Averting Tube Trouble

Intraoperative complications.

By James Paauw, MD

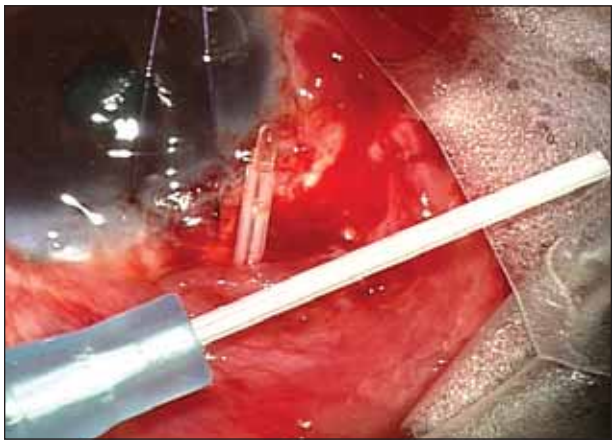
The results of the Tube Versus Trabeculectomy (TVT) Study challenged the traditional mantra to reserve tube shunt procedures for eyes in which trabeculectomy failed or filtering surgery was contraindicated.[1] Surgeons now employ shunts as second-line—or frequently even first-line—incisional options. Most serious complications encountered with trabeculectomies, however, can also occur with tube shunt procedures, and these devices have unique complications of which the surgeon must be aware. Successfully navigating the gauntlet of potential intraoperative complications requires focused attention on each step of the procedure and an understanding of what can go wrong as well as how to avoid and correct it.

GAINING OR LOSING TRACTION

As with most surgery, an early misstep in a tube shunt procedure makes the rest of the case more difficult. A perforating corneal traction suture turns routine surgery into a challenge if the ophthalmologist does not recognize and correct the problem. The gradual ooze may not garner his or her attention initially, but the softening eye risks three complications: lens-cornea touch, perforation of the globe during scleral suturing, and choroidal hemorrhage from hypotony. Replacing an oozing traction suture early minimizes the risk of these miserable consequences.

AVOIDING CLOSING WOES

The conjunctival incision and posterior sub-Tenon dissection are typically uneventful, but remembering that the conjunctiva eventually needs to be closed prompts careful selection of the quadrant. Although a superotemporal location is my default, I pick the quadrant in which I have the best chance of a tight closure. If the patient previously underwent superotemporal surgery, the ophthalmologist must search for virgin conjunctiva elsewhere. When stuck with thin, scarred conjunctiva, however, widening the initial incision and freeing up Tenon capsule more posteriorly often provides enough "real estate" to close at the end.



(Courtesy of Herbert P. Fechter, MD.)

Figure. The surgeon creates an improvised tube extender using a 22-gauge angiocatheter.

PLACING THE PLATE

Whether implanting a valved device such as an Ahmed Glaucoma Valve (New World Medical, Inc., Rancho Cucamonga, CA) or a nonvalved device such as a Baerveldt Glaucoma Implant (Abbott Medical Optics Inc., Santa Ana, CA), the surgeon's failure to place the tube posteriorly enough risks a return trip to the OR. When implanting a Baerveldt device, I put the plate's wings under the rectus muscles to ensure posterior placement and to secure the device in case the sutures break or unravel. The failure to expose the muscles adequately at this point risks entrapment of the Tenon capsule and splitting muscle.

Suturing the plate to the sclera requires patience, especially if exposure is difficult or bleeding obscures the view. Having an assistant dry the blood immediately before placing the suture helps. If there is so much hemorrhaging that electrocautery cannot keep up, the use of gel foam and thrombin will stop the bleeding. A poor view can lead the surgeon to place the fixation suture too deep in the sclera. In the event of a suspected scleral perforation, he or she should remove the needle and immediately correct hypotony with a viscoelastic. If available, intraoperative cryotherapy applied to the region can prevent a retinal detachment. Additionally, a retinal consultation for a sclerally depressed examination is warranted for a suspected retinal break or detachment.

