The utility of ciliary body ablation in the treatment of glaucoma was recognized in the early 20th century. Many of the first attempts at targeting the ciliary processes involved non-penetrating techniques that relied on energy applied through the sclera. These approaches were often successful but were associated with serious side effects, including injury to the sclera, inflammation, hypotony, and phthisis. Norris and Cleasby first described the visualization of intraocular tissue through endoscopy, and Uram reported endoscopic laser ablation of the ciliary processes for the treatment of glaucoma in 1992.

Endoscopic cyclophotocoagulation (ECP) can treat most types of glaucoma and has historically been reserved for disease refractory to medical or other surgical interventions. With the recent refinement of equipment, surgeons sometimes use ECP earlier in the course of treatment. Often combined with phacoemulsification, endoscopic laser cycloablation has proven safe and effective at decreasing IOP while causing limited and infrequent side effects. ECP has been especially effective in treating pediatric glaucoma that is often refractory to other medical or surgical interventions. This article describes our technique for ECP treatment and discusses the pre- and postoperative issues that are important for safe treatment and effective IOP control.

**INFORMED CONSENT**

During the preoperative discussion, patients should be advised that they may experience discomfort when topical anesthesia is used in conjunction with monitored anesthesia care for ECP. Although topical anesthesia often adequately controls pain, certain individuals may require additional measures. Patients should be aware of this possibility and instructed to alert the physician to any discomfort so that it may be addressed promptly.

**TECHNIQUE**

The proper technique for ECP begins with appropriate patient selection. We reserve the procedure for glaucoma patients in three categories. The first group includes those undergoing phacoemulsification who use two or more topical medications for IOP control. The second group comprises patients in whom maximal medical therapy has failed and who have an IOP under 40 mm Hg. The third includes patients with advanced glaucoma in whom previous penetrating surgery has failed. Among the relative contraindications for ECP treatment are...
active uveitic glaucoma and an IOP greater than 40 mm Hg, because the latter eyes may not respond adequately to the procedure.

THE STAGES OF ECP

Anesthesia

Both the topical and retrobulbar delivery of an anesthetic are appropriate for ECP treatments. Retrobulbar anesthesia is administered just as during phacoemulsification and carries with it the same risks of retrobulbar hemorrhage and injury to the optic nerve. The advantage of this form of anesthesia is that it provides excellent and lasting pain control while allowing for akinesia and permitting a novice ECP surgeon greater control compared with the use of topical anesthesia.

Topical anesthesia is appropriate and adequate in most cases of ECP. We apply topical lidocaine jelly onto the cornea and into the superior and inferior fornices prior to preparing and draping the patient. Next, we perform an intracameral injection of unpreserved lidocaine 1% into the anterior chamber for ciliary anesthesia. We have coordinated with experienced specialists in anesthesia for all of our ECP patients to receive intravenous propofol and fentanyl. We instruct patients to

DISCUSSION

By Nina A. Goyal, MD, and Theodore Krupin, MD

In their article, Malik Kahook, MD, and Robert Noecker, MD, MBA, present their technique and preliminary results for endoscopic cyclophotocoagulation (ECP). As they discuss, ciliary body ablation to reduce the production of aqueous humor has a long history beginning with invasive electrocauterization. The procedure was popularized in the late 1960s using the transscleral delivery of cold (cryo) energy and more recently using the transscleral application of Nd:YAG and diode laser energy. External ablation is limited by the approximation of where to apply the energy (transillumination with a light source facilitates the location of the ciliary body) and inadequate visibility of the ciliary body’s response to treatment. Transscleral cilioablation can effectively reduce the IOP while avoiding the complications associated with intraocular surgery in high-risk eyes. The effect on the IOP relates to the extent of the treatment and the type of glaucoma. The procedure has poor results in patients who have neovascularization and uveitis.

Invasive endoscopic laser cilioablation traces back to 1985. Continued technological advances have elevated ECP for anterior segment glaucoma surgery to the 21st century level of endoscopic surgery by our nonophthalmic colleagues. Although we do not perform this procedure, we are impressed with its technical and visual portions.

Ciliodestructive procedures reduce the IOP by ablating the ciliary epithelium and possibly by decreasing the blood supply to the ciliary body. They reduce the energy-dependent active formation of aqueous humor. The entry of fluid into the anterior chamber still occurs, however, by nonsecretory processes (eg, ultrafiltration). The ciliary epithelium can also regenerate.

Drs. Kahook and Noecker describe important modifications that have improved their outcomes with ECP, but we do not believe these changes are sufficient reason to add the procedure to our current armamentarium. First, we would like to see a randomized clinical trial comparing the IOP-lowering benefit and postoperative complications of combined ECP/cataract extraction versus cataract removal alone. It is unclear in the present article if Drs. Kahook and Noecker perform a two-incision ECP during cataract surgery. In addition, a randomized trial should compare the outcomes with transscleral laser (our current preference is diode) cilioablation with invasive ECP. We look forward to these studies.

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alert us to any discomfort, in which case they receive additional intracameral lidocaine and/or propofol.

Surgery
Two surgical approaches are common—a pars plana or a clear corneal incision (Figures 1 and 2). It is easy to create a pars plana incision in a vitrectomized eye that is either pseudophakic or aphakic, and this approach allows the surgeon to visualize the ciliary processes completely. This method was the initial choice in endoscopic cycloablation and resulted in excellent IOP control due to the amount of tissue accessible for treatment. In phakic eyes or those that are not vitrectomized, however, this approach is often difficult at best, and adequate treatment is not possible.

