High-frequency ultrasound biomicroscopy of the anterior segment morphometry before and immediately after pars plana vitrectomy

Meira Neudorfer, Nir Oren, Adiel Barak

Department of Ophthalmology, Tel Aviv Sourasky Medical Center, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv - Israel

PURPOSE. To characterize short-term changes induced by pars plana vitrectomy on anterior segment depth and lens thickness by means of high-frequency ultrasound biomicroscopy.

METHODS. We undertook a prospective case series study on consecutive patients referred for pars plana vitrectomy as the sole procedure in our institution between 2005 and 2007. Twenty-eight eyes of 28 patients undergoing pars plana vitrectomy were studied by ultrasound biomicroscopy. Neither silicone oil nor scleral buckle was used for any of the procedures. Anterior chamber depth and lens thickness were compared before and immediately after surgery, and their results were compared to the postoperative intraocular pressure measurements.

RESULTS. There was a significant decrease in anterior chamber depth in the study eyes of patients who had undergone gas tamponade (p<0.0001) but not in those who had not undergone gas tamponade. No differences were found between the preoperative and the postoperative lens thickness measurements in any of the patients, nor was there any correlation between anterior chamber depth and increased intraocular pressure.

CONCLUSIONS. Uncomplicated pars plana vitrectomy with gas tamponade can induce short-term changes in anterior chamber depth as measured by morphometry. Surgeons may need to reconsider using gas tamponade at the end of surgery in surgical candidates with shallow anterior chambers.

KEY WORDS. Anatomy, Anterior eye segment ultrasonography, Ciliary body ultrasonography, Cross-sectional, Microscopy, Vitrectomy

INTRODUCTION

Anterior segment imaging has evolved during the last few years and was shown to be an important tool for a better understanding of the outcomes of cataract surgery (1, 2), keratorefractive surgery (3, 4), as well as anterior segment pathology (tumors, uveitis, and aniridia) (5, 6). Anterior chamber imaging following pars plana vitrectomy (PPV) has helped in the documenting and understanding of various complications, such as shallowing of the anterior chamber (7), hypotony (8), ciliary body detachment (9, 10), and elevated intraocular pressure (IOP) following gas injection (11-14).

There have been no prior systemic evaluations of the effect of PPV on anterior chamber and lens morphology when the procedure was performed with and without the use of nonexpansile gases at the end of surgery. We carried out anterior segment and lens morphometric measurements and report the changes in anterior chamber depth and lens thickness that occurred immediately after PPV in eyes with and without nonexpansile gas tamponade. Our findings could provide useful information to vitreoretinal surgeons when planning surgery with or without nonexpansile gas tamponade. Awareness of possible shallowing of the anterior chamber as a result of PPV may
lead surgeons to rethink using gas in surgical candidates who have shallow anterior chambers.

METHODS

We used ultrasound biomicroscopy to prospectively evaluate 28 eyes of 28 consecutive patients in the early preoperative and early postoperative periods of PPV carried out as the only procedure. All patients were operated at the Tel Aviv Medical Center between 2005 and 2007. Excluded were cases of PPV that required associated surgical procedures (such as scleral buckling or silicone oil tamponade), lensectomy or intraocular lens implantation, previous anterior segment laser therapy, and the use of any topical or systemic drugs that might affect the pupil or accommodation.

Preoperative examinations were performed not more than 48 hours before surgery. All the eyes underwent a complete ophthalmologic examination consisting of visual acuity and refraction, anplanation tonometry, conventional slit-lamp biomicroscopy, and indirect ophthalmoscopy. The preoperative diagnoses included retinal detachment (n = 7 eyes), complication of proliferate diabetic retinopathy (n = 6, including 1 eye with traction retinal detachment, 2 eyes with vitreous hemorrhage, and 3 eyes with clinically significant macular edema), macular hole (n = 4), submacular hemorrhage (n = 3), epiretinal membrane (n = 5), and non-diabetes-related vitreous hemorrhage (n = 3).

