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Primary 25-Gauge Airbag Vitrectomy in Pseudophakic Rhegmatogenous Retinal Detachment

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Abstract

Purpose: To evaluate the anatomic and functional outcomes and the rate of complications of a novel pars plana vitrectomy approach (airbag vitrectomy), with 25-gauge vitrectomy performed under air infusion, in the treatment of primary pseudophakic rhegmatogenous retinal detachment (PsRD).

Methods: Prospective, noncomparative, interventional case series. One hundred forty-one eyes of 141 consecutive patients with primary PsRD uncomplicated by severe proliferative vitreoretinopathy (grade A or B). All patients underwent primary 25-gauge vitrectomy under continuous infusion of air, laser retinopexy of retinal breaks, and air or gas tamponade. Eyes with minimum follow-up of 6 months were evaluated. The Main Outcome Measures were primary anatomical success rate, defined as retinal reattachment at final follow-up after a single operation without additional surgery, visual outcome and rate of complications.

Results: At 6 months the retina was reattached successfully after a single surgery in 98% of eyes (138/141). In 3 eyes (2%) retinal detachment recurred during the follow-up period, caused by proliferative vitreoretinopathy in 2 eyes and by new retinal breaks in 1 eye. After surgery, best corrected visual acuity improved significantly ($P<0.001$, ANOVA). Mean final visual acuity (SD) was 0.28 (0.34) logarithm of the minimum angle of resolution (logMAR) compared with 0.94 (0.84) logMAR before surgery ($P<0.01$, Tukey–Kramer test). The most common postoperative complication was transitory hypertony (IOP >21 mmHg), detected in 10 eyes (7%) on postoperative day 1.

Conclusions: Primary 25-gauge airbag vitrectomy provides a high anatomic and functional success in eyes with PsRD and is associated with a low rate of complications.

Keywords: Vitrectomy; Retinal detachment; Pseudophakic; Air; Small gauge; Visual outcome; Complications.

Introduction

The incidence of pseudophakic rhegmatogenous retinal detachment (PsRD) has been estimated to range between 0.6% to 1.7% during the first year after cataract surgery and accounts for 30% to 40% of all rhegmatogenous retinal detachments (RDs) [1].

Different surgical techniques have been used to manage PsRD, including pneumatic retinopexy, scleral buckling, and primary pars plana vitrectomy (PPV) with or without scleral buckling [2-15].

Advances in vitrectomy techniques and equipment have increased the role of primary PPV in the management of PsRD [13-15].In comparison to scleral buckling, PPV offers the possibility of removing vitreoretinal traction, complete drainage of subretinal fluid and precisely identifying and treating the retinal breaks [15].

Recently, as an advance in the PPV technique, 25-gauge sutureless vitrectomy has gained popularity in the treatment of vitreoretinal diseases. The preference for 25-gauge transconjunctival sutureless vitrectomy has increased in selected patients as a less invasive technique for vitreoretinal surgery and is reported to reduce surgical time, postoperative inflammation, patient discomfort, and corneal astigmatism [16-19].

Using 25-gauge sutureless vitrectomy has been successful in eyes with PsRD [20-29]. However, despite continuous advances to improve efficacy and safety of PPV, retinal redetachment secondary to iatrogenic peripheral retinal breaks or the progression of proliferative vitreoretinopathy (PVR) remains a serious postoperative complication, which requires additional surgery and with poor visual results [30].

Recently we have demonstrated a new vitrectomy technique for RDs, consisting of 25-gauge vitrectomy performed under continuous infusion of air instead of balanced salt solution and reported preliminary results (Mariotti C. American Society of Retinal Specialists 30th Annual Meeting, August 25-29, 2012).

In a first retrospective study with this technique in eyes treated for macular diseases, we found that 25-gauge vitrectomy under air significantly reduces the incidence of iatrogenic retinal breaks compared with standard 25-gauge vitrectomy [31].We have named this technique “airbag vitrectomy”; the term refers to the bag of air which protects the retina from tractions during vitrectomy.

The purpose of this study was to evaluate the anatomic and functional outcomes and the rate of complications of primary 25-gauge airbag vitrectomy in the treatment of PsRD uncomplicated by severe PVR.