We prefer to fashion a clear corneal incision as we do for phaco procedures. Treatment can then proceed regardless of the eye’s phakic status, and we need not perform a vitrectomy or create incisions proximate to the retina. The incisions often seal themselves and allow for 270° of treatment. The downsides of this method include possible injury to the cornea and iris as well as incomplete visualization of the ciliary processes. In our experience, performing ECP after extracting the cataract but before implanting the IOL improves our ability to view the targeted tissue and results in superior postoperative IOPs. Also, we have found that using a cohesive viscoelastic such as Healon GV (Advanced Medical Optics, Inc., Santa Ana, CA) successfully elevates the iris away from the laser and thus decreases the chance of injury.

Three types of endoprobes are available for use. We prefer the newer curved probe that permits adequate treatment of the ciliary processes while avoiding contact with the surrounding tissue. We have found that the curved shape allows us greater reach to the surrounding tissue and that it is ergonomically easier to use than previous types of probes. The other designs are either straight or shaped like a hockey stick. Both have utility in certain situations, but we do not think they are as effective as the curved probe at reaching the ciliary processes without contacting the surrounding tissue.

Viscoelastic Agents
Ophthalmic viscosurgical devices (OVDs) are necessary during the anterior approach for ECP treatment. The surgeon must inflate the anterior chamber and elevate the iris away from the laser probe. We have found Healon GV to be ideal for occupying space without causing spikes in IOP, as can occur with Healon 5 (Advanced Medical Optics, Inc.). Other OVDs suboptimally elevate the iris (which we have observed with Healon 5 [Advanced Medical Optics, Inc.]) or obstruct laser treatment due to retained air bubbles (which we have seen with Viscoat [Alcon Laboratories, Inc., Fort Worth, TX]).

We inject Healon GV to depress the lens capsule (and lens implant if the eye is already pseudophakic) and to elevate the iris after phacoemulsification. Then, we perform laser treatment (0.25 W on continuous mode) of the ciliary processes, aspirate the OVD, and implant the IOL.

Degree of Treatment
The clinical endpoint for ECP treatment is visualization of shrinking and whitening tissue. This goal is best achieved with a slow and deliberate “painting” of the laser along the ciliary processes rather than the delivery of discrete applications. One must allow the pigmented tissue to absorb the energy so that the laser treatment affects both external and internal tissue, including the vessels within each ciliary process. Treating the epithelium alone will control the IOP only temporarily, and the surviving vessels and stroma will allow the ciliary epithelium to regenerate and, thus, aqueous production to resume.

Early ECP treatments focused on targeting 240° to 300° of ciliary processes through a single incision. We have found that treating 360° through two incisions lowers the IOP to a greater degree for a longer period.
Since adopting this approach, we have not witnessed an increase in postoperative complications such as inflammation and hypotony. The second incision, constructed 100º away from the first, allows us to treat the tissue underneath the initial corneal incision.

During the procedure, it is best to hold the ECP probe within 2 mm of the ciliary processes. This distance allows for adequate treatment of the tissue with less dissipation of laser energy. The physician can judge the distance between the probe and tissue by counting the ciliary processes in view on the ECP monitor. A probe-tissue distance of 2 mm corresponds to six processes in view.

**Postoperative Care**

At the conclusion of the procedure, we remove all of the OVD with I/A, inflate the anterior chamber with balanced salt solution, and hydrate the wounds to ensure that they are watertight. Next, we instill one drop each of prednisolone acetate 1%, a nonsteroidal anti-inflammatory drug, and a fourth-generation fluoroquinolone. The postoperative drop regimen consists of q.i.d. dosing for each drop with a tapering of the steroid slowly over 1 to 2 months to control inflammation.

**OUTCOMES**

There are few prospective studies in the literature on the utility of ECP for decreasing IOP or its effect on patients’ use of topical medication. Lima et al. prospectively assigned 68 eyes of 68 patients to either pars plana ECP or the implantation of Ahmed Glaucoma Valves (New World Medical, Inc., Rancho Cucamonga, CA) for refractory glaucoma. They found that, after 24 months of follow-up, the IOP was 14.73 ± 6.44 mm Hg in the Ahmed group and 14.07 ± 7.21 mm Hg in the ECP group (P= .7). Efficacy and postoperative complications were similar. Gayton et al. compared the efficacy of phacotrabeculectomy versus phaco/ECP in a randomized prospective study involving 58 eyes of 58 patients. The investigators reported that 30% of subjects treated with ECP achieved IOP control (below 19 mm Hg) without medication and 65% achieved IOP control with medication. In the trabeculectomy group, 40% and 52% achieved IOP control without and with medication, respectively.

We have witnessed an average decrease in IOP of 30% to 40% after 360º treatment through a clear corneal incision in more than 300 cases involving patients with primary and secondary open-angle glaucomas, neovascular glaucoma, chronic angle closure, and/or aphakic glaucoma. We have also recorded a decrease of 60% or greater in our patients’ use of topical medications postoperatively. None of our patients has experienced lasting hypotony or phthisis. The most common side effects have been transient (typically lasting less than 3 weeks) inflammation of the anterior segment and hyphema (occurring in fewer than 5% of patients).

**CONCLUSION**

ECP is a safe and effective method for treating various types of glaucoma. We think that this procedure is appropriate in patients who rely on multiple medications for IOP control as well as in those in whom maximal medical therapy has failed. A 360º treatment safely achieves long-term IOP control and decreases patients’ dependence on topical medications while causing few side effects. Long-term prospective studies comparing ECP with other methods of penetrating surgery would help to elucidate the differences in therapeutic outcomes and side-effect profiles.

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