All the study patients underwent the same surgical protocol and were operated on by the same surgeon (A.B.). Briefly, after routine 3-port sclerotomies, PPV was carried out with a 20-gauge vitrector. Throughout the PPV, intraocular pressure (IOP) was maintained at approximately 24 mm Hg. Gas injections were performed in 2 stages. At the end of surgery, air-fluid exchange was performed using active suction until a complete air-filled eye was achieved. One sclerotomy was closed and 50 cc of diluted gas (16% C3F8 and 20% SF6) was manually injected through the infusion sclerotomy, while the intraocular air was allowed to leave the eye through the other sclerotomy, to allow complete exchange of gas. The superior sclerotomies were closed with a 7-0 absorbable “X” suture and the infusion sclerotomy was closed with a 6-0 absorbable “U” suture. Ultrasound morphometric measurements were performed using a high-frequency ultrasound device (I3 Innovative Imaging Inc., CA, USA) with a 20-MHz probe in the following manner. With the patient in the supine position, a drop of topical 0.5% proparacaine was placed into the examined eye. A Tono-Pen tip cover (Ocufilm, Solan Ophthalmic Products, Jacksonville, FL, USA) was filled with balanced saline solution (BCC+) and placed over the end of the probe. Methylcellulose was placed on the Tono-Pen tip cover. The probe was then gently applied to the corneal surface, permitting the imaging of the anterior segment. Axial scans were taken through the cornea, the anterior chamber, and the lens. Each test was repeated 3 times.

The anterior chamber depth was measured from the inner corneal surface to the anterior lens capsule. Lens thickness was measured from the anterior to the posterior lens capsule. Measurements were performed using the internal electronic caliper of the instrument and the values were recorded in millimeters. Accommodation was kept constant by asking the patient to fixate on a far target. Since the aim of this study was to detect early postoperative morphometric changes produced by PPV, all postoperative examinations were performed within 1 to 2 days after surgery.

Data were managed on an Excel spreadsheet. All entries were checked for possible keyboard errors. Prism statistical software (version 4.0) was used for data analysis. The paired t test was used to compare the mean values of all the preoperative and postoperative results. The unpaired t test with Welch correction was used to compare IOP measurements before and after surgery. All tests were 2-tailed, and significance was set at p<0.05.

The study was performed with informed consent and following all the guidelines for experimental investigations required by the Institutional Review Board or Ethics Committee of the Tel Aviv Medical Center.

RESULTS

A total of 30 patients were suitable for enrollment into the study. Two were excluded because silicone oil tamponade was used at the end of surgery, leaving 28 patients for final analysis. Their relevant demographic data, medical history, and reason for surgery are given in Table I. At the time of surgery, 10 of the 28 study eyes were pseudophakic and 18 were phakic. Gas tamponade was used at the end of surgery in 15 patients (7 phakic, 8 pseudophakic), and BSS+ was used to replace the removed vitreous in the remaining 13 patients. The mean ± SD anterior chamber depth of all patients was
3.174±0.8974 mm shortly before surgery and 2.785±0.8874 mm immediately after surgery (p<0.0001; mean of differences 0.3897, 95% confidence interval [CI] 0.2267-0.5526). The anterior chamber depth of the 15 patients whose surgery ended with gas tamponade was 3.072±0.9383 mm before surgery, decreasing to 2.403±0.6665 mm immediately after surgery (p<0.0001, mean of differences 0.6687, 95% CI 0.4113-0.9260) (Fig. 1). The mean ± SD anterior chamber depth of the patients without gas tamponade was 3.343±0.8139 mm before surgery and 3.295±0.8725 mm after surgery (p=0.3032) (Fig. 2). There was no difference in changes in the anterior chamber depth between the right and left eyes or the phakic and pseudophakic eyes.

Pars plana vitrectomy had no significant effect on lens thickness in the BSS+ group or the gas tamponade group. The lens thickness in the BSS+ group was 4.177±0.4337 mm preoperatively and 4.225±0.3708 mm postoperatively (p=0.41). The lens thickness in the gas tamponade group was 4.375±0.3043 mm before surgery and 4.151±0.5556 mm after surgery (p=0.31) (Fig. 3). The mean IOP immediately after surgery was higher in the gas tamponade group (21.79±2.663 mmHg) and 18.17±1.862 mmHg in the BSS+