Methods

In this prospective study, we included all consecutive eyes that underwent primary 25-gauge airbag vitrectomy for PsRD, at the Ophthalmological Clinic of Ancona, between January 2011 and March 2013.

The risks and benefits of the treatment were explained to the patients and informed consent was obtained in accordance with the Helsinki Declaration before the procedures. The study was approved by the Ethical Committee of Università Politecnica delle Marche, Ancona.

Inclusion criteria were RDs occurring after cataract extraction with phacoemulsification and posterior chamber intraocular lens (IOL) implantation, PVR grade A or B, and a minimum postoperative follow-up of 6 months. PVR was considered grade A if vitreous haze, vitreous pigment clumps, or pigment clusters on the inferior retina were observed, and grade B if we observed wrinkling of the inner retinal surface, retinal stiffness, vessel tortuosity, a rolled and irregular edge at the retinal break, or decreased mobility of vitreous [32].

Exclusion criteria were PVR grade greater than B, RDs with giant retinal tears, history of ocular trauma, history of intraocular surgery other than cataract extraction, presence of a posteriorly dislocated lens fragment, eyes operated for congenital cataract, presence of diabetic retinopathy, and other vasculopathies.

Ophthalmologic examination of the patients was performed before primary 25-gauge vitrectomy and postoperatively on the first day, at 3 days, at 7 days, and at 1, 3 and 6 months.

The best corrected visual acuity (BCVA) was determined according to the ETDRS chart. BCVAs were converted to a logarithm of the minimum angle of resolution (logMAR) score for analysis. Intraocular pressure (IOP) was measured with Goldmann applanation tonometry (the mean IOP of 3 successive measurements was taken). Hypotony was defined an IOP of 5 mmHg or less. Biomicroscope findings for the cornea, conjunctiva, and anterior chamber were noted. Fundus examination was performed on the first and third day using binocular indirect ophthalmoscope, and from the seventh day by wide-field contact lenses and binocular indirect ophthalmoscope with scleral depression.

Intraoperative and postoperative complications like sclerotomy wound leakage, vitreous or retinal incarceration, iatrogenic retinal breaks, dialysis at the transconjunctival site, vitreous or suprachoroidal hemorrhage, choroidal folds or detachment, and endophthalmitis were evaluated and recorded. The incidence and timing of retinal redetachment were evaluated.

Surgical Technique

A 3-port 25-gauge vitrectomy was performed under general or local anesthesia by the same surgeon (C.M.). Vitrectomy used the Constellation Vision system (UHS Alcon Constellation, Alcon Laboratories, Inc.) with a cut rate of 5000/min, duty circle control and up to 600 mmHg of linear aspiration. For microincisions, the 25-gauge Edgeplus trocar blade system by Alcon Laboratories, Inc. (Fort Worth, TX), and, after April 2012, the Edgeplus valved cannula system (Alcon Laboratories, Fort Worth, USA) were used. The Resight 700 (Carl Zeiss Meditec AG, Jena, Germany) wide-angle viewing system or the Binocular Indirect Ophthalmo Microscope wide-angle viewing system (BIOM; Oculus Inc, Wetzlar, Germany) were used for viewing.

The periocular skin was disinfected with povidone-iodine 5% and povidone-iodine was instilled into the inferior fornix, and the conjunctiva and the Tenon capsule were anteriorly displaced away from the intended sclerotomy site with forceps to purposefully misalign the conjunctival and scleral incisions. Sclerotomies were placed 3.5 mm posterior to the limbus. A trocar was inserted approximately 30 degrees parallel to the limbus. Once the trocar was past the trocar sleeve, the angle was changed to be perpendicular to the surface and the cannula was inserted into the eye, making a biplanar entry. The cannula was held in place with forceps and the trocar was removed. Posterior capsulectomy was performed when required to improve visualization, and the stability of the intraocular lens was assessed.

The vitrectomy was started with shaving of the anterior vitreous. In all cases, we used a fixed cut rate at 5000 cuts per minute to remove the central and midperipheral vitreous. If not already present, a posterior vitreous detachment was induced. In those cases, the method involved the vitrectomy probe in a cutting-off mode, close to the optic nerve.

