Bipolar Cautery and Internal Thermal Sclerostomy in a Rabbit Model

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ABSTRACT

Internal thermal sclerostomy (ITS) was performed unilaterally in 35 adult New Zealand rabbits using a pinpoint bipolar cautery probe and radio-frequency power supply, with the nonoperated eyes serving as controls. Standard trabeculectomy using a limbal-based flap was also performed on 10 additional rabbits, and served as a second benchmark for comparison with the ITS technique. Intraocular pressure (IOP) was measured in all eyes preoperatively and on postoperative days 2, 4, 6, and 8. A significant (P = .005) difference between the reduction in IOP in the ITS eyes and in the control eyes was found up to postoperative day 8; on that day the reduction in IOP was 5.2 mm Hg. IOP in the eyes undergoing standard trabeculectomy was significantly (P = .05) reduced up to postoperative day 2, and gradually decreased, to 2.5 mm Hg, on postoperative day 8. The greatest reduction in IOP (2.9 mm Hg) for these eyes also occurred on postoperative day 2. Complications of ITS included iris burn (23%), peripheral corneal edema (17%), and iritis (9%). No ruptured blebs, flat anterior chambers, hyphemas, or lens damage occurred. The potential advantages of the ITS procedure using the bipolar cautery probe include a decreased risk of cataract formation because of the curved probe design. The procedure is also technically simple to perform and requires only inexpensive and readily-available equipment.

Internal filtering procedures recently have been advocated as alternatives to conventional external filtering surgery. Reported internal techniques include those using automated trephines, argon and Nd:YAG lasers, and bipolar cautery. The potential advantages of these internal approaches over traditional external filtering approaches include a decreased incidence of flat anterior chambers, elimination of conjunctival dissection and suturing, and decreased risk of wound leak (Zimmerman TJ. Ocular Surgery News. 1989;7:11-12). The reported side effects and complications have included corneal edema, and lens and iris damage. Studies have indicated that the internal approach creates filtration superior or at least comparable to external procedures. The rates of complications for these procedures are also comparable to those of external filtration procedures.

Believing that a properly designed bipolar cautery probe produces the concentrated thermal energy required for thermal sclerostomy, we evaluated a curved bipolar cautery designed for internal thermal sclerostomy (ITS) (Mentor O & O, Inc, Norwell, Mass) using a rabbit model. This procedure, like other ab-interno techniques, has the advantage of decreasing the incidence of subconjunctival scarring, which contributes
to bleb failure. Our overall objective is to develop a simple, quick, and cost-effective alternative to conventional external filtering procedures.

MATERIALS AND METHODS

Surgical Technique

All rabbits were anesthetized with intramuscular injections of ketamine (50 mg/kg) and hydralazine hydrochloride (15 mg/kg). Surgery was performed on the left eye of each rabbit. Part of the superior conjunctiva was then elevated with an injection of balanced salt solution. Using a 15-degree super-sharp blade, a self-sealing stab incision was then made in the limbal cornea, 90° away from the conjunctival elevation. Sodium hyaluronate was used to maintain the anterior chamber depth.

Under an operating microscope, a 20-gauge curved bipolar cautery probe was then passed through the corneal incision, into the anterior chamber, and positioned directly under the conjunctival bleb. The curvature of the probe is designed so that the path of the probe will be away from the lens (Fig 1). The probe was powered by a radio-frequency power supply of 454 kHz at a power setting of 0.2 to 0.4 W (Mentor O & O, Inc). The probe was used for 5 to 10 seconds as it was passed through the sclera to create the sclerostomy. At the endpoint, the surgeon felt a decrease of scleral resistance and could see the tip of the probe under the conjunctiva (Fig 2). The probe was then withdrawn from the anterior chamber and the procedure was concluded.

Postoperatively, the rabbits were treated with one daily drop of prednisolone and gentamicin. All animals, except those killed for histopathologic studies, were followed until postoperative day 8.