### TABLE I - DEMOGRAPHIC DATA, MEDICAL HISTORY, AND REASON FOR SURGERY

<table>
<thead>
<tr>
<th>No.</th>
<th>Age, y</th>
<th>Sex</th>
<th>Eye</th>
<th>Reason for surgery</th>
<th>Medical history</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phakic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>45</td>
<td>M</td>
<td>L</td>
<td>Retinal detachment</td>
<td>HTN, CRVO</td>
</tr>
<tr>
<td>2</td>
<td>66</td>
<td>F</td>
<td>L</td>
<td>Macular hole</td>
<td>HTN</td>
</tr>
<tr>
<td>3</td>
<td>67</td>
<td>F</td>
<td>L</td>
<td>Epiretinal membrane</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>67</td>
<td>F</td>
<td>L</td>
<td>Macular hole</td>
<td>DM, HTN</td>
</tr>
<tr>
<td>5</td>
<td>27</td>
<td>M</td>
<td>L</td>
<td>Tractional retinal detachment</td>
<td>DM</td>
</tr>
<tr>
<td>6</td>
<td>44</td>
<td>F</td>
<td>R</td>
<td>Tractional retinal detachment</td>
<td>DM, HTN</td>
</tr>
<tr>
<td>7</td>
<td>52</td>
<td>M</td>
<td>L</td>
<td>Macular edema</td>
<td>DM, HTN</td>
</tr>
<tr>
<td>8</td>
<td>72</td>
<td>F</td>
<td>R</td>
<td>Macular hole</td>
<td>DM</td>
</tr>
<tr>
<td>9</td>
<td>83</td>
<td>M</td>
<td>L</td>
<td>Submacular hemorrhage</td>
<td>HTN</td>
</tr>
<tr>
<td>10</td>
<td>77</td>
<td>F</td>
<td>L</td>
<td>Submacular hemorrhage</td>
<td>AMD</td>
</tr>
<tr>
<td>11</td>
<td>81</td>
<td>F</td>
<td>L</td>
<td>Submacular hemorrhage</td>
<td>AMD, HTN</td>
</tr>
<tr>
<td>12</td>
<td>72</td>
<td>M</td>
<td>R</td>
<td>Retinal detachment</td>
<td>HTN</td>
</tr>
<tr>
<td>13</td>
<td>68</td>
<td>F</td>
<td>L</td>
<td>Vitreous hemorrhage</td>
<td>HTN</td>
</tr>
<tr>
<td>14</td>
<td>54</td>
<td>F</td>
<td>L</td>
<td>Retinal detachment</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>25</td>
<td>F</td>
<td>L</td>
<td>Vitreous hemorrhage</td>
<td>DM, HTN</td>
</tr>
<tr>
<td>16</td>
<td>31</td>
<td>F</td>
<td>R</td>
<td>Macular edema</td>
<td>DM</td>
</tr>
<tr>
<td>17</td>
<td>49</td>
<td>M</td>
<td>L</td>
<td>Vitreous hemorrhage</td>
<td>DM, HTN</td>
</tr>
<tr>
<td>18</td>
<td>76</td>
<td>M</td>
<td>L</td>
<td>Macular edema</td>
<td>HTN, AMD, glaucoma</td>
</tr>
<tr>
<td><strong>Pseudophakic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>86</td>
<td>M</td>
<td>L</td>
<td>Epiretinal membrane</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>80</td>
<td>M</td>
<td>L</td>
<td>Retinal detachment</td>
<td>DM, HTN</td>
</tr>
<tr>
<td>3</td>
<td>56</td>
<td>M</td>
<td>L</td>
<td>Retinal detachment</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>81</td>
<td>M</td>
<td>R</td>
<td>Vitreous hemorrhage</td>
<td>AMD</td>
</tr>
<tr>
<td>5</td>
<td>75</td>
<td>F</td>
<td>L</td>
<td>Epiretinal membrane</td>
<td>DM, HTN</td>
</tr>
<tr>
<td>6</td>
<td>63</td>
<td>F</td>
<td>R</td>
<td>Vitreous hemorrhage</td>
<td>DM, HTN</td>
</tr>
<tr>
<td>7</td>
<td>56</td>
<td>F</td>
<td>L</td>
<td>Tractional retinal detachment</td>
<td>DM, glaucoma</td>
</tr>
<tr>
<td>8</td>
<td>69</td>
<td>F</td>
<td>L</td>
<td>Macular hole</td>
<td>HTN</td>
</tr>
<tr>
<td>9</td>
<td>63</td>
<td>F</td>
<td>L</td>
<td>Retinal detachment</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>67</td>
<td>M</td>
<td>L</td>
<td>Epiretinal membrane</td>
<td></td>
</tr>
</tbody>
</table>

AMD = age-related macular degeneration; CRVO = central retinal vein occlusion; DM = diabetes mellitus; HTN = hypertension.
Pars plana vitrectomy-induced anterior segment changes

Fig. 1 - Anterior chamber (AC) depth among patients with gas tamponade before and after surgery.

Fig. 2 - Anterior chamber (AC) depth among patients without gas tamponade before and after surgery.

Fig. 3 - Lens thickness before and after surgery in all patients.

Fig. 4 - Overall intraocular pressure (IOP) measurements among gas-filled and balanced saline solution-filled eyes.

group, yet showed no significant difference, presumably due to the small number of participants in each group ($p=0.3956, 95\% \text{ CI} -3.120$ to $10.36$, Mann-Whitney test) (Fig. 4).