SEVERING THE TUBE

After the plate has been sutured in place, the surgical paths between the implantation of a valved or nonvalved device diverge, and each has unique complications. Forgetting to prime an Ahmed Glaucoma Valve leads to primary failure. Because the Baerveldt is nonvalved, it requires a mechanism to restrict flow, typically tubal ligation with a Vicryl suture (Ethicon, Inc., Somerville, NJ). Tightening the suture too much, however, can sever the tube. A tube extender may work in these cases, but usually, the surgeon's only option is to dissect out the tube and implant a new one. When the preoperative IOP is very high, surgeons frequently fenestrate the tube with needle tracks to allow for interim IOP control before the suture dissolves and the tube opens. This step should be executed with caution, because a side-to-side motion can sever the tube.

INSERTING THE TUBE

The surgeon has trimmed the tube, entered the anterior chamber, and inserted the tube. If it is too short, a tube extender is an option, as described previously[2] (Figure). The angle at which the surgeon enters the anterior chamber balances his or her respect for the cornea with a desire to avoid the iris. A ciliary body hemorrhage or iridodialysis ruins an otherwise great case. If the space between the cornea and iris for the tube's placement is insufficient, the options include insertion into the sulcus space or pars plana, which requires an adequate vitrectomy to avoid blockage of the tube by vitreous. If significant hyphema follows the tube's placement, elevating the IOP by injecting a viscoelastic into the anterior chamber through a paracentesis can stop the bleeding.

STOPPING THE BLEEDING

One of the most feared complications in glaucoma surgery remains the intraoperative choroidal hemorrhage. Avoiding hypotony and precipitous drops in pressure minimizes the risk of this disaster. Steps that hazard hypotony include the placement of the traction suture, the plate's fixation to the sclera, and the insertion of the tube. If a hemorrhage begins to develop, expeditiously closing all incisions and pressurizing the eye minimize the possibility of an expulsive hemorrhage and provide the best prognosis.

CONCLUSION

Tube shunt procedures have inherent intraoperative and postoperative risks. Keeping these in mind during surgery reduces their incidence and prepares the ophthalmologist for battle, should they occur.

James Paauw, MD, is in private practice at Moyes Eye Center in Kansas City, Missouri. He acknowledged no financial interest in the products or companies mentioned herein. Dr. Paauw may be reached at (816) 746-9800; jpaauw@moyeseye.com.

1. Gedde SJ, Schiffman JC, Feur WJ, et al. Three-year follow-up of the Tube Verses Trabeculectomy Study. *Am J Ophthalmol.* 2009;148(5):670-684.
2. Fechter HP, Sarkisian Jr S, Budenz DL, et al. How do I extend a tube? *Glaucoma Today.* January 2009;7(1):37-40. http://bmctoday.net/glaucomatoday/pdfs/GT0109_09.pdf. Accessed September 27, 2011.

Postoperative complications.

By Steven J. Gedde, MD

Tube shunt surgery and trabeculectomy are associated with similar postoperative problems, but unique complications may develop after the former procedure related to the implantation of a foreign material. Although careful surgical technique can minimize the risk of postoperative complications, the clinician's appropriate recognition and management of problems when they do occur are essential to optimizing outcomes.

MOTILITY DISTURBANCES

The reported incidence of diplopia is between 1.4% and 37%, and the occurrence of persistent postoperative strabismus has ranged from 2.1% to 77% in case series of tube shunts.[1] Motility disturbances were investigated prospectively in the Tube Versus Trabeculectomy (TVT) Study. The rate of new-onset diplopia was 5% after the placement of a Baerveldt glaucoma implant (Abbott Medical Optics Inc., Santa Ana, CA), and new motility disturbances developed in 9.9% of patients who were randomized to tube shunt surgery.[1] Transient diplopia is common after tube shunt surgery, but it generally resolves as the postoperative periocular edema improves. Restrictive strabismus may occur because of scarring between the rectus or oblique muscles and the implant[2] or due to a crowding effect from a large bleb that limits extraocular motility.[3] Aqueous suppressants may prove helpful for symptomatic diplopia related to a large bleb. Prism, strabismus surgery, and (rarely) removal of the implant are other treatment options for persistent diplopia.

