

The Potential Surgical Benefits of Colored Perfluorocarbon

Colored PFCL can facilitate safe and efficient removal of temporary tamponades.

BY STANISLAO RIZZO, MD

Perfluorocarbon liquids (PFCLs) are commonly used during the surgical management of retinal detachment repair, particularly in eyes with vitreoretinal proliferation or giant retinal tears. Due to their high specific gravity, injecting PFCLs into the posterior chamber flattens the retinal detachment against the retinal pigment epithelial (RPE) cell layer and moves the subretinal fluid anteriorly. This enables the displacement of subretinal fluid through peripheral tears. PFCL can also exert countertraction during epiretinal membrane peeling, acting as a third hand in the case of tenacious vitreoretinal adhesions. Additionally, due to the hemostatic properties of these compounds, PFCLs can be used to remove fibrovascular proliferations in complicated proliferative diabetic retinopathy.

Because of their usefulness, PFCLs have become increasingly popular among vitreoretinal surgeons. PFCLs have been shown to be beneficial in surgery in patients with a dislocated crystalline lens or IOL or for blood dislocation in submacular and subchoroidal hemorrhages. In the late 1980s, Stanley Chang, MD, was the first to describe the use of low-viscosity PFCLs in humans. Chang's initial studies involved retinal detachments associated with vitreoretinal proliferations,¹ trauma,² and giant retinal tears.³

TOXICITY PHENOMENA

The availability of PFCLs has changed the prognosis of complicated vitreoretinal pathologies; however, their use is exclusively intraoperative because they are removed at the end of surgery. Complications of PFCLs are uncommon, but they can be caused by retention of PFCLs after surgery, resulting in toxicity. Moreira et al⁴ demonstrated stromal inflammation, loss of endothelial cells, and corneal vascularization after PFCL injection

into the anterior chambers of aphakic rabbits. Other reported toxicity phenomena include secondary glaucoma from retained intraocular PFCLs⁵ and central scotomas due to retained subfoveal PFCL.⁶ An animal model of retained subretinal PFCL demonstrated changes to the RPE and photoreceptors.⁷

Risk factors for retained subretinal PFCL include large peripheral retinotomies greater than 120° and incomplete saline rinse after PFCL removal.^{4,5} A saline rinse helps to collect the microscopic layer of PFCL that can remain posteriorly, which can then be aspirated.⁸ PFCL residues can also combine with silicone oil, facilitating its emulsification or resulting in heavier-than-water composites (sticky oil) that are adherent to retinal surfaces and are difficult to remove.

The frequency of PFCL-related surgical complications is approximately 7.4%,⁹ but this rate is variable and depends on the type of PFCL used. For example, the rates of intraocular retention for perfluoro-N-octane and perfluoroperhydrophenanthrene are 7.8% and 38.3%, respectively.⁹ These rates are dependent on steam pressure, refractive indices, and viscosity.

IMPROVED VISUALIZATION

Most PFCL-induced complications are related to the transparent nature of the compound, making it difficult to remove completely during exchange with silicone oil and especially air. A colored PFCL that facilitates visualization of PFCL residues may prevent many of these problems.

In partnership with Fluoron GmbH (Ulm, Germany), I have developed a heavy blue-colored liquid composed of a PFCL (perfluorodecalin or perfluorooctane) and a semifluorinated alkane. The blue color is intended to aid surgeons in complete and safe removal of PFCL by making it possible to see even the smallest residual droplets of the compound.

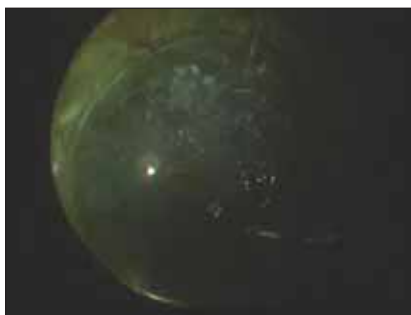


Figure 1. Good visibility of colored PFCL in a retinal detachment case.



Figure 2. Colored PFCL (red arrow); detached retina (white arrow).

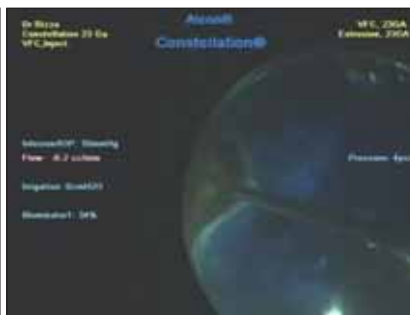


Figure 3. Direct silicone oil- PFCL exchange in an eye with a giant tear.

EARLY DATA

Initial clinical tests designed to evaluate the application of a heavy colored liquid and demonstrate its advantages were performed on freshly enucleated pig eyes. These laboratory experiments simulated fluid-air exchange and direct PFCL-silicone oil exchange. After removing the vitreous, the retina was flattened with the colored heavy liquid. Fluid-air exchange and direct fluid-silicone oil exchange were performed. Cytotoxicity was tested per the standard International Organization for Standardization (ISO) test using L929 cells. The tests were conducted by Nadine Hagedorn, MD.

The solution was observable in the pig eyes during fluid-air exchange. After the eye was filled with balanced salt solution, many small colored droplets were visible, making it easy to remove them. The retina, vitreous, and other tissues were not stained. Direct fluid-silicone oil exchange was possible, but after a few minutes a small amount of dye diffused into the silicone oil, forming a small crown around the residual droplets. There were no signs of toxic effects on the L929 cells.

Initial clinical testing was also performed. The solution was evaluated in 10 patients who underwent pars plana vitrectomy for complicated retinal detachment. In these patients' eyes the colored PFCL demonstrated good visibility (Figure 1). Complete removal of PFCL was possible, and no signs of toxicity or irritation were seen. During surgery, the colored PFCL highlighted the balanced salt solution-air-PFCL interfaces (Figure 2). PFCL coloring has proved to be useful for highlighting the levels of silicone oil and PFCL during direct silicone oil-PFCL exchange in eyes with giant tears (Figure 3).

Overall, the colored PFCL was well tolerated in human eyes. Additionally, the ability to visualize the PFCL under air made removal easier and prevented the inadvertent migration of the PFCL under the retina. No intraoperative or postoperative adverse events related to the blue liquid were seen.

CONCLUSION

Dye coloring of PFCLs may be helpful to ensure their complete removal and safe use. Residual PFCLs can result in side effects such as emulsification of silicone oil and ocular inflammation. Colored heavy liquids can also be used for purposes of training young ophthalmologists in vitreoretinal surgery. ■

Stanislao Rizzo, MD, is Director of U.O. Chirurgia Oftalmica, Azienda Ospedaliero Universitaria Pisana, Pisa, Italy, and Professor at the European School for Advanced Studies in Ophthalmology, Università della Svizzera italiana, Lugano, Switzerland. He is a Retina Today Editorial Board member. Dr. Rizzo states that he has no financial interest in the material presented in this article. He may be reached at e-mail: stanislao.rizzo@gmail.com.



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CONTACT US

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