EDITORIAL

PERFLUOROCARBON HEAVY LIQUIDS

Initially devised as blood substitutes due to their high oxygen solubility and inert nature, perfluorocarbon liquids (PFCL) were introduced to the ophthalmic world by Stanley Chang for use in proliferative vitreo-retinopathy and giant retinal tears.[1,2] Their applications widened as the advantages of these high specific gravity, low viscosity, immiscible, optically clear liquids became apparent. As they are becoming such a widely used intraoperative tool, it is useful to review the current applications of PFCL, and to look to the future.

Their physical properties confer numerous technical advantages. They represent the first high specific gravity tamponade agent (i.e. heavier than water) that also has a low viscocity. They promote retinal reattachment by displacing subretinal fluid (SRF) anteriorly, and are easily infused and aspirated. It is fortunate that their development has coincided with the popularisation of phacoemulsification, as the dislocated crystalline lens (and IOL) will float on the surface of heavy liquid. Recent reports highlight the need for a thorough vitrectomy and complete removal of heavy liquids in these situations.[3] PFCL have a higher boiling point than saline, they do not absorb visible light, and no clinically noticeable side effects result from intraoperative endolaser and endodiathermy. In fact, effective tamponade ensures excellent intraoperative laser uptake by the retinal pigment epithelium, due to the lack of intervening SRF. They are optically clear with a refractive index approximating that of saline, allowing both an unhindered view of vitreo-retinal features whilst also allowing easy visualisation of the interface. Interface visualisation is important, as it enables accurate and complete removal of PFCL at the end of the procedure. Most medical advances add a cost – in this case, £80 (excluding VAT) per 5 ml of the least costly PFCL. Do cheaper, equally effective alternatives exist? In proliferative vitreo-retinopathy (PVR), Chang[1,2] outlined the use of PFCL for allowing counter-pressure for peeling membranes; for allowing opening of the funnel to display residual areas of traction; and for allowing intraoperative endolaser to be performed on flat retina. Although these procedures can be performed without PFCL (e.g. under air), the use of PFCL allows easier manipulation and better visualisation. Use of PFCL can avoid the need for posterior drainage retinotomy by displacing SRF anteriorly via peripheral breaks, although one can often perform fluid–air exchange and drain directly via peripheral breaks, or perform an accessible anteriorly placed retinotomy. However fluid–air exchange can leave a residual puddle of subretinal fluid around the macula in eyes with large posterior staphyloma, and such SRF can be conveniently shifted towards the drainage retinotomy with PFCL (under either air or silicone oil).

Giant retinal tears (GRT) can be managed with silicone oil alone,[4] although heavy liquids have simplified the management of tears greater than 180° and GRT associated with PVR. Moreover, the use of heavy liquids instead of air alone avoids cumbersome intraoperative manipulations of the retina and, indeed, the patient.[1,5]

As mentioned above, a posteriorly dislocated lens can be floated anteriorly on a cushion of PFCL after a full vitrectomy. The options then include removal of the lens via the limbus using expression, a vectis, cryoextraction, or forceps (for IOLs).[6,7] If the cataract is hydrated, one can perform fragmentation without need for PFCL, although fragmentation of the nucleus in mid vitreous on a cushion of PFCL can prevent retinal damage by acting as a shock absorber for ultrasonic energy.[8] However, nuclear fragments can slip off the convex fluorochemical surface into the periphery.

A posterior dislocated posterior chamber IOL can be retrieved and sutured to the ciliary sulcus without heavy liquids, although heavy liquids confer protection by enabling flotation of the dislocated lens away from the retina, thus preventing retinal damage from preretinal manipulation of the lens. Heavy liquids also conveniently stabilise the lens behind the iris plane, simplifying intraocular suturing. Where retinal detachment and dislocated lens (IOL or crystalline) coexist, PFCL combines two useful functions of lens flotation and simultaneous displacement of subretinal fluid anteriorly via the pre-existing breaks.[9]

It is stressed that a complete pars plana vitrectomy should be performed prior to using intraocular heavy liquids, and that heavy liquids should be removed at the conclusion of surgery. Furthermore, it is strongly advised that heavy liquids should not be infused when dislocated nuclei occur during phacoemulsification unless the surgeon is experienced with vitreo-retinal techniques and the use of heavy liquids.

