Surgery as the Primary Management of Proliferative Vitreoretinopathy

A History Reflecting My Experiences and Biases

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Although attempts were made to reattach retinas using proliferative vitreoretinopathy by various techniques before the 1970s, it was the development and subsequent refinement of closed-eye, mechanized pars plana vitrectomy that initiated the rapid rise in the surgical success rate. This article presents a personal history of the milestone accomplishments that facilitated the strong possibility of success that patients with proliferative vitreoretinopathy can now anticipate. Currently, various gasses, chemical compounds, and pharmaceutical agents serve adjunctively to advance surgical techniques with the expectation that they may be the primary curative procedure in the future. As in the past, what is unconventional today may be common tomorrow.

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It is with great humility that I extend my sincere appreciation to The Retinal Research Foundation, The Schepens International Society, and Alice McPherson, MD, for inviting me to be the second lecturer to honor the legacy of Charles Schepens, MD.

I first met Dr Schepens while I was in the Howe Laboratory, Massachusetts Eye and Ear Infirmary, during a year of research on aqueous dynamics that preceded my clinical residency. It was apparent that I needed indirect ophthalmoscopy skills to see the peripheral retina in our experimental model in which we cannulated the pars plana. Dr Schepens mentored my improvement in ophthalmoscopic techniques and promoted my joy in seeing the peripheral retinal structures, including elusive retinal tears. These techniques and Dr Schepens' instruction served me well during my subsequent clinical residency, culminating in my career interest in vitreoretinal diseases.

A LOOK AT THE PAST

Proliferative vitreoretinopathy (PVR), an enigma to retinal surgeons, had a surgical success rate of about 15% prior to 1970, using external scleral techniques of buckling, resection, or imbrications. Attempts to perform premechanized vitreous surgery were made through limbal and pars plana approaches using vitreous aspiration with or without replacement; the former used saline, donor vitreous, air, gas, silicone oil, or collagen to insufflate the vitreous cavity and strip PVR bands or membranes.1-12 Simultaneously, vitreoretinal membrane division/cutting was employed using intravitreal knives, punches, scissors, and balloons.13-16

BEGINNING OF THE MODERN ERA OF PVR MANAGEMENT

Closed-Eye Mechanized Pars Plana Vitrectomy

The 1970s were a decade of both advancement and proliferation of vitrectomy instrumentation, resulting in a doubling of the success rate of PVR surgery to 30%. On April 20, 1970, Robert Machemer, MD, performed his first human closed-eye pars plana vitrectomy with the vitreous infusion suction cutter (written and oral communication, November 1994), profoundly changing ophthalmic surgery and thus helping many patients who were previously considered untreatable. Like other major therapeutic changes in the practice of ophthalmology, vitrectomy, at that time, had detractors as well as advocates, the latter ranging from adamant zeal to remove all portions of the vitreous gel to a more cautious surgical approach. I defended my position in the letter section of Controversies in Oph-

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thalmology,17 stating, “Closed eye vitrectomy represented a true milestone in ophthalmic progress,” but, “The clinician must be on guard as to the future consequences of this surgical therapy.” Dr Schepens presented a cautionary view but concluded, “Vitreous surgery is here to stay. . . . remarkable results can be obtained in eyes that would otherwise be doomed.”17 The vitreous infusion suction cutter was a full-function instrument with cutting, aspiration, infusion, cannulated endoillumination, and even diathermy in the early versions, creating a large (about 16-17 gauge) shaft size when fully assembled with the illumination sleeve. Other full-function instrumentation by various independent clinical investigators followed,18-21 including a stereotaxic unit.24 The cannula size eventually was reduced by splitting the functions into separate illumination, infusion, and cutting.25

Concurrent equipment submilestones during the aforementioned vitrectomy development were advances in illumination and microscopic visualization of the posterior pole. Early illumination was coaxial and/or aligned slit beam light; both had insufficient light intensity and interfering light reflexes at every intervening tissue optical interface. Most problems were minimized by endoscopic light.26 Microscope modification advances included (1) 2-dimensional horizontal (x-y) foot-controlled movement; (2) variable zoom depth with greater steady-state depth of focus; (3) greater range of magnification27; and (4) wide-angle viewing.28

Each advance facilitated other advances. With improved illumination and visualization, same-gauge auxiliary instruments were developed to be interchangeable through sclerotomy ports with the vitrector such as diathermy, scissors, forceps, picks, extrusion devices, magnets, and more.