Intraoperatively, I use a caliper to ensure that I attach the end plate of the device 10 mm posterior to the limbus. I believe this measured distance is particularly important when using the Baerveldt implant, because it prevents crowding of the muscle insertions by the plate

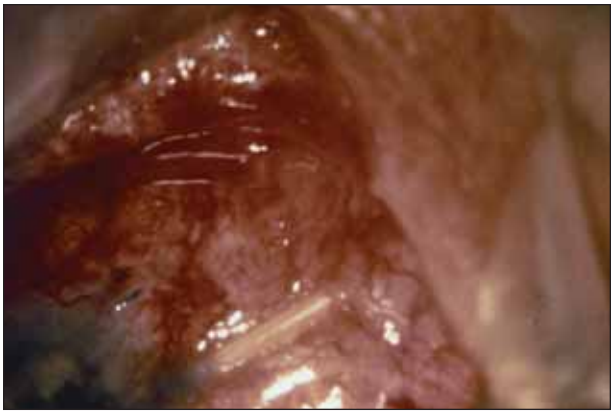


Figure 1. The erosion of a tube.

and may help to reduce the chance of postoperative diplopia. I also avoid the superonasal placement of tube shunts, because it has been described as a risk factor for postoperative motility disturbances.[2]

EROSION OF THE TUBE OR PLATE

Researchers recently performed a meta-analysis of 38 prior studies that included 3,255 eyes of 3,105 patients who received tube shunts.[4] The overall incidence of an exposed tube was 2.0%, with an average rate of exposure of 0.09% per month. No difference in the frequency of exposure was observed between the implants in this study (Ahmed Glaucoma Valve [New World Medical, Inc., Rancho Cucamonga, CA], Baerveldt, and Molteno [Molteno Ophthalmic Limited, Dunedin, New Zealand]). Tube erosion typically develops a few millimeters behind the limbus and may relate to vector forces created at this location when the tube changes direction to enter the eye (Figure 1). I fixate the tube to the sclera approximately 2 to 3 mm posterior to the limbus in an attempt to counteract this vector force, and I am careful to bury the knot of this suture.

I always cover the limbal portion of the tube with a patch graft to minimize the risk of tube erosion. Cornea, sclera, pericardium, and dura mater are all acceptable patch graft materials. Alternatively, various techniques have been described for inserting the tube through a scleral tunnel without a donor patch graft.[5,6] If an eroded tube is detected, prompt surgical repair is indicated. An exposed tube provides a potential route by which bacteria can gain access to the eye, and it is a known risk factor for endophthalmitis.[7] Direct closure of the conjunctiva over the exposed area of the tube is generally inadequate to resolve the problem, and a new patch graft should be placed under a conjunctival flap. I believe that exposure of the plate of a tube shunt is best managed by the removal of the implant and the placement of a new device in a different quadrant. In my experience, plate erosions frequently recur despite attempts at surgical repair.

CORNEAL EDEMA

One of the complications of tube shunt surgery that warrants the greatest concern is corneal edema. Mechanical tube-cornea contact appears to be a major factor contributing to progressive endothelial cell loss, but immune-mediated mechanisms may also be involved. It is important to position the tube well away from the cornea intraoperatively. I much prefer to have a tube touching the iris than the cornea, and I have not encountered problems with chronic iritis due to tube-iris contact. The tube's position can be dynamic such that it intermittently touches the cornea when the patient rubs his or her eye or blinks, especially if the IOP is low.

Localized corneal edema in the region of the tube is best treated by repositioning the tube to a more posterior location. If the space in the anterior chamber is inadequate, the surgeon may position the tube in the ciliary sulcus or pars plana. A complete pars plana vitrectomy with trimming of the vitreous base at the site of the tube's insertion is required for the placement of the tube in the pars plana. Progressive endothelial cell loss with corneal decompensation may necessitate a penetrating keratoplasty or Descemet stripping automated endothelial keratoplasty, and the surgeon should consider repositioning the tube at the time of corneal transplantation.