PFCL are obviously useful intraoperative tools but do they cause untoward ocular effects? Although PFCL are safe for intraoperative use[1,2,10–14] most studies show that long-term tamponade (i.e. more than 2 weeks) is associated with emulsification, pre-retinal membrane formation and a monocellular vitreous response with ingested fluorochemical (foam cells[11]) as well as pathological and electrophysiological changes.[11,13,15,16] Retinal changes include displacement of photoreceptor nuclei into the rod and cone layer (photoreceptor drop down), distortion of photoreceptor outer segments, narrowing of the outer plexiform layer, and retinal pigment epithelial hypertrophy and drusen, confined to the inferior retina.[11,13,15,16] This probably represents a mechanical effect as these changes are in the inferior retina whilst the superior retina differs very little from controls,[11,14] and similar changes have been noted in the superior retina with silicone oil.[14,17] Retained PFCL can cause glaucoma if emulsification and macrophage dispersion occurs, as well as mild lens opacities[11,12,18] and endothelial toxicity following prolonged contact.[10,11]

Therefore untoward effects are probably compression related although chemical toxicity (especially in non-purified PFCL) may play a role.[19] A legitimate question arises: can PFCL be left in the eye for post-operative tamponade? Silicone oil, representing the hope for an optically clear tamponading vitreous substitute, has not been a panacea, not least because of its inability to tamponade inferior pathology, and (perhaps by the concentration of proliferogenic substances) the occurrence of inferior PVR. However, it is a tantalising possibility to combine silicone oil with heavy liquid for short-term post-operative tamponade (e.g. 4 weeks) in such cases as inferior PVR, posterior inferior breaks, inferior GRT and inferior retinectomies. Animal models exist;[12,20] case reports of post-operative heavy liquid tamponade (with no silicone oil) exist;[21] and evidence of no clinically observable untoward effects from small amounts of residual heavy liquid suggests that this could be a possibility worth exploring. However, it is worth noting that animal studies have not analysed the effect of retained intraocular PFCL after their use as a medium for laser, endodiathermy or cryoretinopexy. Intraoperative local temperature rise with diathermy and laser is significant and one can observe a localised boiling of heavy liquid. It is known that polar impurities in oil encourage fibroblastic proliferation on the surface[22] and current research is addressing the possibility that vitreous surgery may create protonated impurities in heavy liquids. However, preliminary analysis with gas chromatography and NMR spectroscopy suggests that no degradation of purified perfluoro-octane occurs as a result of laser, endodiathermy and cryotherapy (Bourke, Simpson, Cooling, unpublished data).

By facilitating hydrokinetic manipulation of intraocular tissues, perfluorocarbon heavy liquids represent a technical breakthrough in vitreo-retinal surgery, analogous to viscoelastics in anterior segment surgery. Similarly, a small cost is added to the procedure, but where PFCL simplifies complex surgery the cost is justified. PFCLs should not be used in the eye without a full vitrectomy and should be completely removed at the end of the procedure. Further experimental studies are required to ascertain whether there is a potential for safely widening the scope of PFCL role in vitreo-retinal surgery.

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SURGICAL MINUTIAE

In this issue is published the first of a series of short articles about the little things which make the difference between doing an operation competently and doing it really well.

Craftsmen in any field appear to make their tasks look easy. This is not because they approach their work in any different way to the novice or trainee, but through constant repetition of each section of the exercise they know which corners can be cut and, more importantly, those parts which require particular care and attention. In addition by adding or subtracting little pieces to the job, they end with a product which is uniquely their own. So it is with surgery. By observing the way the sutures are placed, their tension and the method of tying the knots it is almost always possible to tell which surgeon has performed a particular operation. It is these little 'tricks of the trade' which we wish to explore in these articles.

The articles themselves have been solicited from surgeons who are constantly involved in the procedures they have been asked to discuss. The ideas expressed in them are theirs, or distillates of the experiences of others, and, although they may not always be of use in all the circumstances of everyday practice, they should undoubtedly be of value in many of them.

P. G. Watson