Perfluorocarbon liquid was injected thorough a soft-tip cannula (Alcon Laboratories) to stabilize the posterior retina and facilitate egress of subretinal fluid through peripheral retinal breaks.

An active fluid-air exchange was performed, with air infusion between 28 and 30 mmHg. Anterior subretinal fluid was drained through the preexisting retinal break, by using the vitreous cutter placed in the proximity of the retinal break, to aspirate the subretinal fluid and, at the same time, cut and removed the vitreous adherent to the edge of the break; then, the subretinal fluid remaining was drained with needle through the retinal break, and perfluorocarbon liquid and the floating fluid in the vitreous chamber were removed by needle.

After complete retinal attachment was achieved, a 360-degree vitreous base shaving was performed under air. The air highlighted a ring of vitreous corresponding to the vitreous base, owing to the air bubble pushing the vitreous residue towards the retina. The cutter was barely inserted into the vitreous, which was shaved it until the ring of vitreous disappeared. Particular attention was paid to completely shaving the vitreous from the internal sclerotomy site.

After 360 degree vitreous base shaving, endolaser photocoagulation was applied around the retinal breaks and suspected thinned retinal areas, as three to four rows of burns. After the vitrectomy was completed all patients had a peripheral retinal examination to check for retinal breaks. Any retinal break detected intraoperatively was treated with endolaser photocoagulation.

During vitrectomy under air infusion, in case of poor visualization due to condensation on the posterior lens capsule, we irrigated the posterior capsule with balanced salt solution using a needle, restoring clear visualization. In the presence of air into the anterior chamber, viscoelastic was injected into the anterior chamber through a paracentesis. If, in spite of these maneuvers, vision of the fundus during surgery was difficult, the vitrectomy was completed under fluid infusion.

The choice of tamponade agents changed according to the detachment characteristics. Specifically, eyes with retinal tears located in the superior quadrants (from 3 to 9) were treated with air tamponade, whereas eyes with inferior breaks were treated with C3F8 at 12%.

Before removal of each microcannula a cotton swab was placed on the tract of the oblique sclerotomy and moderate pressure was applied in this area while the microcannula was removed. After each microcannula was removed moderate pressure was applied to the entry sites with the cotton swab and the overlying conjunctiva was displaced slightly. All entry sites were checked for localized bleb formation from air or gas. When present, these required transconjunctival suture placement.

All patients were asked to maintain a particular head position, dependent on the location of the primary tear, for a period of 5 days to 7 days after surgery.

Statistical Analysis

Measured Snellen visual acuities were converted to decimal and logarithm of the minimum angle of resolution (logMAR) for subsequent analysis. Visual acuities of count fingers, hand motion, and light perception were assigned logMAR values of 2.0, 3.0, and 3.3, respectively [33].

The mean values of BCVA and IOP detected before and after treatment were compared by analysis of variance (ANOVA), and if the difference was significant, multiple comparisons were performed with the Tukey-Kramer test.

A P value less than 0.05 was considered statistically significant. Statistical analysis of the data used the Statistical Packages for the Social Sciences, v.17.0 for Windows (SPSS, Chicago, IL).

Results

One hundred forty-four consecutive eyes with a diagnosis of primary PsRD that met the inclusion criteria of the study were enrolled; of these, 3 were excluded (2 for a poor visualization during vitrectomy under air infusion that required a conversion to vitrectomy under fluid infusion, one because of loss to follow-up).

Therefore 141 eyes of 141 patients were included (Table 1). The mean (SD) age of patients was 62.7 (14.3) years. 82 patients (58%) were men and 59 (42%) were women. At the time of surgery, 86 patients (61%) had the macula off, and 55 patients (39%) had the macula on; 89 patients (63%) had retinal tears in the superior quadrants and 52 patients (37%) had retinal detachment with breaks on the inferior quadrants. 79 patients (56%) received air tamponade and 62 patients (44%) received C3F8.