DISCUSSION

The results of the current study revealed a significant reduction in anterior chamber depth immediately following PPV in eyes in which the procedure included gas tamponade, but not in eyes in which there had been no gas tamponade at the end of PPV. There were no significant changes in lens thickness in any of the operated eyes, nor were the anterior chamber depth reductions significantly correlated with IOP elevations. These findings of anterior chamber depth reduction after nonexpansile gas tamponade in both phakic and pseudophakic patients have not been reported before, but they are not unexpected. In pneumatic retinopexy, which includes the injection of expansile gases (e.g., small bubbles of $100\% \text{ SF}_2$ or $\text{C}_3\text{F}_8$), the rapid expansion of the bubble that occurs immediately after injection may cause shallowing of the anterior chamber and elevated IOP, both of which usually resolve within days from surgery (13, 15-18).

Marigo et al (19) applied ultrasound biomicroscopy for
Neudorfe et al

comparing anterior segment morphometry before and after PPV, but the authors only checked eyes that had no gas tamponade. Moreover, they measured anterior chamber depth after 3 months and not immediately following surgery. This is an important drawback because when gases are used their evaporation may obscure early postoperative changes that may have already resolved after 1 month. Physical mechanisms are responsible for the anterior chamber changes after nonexpansile gas injection: a gas bubble possesses high surface tension and applies buoyant force on the anterior chamber, thus creating enough force to shallow the anterior chamber (20). There is high surface tension between the gas bubble and the intravitreal fluids. This set of conditions can push the lens-pupil diaphragm outward and can also prevent movements of fluids inside the ocular globe. A buoyant force develops because gases have lower specific gravity than water. The gas bubble elevates toward the top of the ocular globe, and can push the lens-pupil diaphragm outward while doing so. While anterior chamber collapse following vitrectomy and gas tamponade in aphakic patients has been reported before (21), the occurrence of such shallowing in phakic patients has not. Gopal et al (21) have also reported a surprising finding: they claimed that the incidence of anterior chamber collapse after surgery was higher in right eyes compared to left eyes (11 out of 162 right eyes versus 2 out of 152 left eyes). We found no comparable differences among our patients.

Our findings may have clinical importance to vitreoretinal surgeons when planning surgery. Many surgeons prefer to end sutureless vitrectomy with gas tamponade in order to prevent wound leakage (22, 23). Our findings of the occurrence of early reduction of anterior chamber depth following vitrectomy with gas tamponade call for routine preoperative gonioscopy in cases where injection of intravitreal gas is planned, especially in patients with glaucoma or narrow angles. The findings of shallow anterior chamber, narrow angles, significant peripheral anterior synechiae, or angle neovascularization may preclude the use of nonexpansible gases when it is not essential for surgical success, and mandate for closed observation for subsequent shallowness of the anterior chamber and pressure elevation.

We measured anterior chamber depth using a 20-MHz ultrasound probe and not the more conventionally used 50-MHz probe for 2 main reasons. The first is that the 20-MHz probe penetrates better into the lens volume and gives more accurate results when lens thickness measurements are needed (24). The second and more important consideration is the easier use of the 20-MHz probe: the technique involves a Tono-Pen tip cover over the end of the probe, and gentle application of the probe over the corneal surface, without the use of an immersion cap. We were concerned that our patients would not tolerate the immersion cap technique immediately after surgery and preferred the more gentle approach. The method has been previously used and validated using a 50-MHz probe (25) and is based on a method developed by Pavlin and Foster (26).

Our article has limitations. The most important one is the small sample size of our cohort: due to the small number of phakic and pseudophakic eyes, we were unable to determine important differences. In particular, IOP and anterior chamber depth behavior before and after PPV may be different in phakic or pseudophakic eyes, but the small sample size prevents their detection. Another important aspect which could not be detected was correlation of IOP changes after surgery compared to presurgery (rather than absolute postoperative IOP) with anterior chamber depth changes; this, again, overall and separately by phakic and pseudophakic eyes. Another drawback of our study is the short follow-up period of our cohort. It would have been more interesting to follow-up patients after surgery for a longer period to look at changes of IOP and anterior chamber until the gas was completely reabsorbed. We plan to conduct a new study that will overcome these drawbacks.

In conclusion, we demonstrated a significant reduction in anterior chamber depth immediately following PPV in eyes that had gas tamponade but not in eyes that had no gas tamponade. These findings may have potential clinical relevance for patients whose eyes have a shallow anterior chamber, which might make them more prone to complications after gas injection.

The authors report no proprietary interest or financial support.

Address for correspondence:
Adiel Barak, MD
Department of Ophthalmology
Tel Aviv Sourasky Medical Center
6 Weizman Street
Tel Aviv 64239
Israel
omadb@post.tau.ac.il

© 2010 Wichtig Editore - ISSN 1120-6721
REFERENCES


