The use of small-gauge vitrectomy (25-gauge and 23-gauge) has increased rapidly since 2002 due to its advantages of decreased surgical time, less postoperative inflammation, and faster visual recovery. The 2009 Preferences and Trends (PAT) Survey of the American Society of Retina Specialists reported that nearly 80% of respondents commonly employ small-gauge systems. Recently, however, concerns have arisen that use of small-gauge systems may increase the risk of endophthalmitis. Proper preoperative sterilization techniques along with improved methods of entry, exit, and surgical technique should decrease these risks.

**POTENTIAL RISKS OF SMALL-GAUGE SYSTEMS**

The risk of endophthalmitis with 20-gauge vitrectomy has been previously reported to be 0.03% to 0.05%. Retrospective reviews of 25-gauge endophthalmitis data have reported conflicting information. As compared with 20-gauge studies, Kunimoto et al reported a 12-fold increased risk, Scott et al reported a 28-fold increased risk, but Hu et al reported no statistically significant difference (a 0.07% [1/1424] rate for 25-gauge cases).

Several hypotheses have been proposed to explain why 25-gauge vitrectomy may lead to a higher rate of postoperative endophthalmitis, including the following:

- wound closure may be incomplete;
- unsutured wounds that lead to early postoperative hypotony may allow intraocular influx of extraocular fluid and microorganisms;
- lower infusion rates with reduced influx and efflux of fluid may allow a greater bacterial inoculum to remain in the eye;
- residual vitreous skirt may facilitate bacterial adherence and sequester bacteria from normal immunologic factors and extraocular antibiotics; and
- vitreous wick prolapse through the sclerotomy site may create a potentially open conduit through the conjunctival and scleral wound, facilitating entry of bacteria into the eye.

**IMPROVEMENTS IN ENTRY TECHNIQUE**

Successful outcomes in small-gauge vitrectomy are highly dependent upon the preoperative preparation and entry technique. Preoperatively, the use of povidone-iodine along the lid margins and perioperative area significantly reduces the bacterial flora, thus decreasing the risks of endophthalmitis. Furthermore, placing povidone-iodine for a few seconds near entry sites may further lower the risk as direct application has been demonstrated in well-controlled studies to decrease the microbiologic flora before intraocular surgery.

Modifications in entry technique have also decreased complication risk. Original 25-gauge surgical systems employed a direct perpendicular entry through intact conjunctiva without displacement, allowing a direct opening to the vitreous cavity and thus increasing the risks of endophthalmitis, hypotony, and choroidal detachment in early studies. My colleagues and I reported no cases of endophthalmitis but did report...
an incidence of 4% of hypotony and persistent choroidal detachments associated with small blebs. Gupta et al\textsuperscript{22} also reported hypotony within the first 24-hour period in numerous eyes.

Such complications necessitated the following improvements in entry technique (Figure 1). First, the conjunctiva and sclera should be flattened in order to allow entry more parallel to the limbus. Second, the conjunctiva should be displaced laterally to prevent communication between this incision and the scleral incision. Third, rather than a perpendicular incision, a two-step incision was developed in which an oblique, beveled incision parallel to the limbus through the conjunctiva and sclera is followed by a perpendicular tunnel entry, thus creating a self-sealing wound.\textsuperscript{23} In one study, angled incisions were associated with a significantly lower risk for external communication as opposed to straight incisions (Figure 2).\textsuperscript{24}
Cover Story

Flattening and displacing the conjunctiva to create a self-sealing incision was an important development. This may be performed with a variety of instruments, such as a cotton-tip applicator, 0.3-mm forceps, or plug-pulling forceps. Another option is the Dugel EndPlate (DEP) (Peregrine Surgical, New Britain, PA). This instrument simultaneously flattens and displaces the conjunctiva, then designates the angle of entry, and finally aids in trocar removal (Figures 3 and 4).

Improvements in Surgical Procedure and Cannula Removal

A variety of techniques may be employed during small-gauge vitrectomy in order to decrease the risks of hypotony and endophthalmitis. Previous studies have postulated that insufficient vitreous removal during 25-gauge vitrectomy may provide an area for bacterial adherence.18 Thus, performing a more complete vitrectomy, particularly with triamcinolone acetonide staining near the sclerotomy sites, is a simple way to correct this problem. Another potential issue is that prolapse of a vitreous wick through the sclerotomy site may create a potentially open conduit through the conjunctival and scleral wound, facilitating entry of bacteria into the eye.19 Once again, more complete vitrectomy at or near the sclerotomy sites decreases this risk. Additionally, the use of air tamponade at the conclusion of surgery may act as both a barrier to bacterial inoculation and a way to prevent hypotony.