HYPOTONY-RELATED COMPLICATIONS

Hypotony may develop after tube shunt surgery, along with its associated complications, including choroidal effusions, anterior chamber shallowing, corneal edema, hypotony maculopathy, cystoid macular edema, and suprachoroidal hemorrhage. Valved implants reportedly have a lower risk of hypotony-related complications compared with nonvalved implants,[8] and the former seem especially desirable when aqueous hyposecretion may be present (eg, eyes with uveitic glaucoma or a history of cyclodestruction). Hypotony can still develop in eyes with valved implants, however, due to leakage around the tube or an inadequately functioning valve. I routinely inject balanced salt solution into the anterior chamber at the conclusion of tube shunt surgery to assess the IOP at equilibrium. If the IOP is low after the placement of a valved implant, I will fill the anterior chamber with Healon (Abbott Medical Optics Inc.).

After their introduction, nonvalved implants were associated with a relatively high rate of postoperative hypotony. Surgeons then developed techniques by which to temporarily restrict aqueous flow through the device until encapsulation of the end plate occurred. Methods

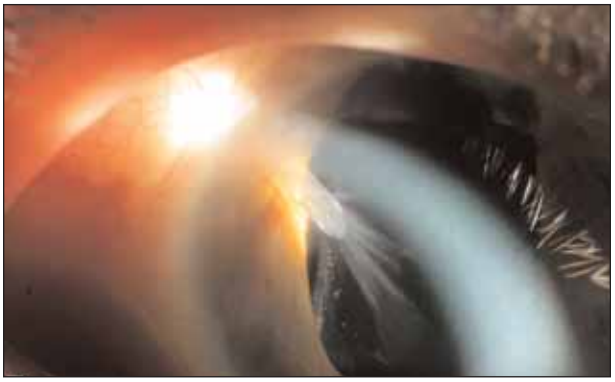

(Courtesy of Donald Budenz, MD, MPH.)

Figure 2. Vitreous has obstructed this tube.

of restricting flow with single-stage implantation include ligation of the tube with a polyglactin or Prolene (Ethicon, Inc., Somerville, NJ) suture or obstruction of the tube with a luminal suture. Alternatively, the surgeon may use a two-stage technique in which he or she first attaches the implant to the sclera. Several weeks later, he or she inserts the tube into the anterior chamber.

I generally ligate the tube with a 7–0 polyglactin suture near the tube-plate junction to achieve a watertight closure. This suture lyses approximately 4 to 6 weeks after surgery. Occasionally, I will open a tube after adequate time has elapsed to allow a capsule to fully form around the plate (a minimum of 4 weeks) with multiple applications of argon laser energy (typically, 25-75 shots) to the polyglactin suture using a Hoskins lens and laser settings similar to those for laser suture lysis after trabeculectomy.

OBSTRUCTION OF THE TUBE

Fibrin, blood, iris tissue, or vitreous may obstruct the distal tip of the tube postoperatively (Figure 2). When the surgeon notices free vitreous in the anterior chamber preoperatively, he or she should perform a vitrectomy at the time the tube shunt is placed to prevent blockage of the tube by vitreous. Intracameral tissue plasminogen activator can resolve obstruction of the tube by fibrin or blood.[9] Using a sterile technique, I remove 0.1 mL of aqueous and subsequently inject 10 µg of tissue plasminogen activator (10 µg/0.1 mL) into the anterior chamber. Laser treatment may be effective at relieving blockage of the tube by iris tissue or vitreous.

