Using Perfluorocarbon Liquids as Short-term Postoperative Intravitrebral Tamponade

BY LIHTEH WU, MD

Complex retinal detachments, including proliferative vitreoretinopathy, giant retinal tears and trauma cases, often involve vitreous surgery for their repair. Intraocular tamponade plays an important role in the outcomes of these eyes. An effective tamponading agent will make contact with the retina and prevent the passage of fluid through the breaks. Commonly used tamponading agents such as silicone oil and gases (C3F8 or SF6) have a specific gravity lighter than water. Therefore, they float and are a perfect tamponading agent for retinal pathology in the superior half of the retina. They make poor contact, however, with the inferior half of the retina—in particular, in an underfilled eye. In view of the limitations of postoperative positioning, intraocular tamponade with silicone oil and perfluorocarbon gases can be problematic in eyes with complex retinal detachments with inferior pathology. An ideal tamponading agent for the inferior retina would have to have a specific gravity higher than water.

Perfluorocarbon liquids (PFCLs) exhibit biological inertness, a good surface tension in an aqueous environment, a higher specific gravity than water, low viscosity, transparency, and optical clarity. PFCLs are also immiscible with water, silicone oil and blood. They have revolutionized the treatment of complex retinal detachments, in particular giant retinal tears. Prior to the introduction of PFCLs, the giant tear had to be unfolded with the patient in the prone position. PFCLs allow the unfolding of the folded giant retinal break with the patient in the usual supine position.

Retinal Toxicity Concerns
Multiple animal studies have shown retinal toxicity when PFCL is left in the vitreous cavity as a postoperative tamponading agent. The ocular toxicity of PFCLs has been ascribed to a combination of chemical and mechanical toxicities. As mentioned previously, pure PFCLs are biologically inert. The chemical toxicities of perfluorocarbon liquids are related to the impurities that are found in them. Such impurities include compounds with nitrogen bonds and compounds containing hydrogen and fluoride.

Velikay et al compared the retinal tolerance to unpurified and purified perfluorodecalin in rabbit eyes after long-term intravitreal tamponade. In eyes with unpurified perfluorodecalin, severe inflammation and retinal damage were evident by 4 weeks. Eight out of 10 eyes developed retinal detachment. In contrast, the purified perfluorodecalin-injected eyes showed changes in the photoreceptor, outer nuclear and ganglion cell layers by 2 weeks. Localized areas of retinal atrophy were evident in the inferior retina after 8 weeks.

Eckardt and colleagues reported similar findings. It appears then, that due to the fact that they are heavier than water, the perfluorocarbon liquids exert a mechanical physical effect on the retina that is manifested as selective compression of the inferior retina. Chang and colleagues examined the effects of per-
fluorotributylamine when left in the vitreous cavities of rabbit eyes for up to 5 months. Postoperative inflammation was similar in eyes with perfluorotributylamine and control eyes. By postoperative day 10 to 14, the large perfluorotributylamine bubble started to disperse into smaller droplets at the vitreous-perfluorotributylamine interface. Retinal visualization through the bubble may become impaired. These small bubbles may pass through the retinal breaks into the subretinal space. Increasing amounts of cellular aggregates clustered on the posterior lens surface and the residual cortical vitreous by 4 weeks.

Histopathological studies revealed photoreceptor toxicity and an inflammatory response characterized by foam cells (macrophages that had phagocytosed perfluorotributylamine droplets). The small PFCL bubbles in conjunction with the foam cells may clog up the trabecular meshwork leading to glaucoma.

In rabbit eyes, perfluoroether caused cataract formation, preretinal membrane formation, and retinal gliosis by 1 month. By 3 months, tractional retinal detachment was evident.

Based on these data, perfluorocarbon liquids have traditionally been used as intraoperative adjuncts and, as such, have been removed at the conclusion of surgery.

Other experimental studies, however, have called into question the toxicity of perfluorocarbon liquids when left as tamponading agents. Perfluorophenathrene was left in the vitreous cavity of rabbit eyes for up to 6 weeks and in primate eyes up to 5.5 months without any signs of toxicity. In a similar fashion, Flores-Aguilar et al. did not see any retinal toxicity in perfluoro-octyl bromide tamponade for up to 6 months. Mackiewicz and co-authors also did not find any retinal structural damage after a 3-month tamponade with perfluorodecalin in rabbit eyes.

**REDETACHMENT RATES WITH PFCL TAMPONADE**

With current techniques, the retinal reattachment rates in eyes with giant tears are as high as 94%. The problem is that the redetachment rate can be as high as 45%. The most likely cause of this redetachment is an inadequate retinal tamponade that allows fluid to go under the tear and redetach the retina. Recently, several investigators have reported the use of perfluoro-
ro-n-octane as a short- and medium-term postoperative intravitreal tamponade.10–12
Rofail and colleagues10 reported a retrospective series of 16 patients with giant retinal tears without any significant proliferative vitreoretinopathy in whom perfluoro-n-octane was used as a short-term postoperative tamponade. The perfluoro-n-octane was left in the vitreous cavity for an average of 16.4 days (range, 6–50 days). They reported that only one (6.3%) eye suffered retinal redetachment. In addition, they found no adverse effects directly attributable to the perfluoro-n-octane.

Similarly, Sirimaharaj et al11 reported on 62 eyes with giant retinal tears that were left with perfluoro-n-octane as a postoperative tamponading agent for up to 14 days. In this series, the redetachment rate was 22.6%, and no complications secondary to the perfluoro-n-octane were reported.

In another study, perfluorohydrophenanthrene was left as a postoperative tamponade. The perfluoro-n-octane was left in the vitreous cavity for an average of 16.4 days (range, 6–50 days). They reported that only one (6%) eye that developed transient elevation in intraocular pressure.13

In another study, perfluoro-1,7-hexafluoro-3,5-octadienyltrifluoromethyl undecanoate (perflubron).14

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Ventura and colleagues12 used perfluoro-octane as a tamponading agent for 5 days in 10 eyes with giant retinal tears and proliferative vitreoretinopathy grade B or worse. After 5 days, a PFCL-gas or silicone oil exchange was performed. None of the eyes had evidence of retinal toxicity.12 In eyes for which perfluoroperhydrophenanthrene was left as a postoperative tamponading agent, two eyes developed lens opacities and one eye developed transient elevation in intraocular pressure.13

In summary, PFCLs are important intraoperative tools for vitreoretinal surgeons. There is a growing literature challenging the notion that they should be removed immediately after surgery. Their high specific gravity makes them ideal tamponading agents, in particular for eyes with pathology of the inferior retina. While its tempting to use PFCLs as short- or medium-term tamponade on a routine basis, I would urge caution and selection of patients on a case-by-case basis, until we know how toxic PFCLs really are.

SUMMARY

In summary, PFCLs are important intraoperative tools for vitreoretinal surgeons. There is a growing literature challenging the notion that they should be removed immediately after surgery. Their high specific gravity makes them ideal tamponading agents, in particular for eyes with pathology of the inferior retina. While its tempting to use PFCLs as short- or medium-term tamponade on a routine basis, I would urge caution and selection of patients on a case-by-case basis, until we know how toxic PFCLs really are.

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