Intraocular Solutions and Gases

During the first decade of closed-eye vitrectomy, little was known about the tolerance of the eye for infused liquids, particularly for the volume and duration of early vitrectomy infusions that compounded the patients’ debilitating ocular conditions such as diabetes, sickle cell, trauma, and multiple previous surgeries. Vitrectomy surgeons thus noted while using the basic saline or lactated Ringer solutions that were available (or variants thereof) that the corneas and lenses lost clarity during surgery and, postoperatively, the corneas were thickened for a considerable period of time. Eyes of diabetic patients that developed intraoperative cataract necessitating concurrent lensectomy then had a greater risk of postoperative ruberosis iridies.

A great advance that eventually saved the vision of many postoperative patients occurred when Henry Edelhauser, PhD, developed the prototype glutathione bicarbonate ringers solution with osmolality, buffering capacity, and pH compatible with the aqueous humor.29 Further research by Haimann and Edelhauser at al30 showed that the eyes of persons with diabetes, invariably accustomed to higher prooperative intraocular aqueous glucose levels (hence higher osmolality), maintained intraoperative lens clarity better when adding additional dextrose to the irrigating solution.

Retina surgeons had used air for many years for intravitreal tamponade of retinal holes and to maintain proper retinal alignment. Air had been used intraoperatively during vitrectomy in the late 1970s but was not practical until automated air injection in the early 1980s. Because air dissipated quickly from the vitreous cavity, vitreoretinal surgeons were also excited by studies in the mid 1970s that demonstrated the ability of sulfur hexafluoride gas to expand and persist for many days in the eye.31 This was followed by other gaseous compounds such as perfluoropropane, which expanded and persisted even longer.32,33 Surgery in an air-filled eye had greater interface surface tension than a fluid-filled eye so tangential traction in a fluid-filled eye could be severed and maintained postoperatively with an air-gas exchange at the conclusion of surgery. Thus, the therapeutic armamentarium of the surgeon expanded, albeit with some risk.

Intraocular Laser

Endocogulation initially used a xenon light source but was ineffective in an air-filled eye, so it was soon replaced by intraocular laser. This dramatically altered the technical capabilities of the vitreoretinal surgeon, permitting intraoperative treatment of retinal holes and demarcation of intractable anterior disease in air-filled eyes. These capabilities allowed success in some eyes that would otherwise have failed and increased the overall rate of surgical success in PVR to 63%.34-36

Sustained Retinal Tamponade

Silicone oil has been used since the previtrectomy 1960s when Cibis37 used it as a substance to separate pre-retinal tractional membranes and afford long-term retinal tamponade. Except for the surgical tenacity of Scott38 and a few others who continued to use silicone oil, it was rarely used in the early 1970s. It’s renewed interest came as an adjunct to pars plana vitrectomy techniques,39-41 leading to a randomized clinical trial comparing silicone oil to long-acting gas as a retinal tamponade in PVR.42,43

During this time, 2 further advances occurred: (1) recognition of the significance of proliferation in or about the posterior insertion of the vitreous base, ie, the anterior component of PVR,35,36 and (2) developing clinical experience with perfluorocarbon liquids; a variety were available but perfluoro-N-octane became the most clinically used to reposition the mobilized retina after membrane dissection.44 By understanding the mechanisms and significance of periretinal membrane proliferation and developing the surgical corrections, the success rate of PVR surgery rose to 78% by 198735 and currently is even higher.

Anticipated Pharmacologic/Immunologic Milestones for PVR

Thirty three years ago, Dr Schepens aptly stated, “The greatest limiting factor of vitreous surgery cannot be overcome...the continuing growth of new formed tissue...in instances of massive preretinal retraction...the control of such regrowth will certainly require considerable research work.”45 Such research continues, and headway is being made.

Because initial surgical reattachment of primary retinal detachments
can now usually be achieved, prevention of cellular migration, adhesion, and proliferation, ie, PVR, should be targeted. Risk factors for subsequent PVR are known and should be the template for determining candidate eyes for preventative treatment in primary retinal detachment and as an adjunct at the time of PVR surgery to prevent reoccurrence.45,46

Several of the many known cytokines are prospects for pharmacologic inhibition and/or modification to prevent cellular proliferation. Inhibition of cellular migration and adhesion may be inhibited by plasma fibrin and fibronectin in the early assembly of a provisional extracellular matrix and/or inhibition of a subsequent matrix of collagen and cellular/fibronectin. Several laboratories are working on these pathways45-46 as well as the best delivery systems for PVR therapeutic/prophylactic agents.48

I conclude that while epidemiologic and therapeutic evidence suggests pharmacologic/immunologic treatment is necessary, at present, surgery is still the primary management of PVR.

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