ENCAPSULATED BLEB

Uncontrolled IOP after tube shunt surgery may occur secondary to encapsulation of the bleb around the end plate. This complication is analogous to an encapsulated bleb that develops after trabeculectomy, and it is generally treated in a similar fashion with glaucoma medications. Some surgeons have suggested that an encapsulated bleb is less likely to develop if the IOP is maintained in the teens postoperatively. I have therefore become less aggressive about discontinuing glaucoma medications in the early postoperative period after tube shunt surgery. The encapsulated-bleb phase frequently resolves over the course of several weeks to months. In rare cases, I will needle the bleb of a tube shunt (using my same technique for needling an encapsulated bleb after trabeculectomy) if the IOP is refractory to medical therapy. A 43% success rate has been reported after needle revision of tube shunt blebs.[10]

A higher rate of encapsulated blebs (or hypertensive phase) has been observed with valved versus nonvalved implants.[11-13] The immediate filtration of aqueous rich in inflammatory mediators may stimulate the creation of a thicker capsule after the placement of a valved implant, and delayed aqueous flow with nonvalved implants may elicit a lesser fibrotic reaction.

CONCLUSION

The implantation of a tube shunt is a valuable surgical option for select patients with medically uncontrolled glaucoma. Postoperative complications may develop after this procedure, but the early diagnosis and treatment of these problems can minimize their adverse consequences. ❑

Steven J. Gedde, MD, is a professor of ophthalmology at Bascom Palmer Eye Institute in Miami. He acknowledged no financial interest in the products or companies mentioned herein. Dr. Gedde may be reached at (305) 326-6435; sgedde@med.miami.edu.

1. Rauscher FM, Gedde SJ, Schiffman JC, et al. Motility disturbances in the Tube Versus Trabeculectomy Study during the first year of follow-up. *Am J Ophthalmol.* 2009;147:458-466.
2. Christmann LM, Wilson ME. Motility disturbances after Molteno implants. *J Pediatr Ophthalmol Strabismus.* 1992;29:44-48.
3. Ball SF, Ellis GS, Herrington RC, Liang K. Brown's superior oblique tendon syndrome after Baerveldt glaucoma implant. *Arch Ophthalmol.* 1992;110:1368.
4. Stewart WC, Kristoffersen CJ, Demos CM, et al. Incidence of conjunctival exposure following drainage device implantation in patients with glaucoma. *Eur J Ophthalmol.* 2010;20:124-130.
5. Ollila M, Falk Q, Airaksinen PJ. Placing the Molteno implant in a long scleral tunnel to prevent postoperative tube exposure. *Acta Ophthalmol Scand.* 2005;83:302-305.
6. Rossiter-Thornton L, Azar D, Leong J, et al. Graft-free Molteno tube insertion: 10-year outcomes. *Br J Ophthalmol.* 2010;94:665-666.
7. Gedde SJ, Scott IS, Tabandeh H, et al. Late endophthalmitis associated with glaucoma drainage implants. *Ophthalmology.* 2001;108:1323-1327.
8. Tsai JC, Johnson CC, Kammer JA, Dietrich MS. The Ahmed shunt versus the Baerveldt shunt for refractory glaucoma II. Longer-term outcomes from a single surgeon. *Ophthalmology.* 2006;113:913-917.
9. Zalta AH, Sweeney CP, Zlata AK, Kaufman AH. Intracameral tissue plasminogen activator use in a large series of eyes with valved glaucoma drainage implants. *Arch Ophthalmol.* 2002;120:1487-1493.
10. Chen PP, Palmberg PF. Needling revision of glaucoma drainage device filtering blebs. *Ophthalmology.* 1997;104:1004-1010.
11. Tsai JC, Johnson CC, Dietrich MS. The Ahmed shunt versus the Baerveldt shunt for refractory glaucoma. A single-surgeon comparison of outcome. *Ophthalmology.* 2003;11:1814-1821.
12. Ayyala RS, Zurakowski D, Monshizadeh R, et al. Comparison of double-plate Molteno and Ahmed Glaucoma Valve in patients with advanced uncontrolled glaucoma. *Ophthalmic Surg Lasers.* 2002;33:94-101.
13. Nassiri N, Kamali G, Rahnavardi M, et al. Ahmed Glaucoma Valve and single-plate Molteno implants in treatment of refractory glaucoma: a comparative study. *Am J Ophthalmol.* 2010;149:893-902.