Method

Thirty-five adult New Zealand rabbits, each weighing 3.5 to 4.5 kg, underwent ITS as described above, using the nonoperated eye as the control eye. The control and experimental intraocular pressures (IOPs) were measured using a pneumotonometer (Digilab Modular One, Richmond, Calif) both preoperatively and on postoperative days 2, 4, 6, and 8. Groups of three rabbits were killed on postoperative days 2, 4, 6, and 8 for histopathologic studies. Before enucleation, the anterior chamber of the experimental eye was injected with India ink to help delineate the sclerostomy track. Tissue samples were then blocked, dissected, fixed in formalin, and immersed in graded alcohols before being embedded in paraffin. Serial sagittal sections, 6 μm thick, were made and stained with hematoxylin-eosin and Masson trichrome stains.
In addition, 10 New Zealand white rabbits underwent standard trabeculectomy. The technique of the trabeculectomy included a limbal-based conjunctival flap and a 2- × 1-millimeter scleral flap. This standard trabeculectomy served as a second benchmark in the evaluation of the ITS procedure.

After an ITS or trabeculectomy was performed, the IOPs for postoperative days 2, 4, 6, and 8 were tabulated. The differences between the IOPs in the operated and control eyes were then calculated. Pressures in the standard trabeculectomy group and the ITS group also were compared. All data were analyzed
for statistical significance using the paired Student's t-test.

RESULTS

The mean differences between the IOP in the control eyes and in the ITS eyes are summarized in Figure 3. As can be seen from the graph, the greatest fall in IOP occurred on postoperative day 2. The pressure then gradually approached preoperative values after day 8. The difference between the mean IOPs of the operated and control eyes was 5.2 mm Hg on day 2, 4.6 mm Hg on day 4, 4.7 mm Hg on day 6, and 2.5 mm Hg on day 8.

Surgical complications included iris burn, peripheral corneal edema, and iritis. These occurred in 23%, 17%, and 9% of the operated eyes, respectively. No ruptured blebs, flat anterior chambers, hyphemas, or lens damage occurred.

The histopathologic findings from a representative postoperative-day-2 eye are shown in Figures 4A and 4B. Figure 4A shows the fistula outlined by India ink and the surrounding coagulative degeneration of the collagen fibers. No corneal or iris damage is apparent. Figure 4B shows a section through the conjunctiva of the same eye. The India ink is seen extending into the conjunctiva and occupying the space between the widely separated collagen fibers. Figures 4A and 4B may be contrasted with Figures 5A and 5B, which show sections taken from a postoperative-day-8 eye. No India ink or patent fistula is apparent in Figure 5A. Instead, the fistula is obstructed by immature fibroblasts. The conjunctiva in the specimen shown in Figure 5B does not have the widely-spaced collagen fibers seen in the postoperative-day-2 rabbit, nor were any corneal or iris changes noted.

The size of the thermal fistulas produced by ITS was measured on the photomicrographs of all day-2 specimens. The mean diameter of the fistulas was 0.22 mm ± 0.08 mm. The necrotic area was likewise determined on the day-2 specimens. The zone of thermal necrosis was easily demonstrated in the histologic specimens by the Masson Trichrome stain. The diameter of this zone was 0.52 mm ± 0.10 mm.

DISCUSSION

Our data indicate that ITS produced significant decreases in IOP up to 8 days postoperatively and that these reductions were significantly (P < .05) higher than those produced by standard external trabeculectomy. Also, the reduction in IOP correlated well with the progressive closure of the fistulas seen in the histopathologic studies; this correlation can be readily appreciated by comparing the histology figures from postoperative day 2 with those from postoperative day 8. As previously noted, the postoperative-day-8 eye had collagen deposits with the fistula, and the conjunctiva had more closely-arranged collagen fibers. This appearance correlated with a return of IOP to control values. This type and rate of wound healing is well recognized in the rabbit model and seems to apply to all filtration procedures.9,10

In our study, the incidences of iris burns and peripheral corneal edema were 23% and 17%, respectively. The relatively narrow angle of the rabbit animal model is well known and probably contributed to an increase in these complications.9

One of the advantages of the ITS approach is that the curved design of the bipolar cautery probe does not require passing the probe across the center of the anterior chamber. This reduces the risk of lens damage and cataract formation, which can result from a straight-instrument design. Also, the procedure poses little risk of bleeding and leaves open the option of repeated operations. Finally, ITS is technically simple to perform and cost effective; only inexpensive and readily-available equipment is needed. These latter advantages could have important implications for glaucoma treatment in third-world countries.

REFERENCES