attached and retinal break in the temporal through the air bubble with the strong reflection. The eyelid was usually swelling due to the prone position on the early stage after the surgery so that the superior laser burns were invisible. B: On POD 3, the image showed the a double-layered of the bubble. The banana-shape was block the middle of the retina. It just showed a mirror image. C: On POD 5, the air bubble was getting smaller. The retina was attached and the laser burns around the retinal break were clear. D: On final follow-up, the air bubble was completely disappeared. The image showed the retina was attached and the laser scar around the retinal break.

Table 1 Characteristics of patient with primary RRD

No.	Age/Gender	Quadrants	Break position (o'clock)	Breaks No. (type)	Break position in related to equator	Macular	Breaks size
1	47/M	2	1	1 (HST)	A	Off	1/3
2	68/F	1	2	1 (HST)	A	On	1/4
3	40/M	3	11, 9	2 (HST, HST)	A, E	Off	1, 1/2
4	52/M	1	1:30	1 (HST)	A	On	1/4
5	46/F	2	11	1 (HST)	A	Off	1/2
6	64/M	3	10	1 (HST)	A	Off	1/2
7	56/F	2	11	1 (HST)	E	Off	1/2
8	37/M	3	11	1 (HST)	A	Off	1/2
9	69/M	4	1, 9	2 (HST, AH)	E, P	Off	1, 1/2
10	62/F	2	2,10	2 (HST, AH)	A, A	On	1/2, 1/4
11	48/M	2	11	1 (HST)	A	Off	1/2
12	54/M	1	1	1 (HST)	A	On	1/2
13	58/M	2	11	1 (HST)	A	Off	1/4
14	54/M	2	2-3:30	1 (HST)	A	Off	2
15	65/F	2	12	1 (HST)	A	Off	1/2
16	48/F	2	10	1 (HST)	E	Off	1 1/2
17	42/M	2	2:30, 3	2 (HST, HST)	A	Off	1, 1/4
18	68/F	2	12	1 (HST)	E	Off	1/3
19	68/F	2	2	1 (HST)	A	Off	2
20	52/F	1	2	1 (HST)	A	Off	1/4
21	69/M	2	3-4	2 (HST, HST)	E, P	Off	1/2, 1/4
22	64/F	2	2	1 (HST)	A	Off	1/3
23	67/F	2	10	1 (HST)	A	On	1/3
24	45/F	2	3-4	1 (HST)	P	Off	2
25	45/M	2	12:30-1	1 (HST)	A	Off	1

HST: Horseshoe tear; AH: Atrophic hole; A: Anterior; E: Equatorial; P: Posterior.

superior area was observed in 15 cases (60%). Air disappeared completely on a mean of 9.84d postoperatively. On the POD 14 and 1mo follow-up, the air bubble was absorbed in all cases. Retinal attachment rate was 100%. The retinal breaks and choroaretinal scar were seen from the images (Figure 1). Final postoperative best-corrected visual acuity (BCVA) are range from 0.9 logMAR to 0.1 logMAR (mean 0.35 logMAR).

Mean final postoperative BCVA improved significantly relative to mean preoperative ($P<0.05$). VA improved range 3-5d in macular-off cases. Final VA of 0.3 logMAR or better was seen in 13 eyes. No serious complications occurred during the surgery. Preoperative cataract of 2 cases was no aggravation. Lens feathering was found in 3 cases and disappeared on the 5th day after the operation.

DISCUSSION

PPV has become the more popular surgical procedure for the repair of RRD. Air tamponade is recommended agent after PPV for selected RRD. Several studies have reported satisfactory results with air tamponade^[5,7-11,17]. Tan *et al*^[10] found that there were no significant differences overall in the success rates between air and 20% sulfur hexafluoride (SF₆) tamponade. But the author suggested that air tamponade should only be used in superior RDs. In contrast, Zhou *et al*^[11] conducted a prospective, randomized, comparative study including 64 eyes with RDs and they reported that air had equivalent tamponade effects to C₃F₈ in the surgical management of inferior RDs.

In our study, retinal breaks on 8-4 o'clock with vitreous traction RDs were selected. PPV and fluid-air exchange are performed in our all cases. According to the physical properties and dynamics of intraocular tamponade, air is nonexpansile and persists in the vitreous cavity for 5 to 7d^[18]. Compared long-acting gas tamponade, facedown position period and visual rehabilitation could be shorten. Our primary reattachment rate is 100% with favorable results. Vitreoretinal surgical expertise during the surgery is importance. First, the key to the surgery is to remove the vitreous around the retinal break completely and extent of peripheral vitrectomy. Peripheral retinal break and vitreous shaving as completely as possible was performed by wide-angle viewing system with rotation eyeball passively and 360° scleral depression. Second, SRF was drained off completely, which was the key to retinopexy with endolaser photocoagulation. Furthermore, usage of wide-angle viewing system can discover the retinal break in peripheral and SRF was drained with a flute needle in direct visualization. It may reduce the usage of perfluorodecalin, then retinopexy with endolaser photocoagulation during fluid-air exchange. Thus, it would simplify the surgical procedure and speed up the process. In addition, the authors suggest photocoagulation is superior to cryopexy. Theoretically, the enhance adhesion between neurosensory retina and retinal pigment epithelium (RPE) will occur within 24h after laser photocoagulation. Nevertheless the adhesion after the cryopexy in the same situation will occur at least 1wk^[19-20].