Improvements in cannula removal and appropriate use of subconjunctival antibiotics near the sclerotomy sites may reduce potential complication risks. Vitreous wick prolapse may be prevented19 during closure simply by placing the light pipe through the microcannula during removal (Figure 5). This prevents the suction-like effect that may occur during cannula removal. This mechanism of cannula removal with air tamponade may allow air rather than vitreous to seal the sclerotomy site wound. Finally, injection of subconjunctival antibiotics adjacent to the sclerotomy sites may decrease bacterial entry through scleroto-

Figure 5. The light pipe is inserted through the microcannula prior to removal to prevent vitreous wick prolapse (A). With the light pipe still positioned through the sclerotomy, the microcannula is removed with a plug-puller (B). Once the microcannula is removed, the light pipe is safely removed, and no discernible bleb or sign of extrusion is noted (C). Subconjunctival antibiotics are placed adjacent to the sclerotomy site as an added deterrent to bacterial migration into the eye (D).

Figure 6. Results of single-surgeon, prospective, randomized comparative case series. Comparison of intraocular inflammation between fluid-filled eyes (light blue) and air-filled eyes (dark blue) (A). Comparison of intraocular pressure between fluid-filled eyes (light blue) and air-filled eyes (dark blue) (B).
It has recently been proposed that there is a correlation between relative hypotony at the conclusion of surgery and the influx of bacteria through sclerotomy sites, increasing the risk of endophthalmitis. Thus, air tamponade and relatively higher intraocular pressure (IOP) may be a deterrent to bacterial influx. Extra insufflation of air may also be necessary if the IOP is deemed too low. Many of these recommendations for small-gauge surgery improvements have been proposed by the Microsurgical Safety Task Force at the most recent meeting of the American Society of Retina Specialists.

**PROSPECTIVE, RANDOMIZED STUDY**

Due to a lack of prospective data, the supposition that air tamponade may be beneficial has not been wholly proved. With this in mind, I conducted a single-surgeon, prospective, randomized comparative case series comparing eyes that had undergone 23-gauge vitrectomy with and without air tamponade. The purpose of the study was to assess if air tamponade reduces the risk of hypotony and endophthalmitis in 23-gauge vitrectomy as compared with fluid-filled eyes. All eyes were phakic, and none had previously undergone vitrectomy. Povidone-iodine was placed on the conjunctiva prior to entry. In all eyes, conjunctival displacement was followed by two-step, beveled incision and 23-gauge vitrectomy with or without air tamponade (Figure 4). All air-filled eyes had 70% or greater tamponade; light-pipe assisted cannula removal was performed on all eyes (Figure 5); eyes subsequently requiring gas or silicone oil tamponade were excluded. A separate, masked ophthalmologist evaluated all study eyes on postoperative days 1, 3, and 7 in terms of IOP and anterior segment inflammation; the surgeon performed fundus exams on postoperative days 1 and 7.

This case series included 53 eyes (52 patients) in the air-tamponade group and 47 eyes (46 patients) in the fluid-filled group. IOP measurements on postoperative day 1 were 16.8 ±2.2 (air-tamponade group) and 11.2 ±2.6 (fluid-filled group [P=0.17]) mm Hg. No choroidals were noted. On postoperative day 7, IOP levels were 17.9 ±1.2 (air-tamponade group) and 16.3 ±2.4 (fluid-filled group) mm Hg. In regard to intraocular inflammation, all air-tamponade eyes on postoperative day 1 had 0 or trace anterior segment cells, while 28 fluid-filled eyes had the same results.

Fifteen fluid-filled eyes had 1+ cell, and 4 eyes had 2+ cell. On postoperative day 7, 10 eyes in the fluid-filled group still had trace to 1+ cell. No eyes developed endophthalmitis (Figure 6).

Based on these results, we concluded that air tamponade in 23-gauge vitrectomy may reduce the risk of hypotony and consequently decrease fluid inflow and egress through the wound in the first 3 days after vitrectomy. This latter effect may also reduce the risk of endophthalmitis. Additionally, light-pipe–assisted cannula removal may reduce the risk of vitreous wick prolapse.

**CONCLUSIONS**

For experienced surgeons, there has been a steep learning curve to small-gauge vitrectomy in terms of entry, surgical technique and instrumentation, and microcannula removal. Improvements in these areas have decreased the relative risk of endophthalmitis, but longer-term study is needed.

Currently, the prevailing evidence emphasizes the importance of the following measures to reduce endophthalmitis risk:

- lid scrubbing;
- direct povidone-iodine application;
- conjunctival displacement and angled-beveled incision creation;
- more complete vitreous removal adjacent to the sclerotomies;
- air tamponade;
- repositing potential extraconjunctival vitreous wick with light-pipe assisted cannula removal and subconjunctival antibiotic injection; and
- extra insufflation of air or gas if necessary to stabilize intraocular pressure.

Hu et al determined that there is no statistically significant difference in endophthalmitis rates between 20-gauge and 25-gauge systems, thus directly contradicting two previous studies. As a surgeon having performed thousands of 25-gauge and 23-gauge vitrectomies since 2002 without one case of endophthalmitis, I believe that the increased risk is technique-dependent. The documented risk modifications described above should decrease the risk of endophthalmitis dramatically.

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28. Lakhmanpal RR. Air tamponade may reduce complications in 23-gauge vitrectomy. Presented at the 43rd Annual Meeting of The Retina Society; September 24, 2010; San Francisco.