	Study Group (n = 141)
Gender, n (%) Male Female	82 (58%) 59 (42%)
Eye, n (%) Right Left	75 (53%) 66 (47%)
Mean ± SD age (years)	62.7 ± 14.3
Mean ± SD BCVA (logMAR)	0.94 ± 0.84
Macula status, n (%) Macula-on Macula-off	55 (39%) 86 (61%)
Mean ± SD preoperative IOP (mmHg)	12.1 ± 4.1
Mean ± SD symptom duration (days)	6.2 ± 5.8
Mean ± SD axial length (mm)	25.1 ± 0.8
Method of tamponade, n (%) Air C3F8	79 (56%) 62 (44%)
BCVA: Best-Corrected Visual Acuity; SD: Standard Deviation; logMAR: logarithm of the Minimal Angle of Resolution; IOP: Intraocular Pressure	

Table 1: Preoperative characteristics of eyes undergoing primary 25 gauge airbag vitrectomy.

The primary anatomical success rate, defined as retinal reattachment at final follow-up (6 months) after a single operation without additional surgery, was 98% (138 of 141 eyes). Recurrence of retinal detachment occurred in 3 eyes during the follow-up period. The recurrent detachment was attributed to a new retinal tear associated with PVR in 2 eyes (1 eye with grade B PVR and 1 eye with grade C PVR) at month 2 and at month 3 after surgery, and to a new retinal break in the inferior quadrant in the remaining eye, 3 weeks after surgery. All those eyes were reoperated with 25 gauge vitrectomy and C3F8 or silicone oil tamponade and resulted in retinal reattachment. Then, the final anatomical success rate, defined as retinal attachment at final follow-up without regard to additional procedures, was 100%.

At baseline, the mean (SD) logMAR BCVA was 0.94 (0.84). After treatment, BCVA improved significantly (P<0.001, ANOVA). One month after treatment, the mean (SD) logMAR BCVA was 0.46 (0.40), 0.32 (0.46) logMAR at third month and 0.28 (0.34) at 6 months; compared with baseline, a significant BCVA improvement was seen on all measurements (P<0.01, Tukey–Kramer test). Postoperatively, BCVA increased in 124 eyes (87%) and was unchanged in 17 (13%) eyes. Intraoperative and postoperative PPV-related complications are listed in Table 2.

	Study Group (n = 141)
Iatrogenic retinal breaks, n (%)	4 (3%)
Clinical CME, n (%)	3 (2%)
Macular pucker, n (%)	4 (3%)
Choroidal detachment, n (%)	2 (1%)
Postoperative IOP >21 mmHg, n (%)	10 (7%)
Postoperative IOP <5 mmHg, n (%)	4 (3%)
IOL subluxation, n (%)	1 (1%)
CME: Cystoid Macular Edema; IOP: Intraocular Pressure; IOL: Intra Ocular Lens.	

Table 2: Intraoperative and postoperative complications in eyes undergoing primary 25 gauge airbag vitrectomy.

After surgery, no significant IOP changes were detected (P=NS, ANOVA). The mean (SD) preoperative and postoperative IOP at 1 day, 1 week, 1 month, 3 months and at the last control visit were 12.1 (4.1), 13.2 (3.2), 14.6 (6.2), 13.7 (4.7), and 13.7 (4.5). Hypotony was detected in 4 eyes (3%) on postoperative day 1; in these eyes IOP increased without any additional procedure. Postoperatively, IOP was >21 mmHg in 10 eyes (7%) on day 1, in 4 eyes (3%) at week 1, and in 2 eyes (1%) at month 1; in these eyes IOP was controlled with topical antiglaucomatous agents. At the last visit IOPs were in the normal range in all eyes without medication. Iatrogenic retinal breaks occurred during surgery in 4 eyes (3%), all treated successfully by laser endophotocoagulation. During follow-up, clinical cystoid macular edema was detected in 3 eyes and 4 eyes developed a visually significant epiretinal membrane.

After surgery, IOL subluxation occurred in 1 eye that had successful IOL repositioning. No eyes had vitreous or retinal prolapse external to the sclerotomy site, incarcerations or dialyses on the intraocular side where the trocar had been placed. Two eyes developed choroidal detachment. Suture placement at the end of surgery was necessary in 4 eyes (3%), for a localized bleb of subconjunctival air or gas. None of the patients had endophthalmitis after surgery.

Discussion

In this prospective clinical study we showed that 25-gauge airbag vitrectomy was effective in eyes with primary PsRD uncomplicated by severe PVR, leading to a success with a single operation. Previous studies in eyes with PsRD uncomplicated by severe PVR treated with 25-gauge vitrectomy, have reported primary success rates between 83% and 97% [20-29].