Previous studies indicated that one of the risk factors of redetachment were new or missed retinal breaks^[11,21-22]. In the gas-filled eye after the retinal surgery with PPV, the reflection of the light becomes scattered. Non-contact lens (90 D) or three-mirror contact lens can assist the surgeons to find out the retinal breaks. But it's difficult to recognize because of the air-bubble scatter and unable to document. Traditional fundus camera can obtain the images of posterior retina in some cases. But the retinal breaks are typically in periphery. Though the instrument cooperation and patient moves their eyes during the photography and several photos are taken for creating a montage, 96° of retina will be covered. Traditional

fundus camera just capture portions of peripheral retina and the images are not clear^[23]. Recently advancements in widefield photography have dramatically improved the ability to image the peripheral retina. Optos ultra-widefield image system (Daytona, Optos PLC, Scotland, UK) is based on confocal scanning laser ophthalmoscopy. The Optos utilizes green laser with 532 nm wavelength and red laser with 633 nm wavelength as light source respectively, with an optical elliptical mirror to create images of the extending to peripheral retina. So the device provides a 200° view of the retina and capture 82% of the retina in a single image without mydriasis. Due to the Optos can penetrate to the retina layer and the choroid layer, it is less affected by scattering reflected light, the final formation of high-resolution retinal images. It allows surgeons to evaluate the retina far beyond the equator of the fundus^[12,24].

In our study, ultra-widefield image system was a useful facility for monitoring retinal breaks after PPV with air tamponade. On POD 1, the air volume was >60%. It's difficult to detect information from the ultra-widefield images in 4 cases. One case was not recognizable due to peripheral break on 12 o'clock which was blocked by cortical cataract preoperatively (case 15). Three cases were difficult to recognize due to feather-like subcapsular lens opacity enhance scattering of light of the air bubble. The typically subcapsular feathering may cause by oxidative stress to the lens. It may be reversible by diligent prone positioning. On POD 1, patients were required to remain facedown position. On POD 3, the air bubbles become smaller gradually. The images showed that the bubble was divided into two components with oval area in the superior and banana-shaped area in the inferior^[14]. The retinal breaks and laser burns were detected through the oval-shaped air bubble in superior area. The banana-shaped was a mirror image of inferior retina, especially peripheral retina. It is caused by light reflection from gas-liquid interface (Figure 2). Inoue *et al*^[14] reviewed ultra-widefield fundus images in 40 eyes of 40 patients who had undergone vitrectomy with gas tamponade for RD. In the primary position, the rate of detecting tears in the superior area in eyes with gas volume of ≥60% was significantly higher than gas volume <60%. They can detect the superior retinal breaks from the images which capture under the gas-bubble when the gas volume ≥60%. It's the similar result in our study. With the banana-shaped appearing, light reflection from gas-liquid interface would disturb the estimating retinal breaks in banana-shaped area. Nakao *et al*^[25] analyzed Optos high-quality fundus autofluorescence (FAF) images of 18 eyes with unilateral macular holes (MHs), who underwent vitrectomy with SF₆ tamponade. On POD 2, 6 of 18 eyes (33.3%) could not obtain a clear FAF image could due to the gas-liquid interface being in the MH area. Changing the orientation of the patient's face or the eye fixation may improve the Optos image quality. It

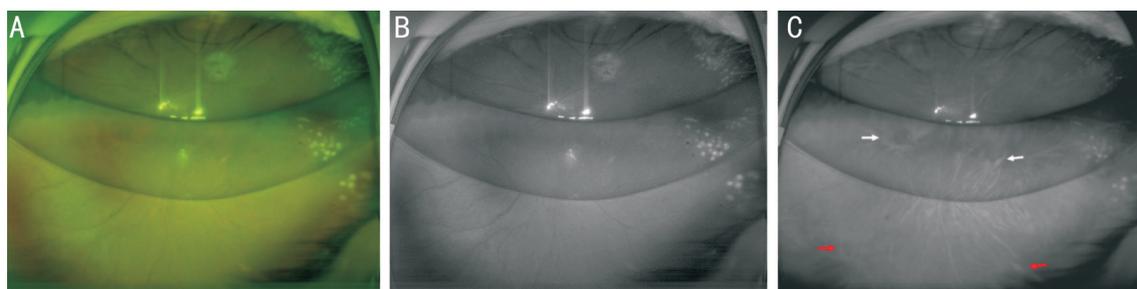


Figure 2 Three days postoperative ultra-widefield images of a 68-year-old female patient A: The colour fundus image of the left eye shows attached retina with double-layer bubble: oval-shape superiorly and banana-shape inferiorly. The laser burns seen in the banana-shape area are mirror image of peripheral retina what are not visible inferiorly. B: Green laser image of the patient from panel A, which showed retinal vessels and the laser burns were seen clearly even under the air bubble. C: Red laser image of the patient from panel A, which showed the mirror image of vortex vein due to the light reflection (white arrow). The vortex vein and choroid vein are in inferior area beyond the equatorial (red arrow).

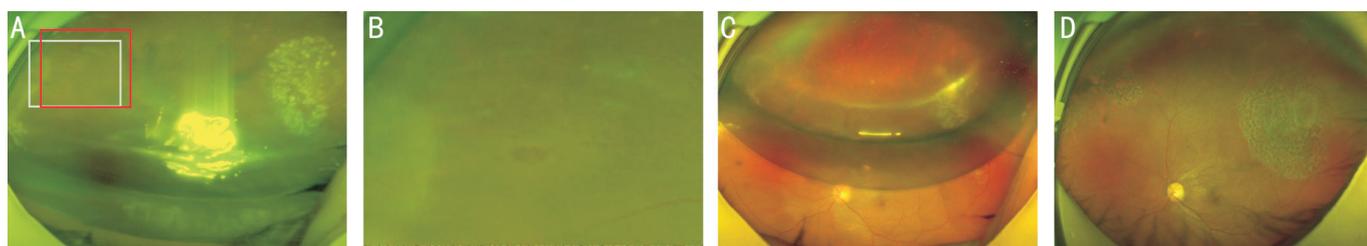


Figure 3 A 54-year-old male patient who diagnosed fresh RRD with a retinal break on 1-2 o'clock underwent PPV with air tamponade. The ultra-widefield colour fundus photographs of the left eye were shown A: One-day postoperative colour fundus image shows attached retina and laser burns on 1-2 o'clock. But a missed retinal hole was also detected on the nasal retina in superior area (white box). B: Magnified fundus image (A) shows the missed retinal hole under the air. C: Three-day postoperative colour fundus image shows laser burns around the missed retinal hole (red box). D: Final follow-up image shows the retina is attached and the laser scar around the retinal breaks.

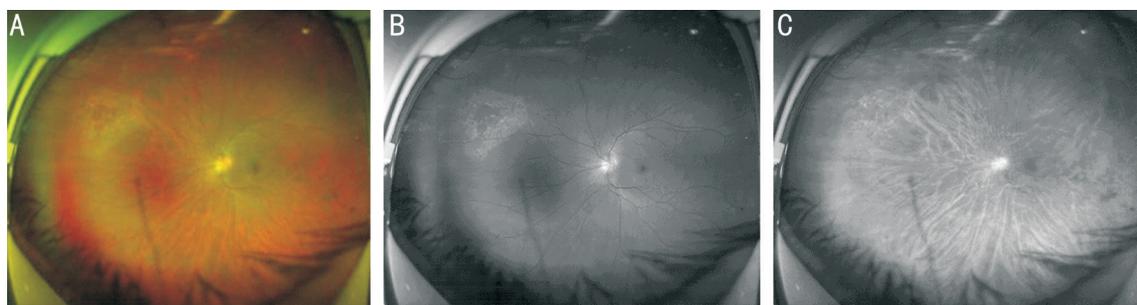


Figure 4 A 48-year-old female patient underwent PPV with air tamponade on 14d postoperatively A: The ultra-widefield colour photograph shows retina attachment and laser scar with pigmentation around the retinal break on 10 o'clock; B: The green laser photograph shows the retinal break and laser scar clearly in the retina layer; C: The red laser photograph shows cloudy laser scar in the RPE layer, and the retinal break was not detected.

help surgeons detect more retinal breaks and decide the release of the patient from facedown posturing. Patients could take a seat position or side-lying position replaced of facedown position. Positioning would be changed depend on the retinal breaks and air volume in patients' follow-up.

In case 10, a missed retinal hole was detected on ultra-widefield image on the POD 1, at the meanwhile intravitreal air was approximately 50%. The air bubble presses against the hole effectively and no RD. Because of the reflected air bubble, laser can't focus the retinal break on the first day. We performed the retinal photocoagulation treatment and follow-up closely was necessary (Figure 3).

On the POD 14 and 1mo, Optos ultra-widefield images were documented. There were no missed and new retinal breaks and no RD in all cases. The images showed the retinal breaks and choroaretinal scar around the treated breaks. Separating into two wavelength laser scans provide further information. The green laser can describe better images of the retinal break and laser burns. The red laser can penetrate into the deeper layers of the retina and the choroid. The images showed the choroidal vessels and vortex vein (Figure 4).

In conclusion, we report that PPV with air tamponade is an effective management for fresh RRD with superior retinal breaks. The ultra-widefield fundus imaging system is a useful

tool in following up after the retinal surgery. It can detect postoperative retinal breaks, especially the new or missed hole in air-filled eyes. Patients may be allowed to facedown position and acquired visual rehabilitation in shorter time.

There were strict indications in our cases selection. Firstly, fresh RRD with severe synchysis or vitreous traction induced horse hole. Secondly, superior break at 8 to 4 o'clock were selected. RRDs with the above condition can be effectively managed by PPV combined with air tamponade. But our study has limitations. We need more cases and long-term observation.

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