In our prospective study of 141 eyes, the primary success rate was 98%. Although the sample of our study was similar to others in terms of inclusion criteria, many variables, such as vitrectomy cut rates, the use or not of 360-degree laser retinopexy, a partial or extensive vitrectomy, and the type of tamponading used, makes it difficult to compare with these studies in terms of results.

One possible explanation for favorable results of our technique is the use of air during vitrectomy. The air, thanks to its physical properties, has optical and mechanical advantages; the difference in the refractive index between air (1.00) and balanced salt solution (1.33) allows for a wider view of the retina under air [34]. Moreover, the air–vitreous interface is more pronounced compared with the liquid-vitreous interface [34]. These factors allow an easier identification of the residual vitreous, that should be extensively removed without the need for deep extensive scleral indentation, improving the chances of surgical success.

The second advantageous physical property of air is its surface tension. Different liquids have different surface tension, depending on their molecular characteristics and their intermolecular attraction forces [35]. At room temperature, the surface tension between air and water-based structures is higher than between other agents used during the vitrectomy [34,35]. This force, as well as contribute to a better identification of the residual vitreous, stabilizes the retina, counteracting the aspiration of the vitreous cutter during the removal of the vitreous tenaciously adherent to the retina; this dynamic, with the use of more recent small-gauge vitreous cutters, with ports closer to the tip, affords a safe and precise vitrectomy, limiting the possibility of iatrogenic retinal breaks [34].

Moreover, in the presence of a retinal break with detached retina, the air prevents an increase of subretinal fluid during traction removal, allows a complete shaving of remaining vitreous, and a post-reattachment retinopexy with precise localization of the endolaser, using lower energy [35].

In addition to the benefits of the air, the high success rate of this study is probably related to the small gauge high-speed vitrectomy; the small caliber of the instruments and the presence of trocars to reduce traction around the insertion sites, thus limiting the risk of iatrogenic tear formation [36]; in addition, the intrinsic nature of 25-gauge instrumentation, sutureless, tranconjunctival, and small diameter, reduces the inflammatory response in the eye and the production of proinflammatory factors that might contribute to PVR formation [36]. Moreover, it has been proposed that high-frequency cutting may be critical in avoiding iatrogenical retinal breaks predisposing to redetachment [37].

These advantages resulted in a low incidence of iatrogenic breaks and PVR, which are the two main causes of redetachment after vitrectomy. In our study, only one eye developed redetachment at 3 weeks postoperatively owing to opening of a new retinal break. No new tears or redetachment due to vitreous incarceration into the microcannulas were encountered. The low rate of PVR progression was probably due to the extensive removal of the vitreous and the limited use of the laser.

Among the other possible complications of 25-gauge sutureless vitrectomy, postoperative leakage, hypotony, choroidal detachment, vitreous hemorrhage, and endophthalmitis have been reported [16-18, 38-40]. Complications with our technique include 10 eyes (7%) with limited postoperative transitory ocular hypertension, all controlled medically. Postoperative hypotony was observed in 4% of eyes on postoperative day 1, but IOP increased in few days without any additional procedure. During follow-up, 4 patients developed a visually significant postoperative epiretinal membrane, and 3 patients developed clinically cystoid macular edema. No endophthalmitis was observed in our study group, although our study did not have a sufficient number of patients to assess this risk.

Besides the advantages of vitrectomy under infusion of air, a possible limitation to its use is the reduced viewing that can occur in some situations. In a pseudophakic eye with a disrupted posterior capsule, air can fog the intraocular lens [41] and migration of air into the anterior chamber via zonular dialysis can compromise visualization of the posterior segment [34]. In most of these situations it is possible with simple maneuvers to restore a good retinal view, but nevertheless, in the rare cases where the vision remains poor, it is possible to convert the procedure to a standard technique and complete the vitrectomy under fluid infusion.

The limitations of our study include the short follow-up period, the selection of cases without severe PVR and lack of comparison with the standard vitrectomy procedure used in the management of PsRD.

In summary, airbag vitrectomy improves visualization of the peripheral retina and the vitreous base interface and stabilization of the retinal surface, with potentially better anatomical and visual results.

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