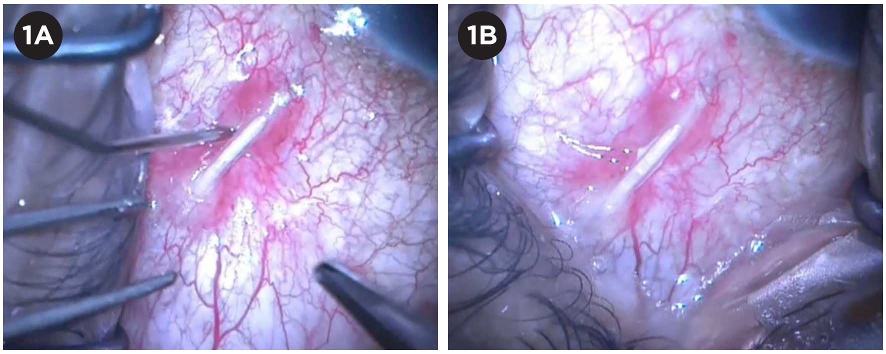
Management of Tube Exposure

The results of the Tube Versus Trabeculectomy Study provided evidence for the use of glaucoma drainage devices (GDDs) in patients with refractory glaucoma or those in whom filtering surgery failed to achieve adequate control of IOP.[1] Such devices include the Ahmed glaucoma valve, Baerveldt, Krupin, Molteno, and Ahmed ClearPath GDDs.[1] These implants consist of a plate with or without a valve, sutured onto the sclera posteriorly, and connected to tubing that enters the globe via the anterior chamber, sulcus, or pars plana. These devices are entirely buried under the conjunctiva and divert aqueous humor to a posterior reservoir bleb, where it is subsequently resorbed through the venous and lymphatic system.

The use of GDDs has had a fourfold increase in the past 20 years.[2] As a result, there has been an increased incidence of GDD-related complications.[1] Tube exposure with overlying conjunctival erosion is an inherent risk of GDDs, given that a foreign object is introduced into the eye. Exposure carries a significant risk for endophthalmitis, reinforcing the need to review the etiology, risk factors, and repair techniques for tube exposure.[3]



SURGICAL REPAIR. *(1A) The first step in surgical repair is identifying the location of tube exposure. (1B) The surrounding conjunctiva is mobilized.*

Etiology

The underlying etiology of conjunctival erosions and subsequent tube exposure is not well understood but is presumed to be a combination of mechanical, inflammatory, or ischemic factors.

Early tube exposure (<3 months after surgery) is attributed to wound dehiscence and high-grade inflammatory response.[2] Notably, a case of early exposure was reported to have responded to oral doxycycline and topical prednisone alone.[2]

Conversely, late tube exposure results from gradual conjunctival erosion caused by mechanical friction and low-grade immune response.[4] One hypothesis is that GDDs are rigid and retain their original shape; thus, as the tube enters the anterior chamber in a curvilinear path, its rigidity creates a constant outward force against the overlying tissue. If there is minimal resistance at the limbal entrance, the tube will tend toward the corneal endothelium. Otherwise, the forces are directed against the conjunctiva, contributing to tube exposure.[1] Other hypotheses are that a combination of change in globe contour and mechanical rubbing of the eyelid margin, as well as smaller orbits, contribute to forces against the conjunctiva.[4] Exposure commonly occurs over the tube, although it can occur over the plate.[3,4]

Rate of Tube Exposure

When GDD surgeries were initially introduced, tube exposure rates were estimated at 30%. In recent years, patch grafts over the tube and scleral tunnels have provided additional barriers that reduce exposure risk to $2.0 \pm 2.6\%$ in the first 26.1 ± 3.3 months.[5] Various factors, however, can increase the risk of exposure.

Risk Factors

The risk factors for tube exposure can be divided into patient and surgical factors, but no risk factor has been implicated with great repeatability.

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Patient factors. Most studies found no association between sex or ethnicity of patient and tube exposure rates.[2] Age is not a proven risk factor for tube exposure among studies of adult population.[2] However, tube exposure rates among the pediatric population may be higher as confounded by repeat surgery, increased eye rubbing, or increased tube mobility. Diabetes and neovascular glaucoma have been proposed to increase tube exposure by means of ischemic factors.[4] And ocular surface disease, although anecdotally contributory, has not been statistically proved to increase rates of tube exposure.[2] Steroid-associated cases of tube exposure have also been reported.[2]

Three of seven studies identified prior ocular surgery as a significant risk factor for tube exposure.[4] However, a large retrospective study (763 eyes) found no statistically significant risk with prior GDD surgeries, although they noted lower exposure rates for primary GDD compared with secondary surgeries (5.8% vs. 13.1%, respectively, during follow-up of 34.0 ± 26.1 months).[2] Prior trabeculectomy has been proposed as a risk factor based on one study of 41 eyes with tube exposure. Antifibrotic agents were used in all of the trabeculectomies, which was presumed to be associated with conjunctival breakdown.[2] A confounding factor in these studies, and for clinical consideration, is that secondary tube surgery is often performed at a less ideal location, for example, inferiorly.[2]

Surgical factors. Although surgical techniques differ for GDD implantation, inferior device placement poses a higher risk of exposure than other locations.[4] The inferior fornix is shorter, with increased mechanical irritation from the lids and makes an optimal zone for bacterial pooling.[4] Conversely, pars plana placement reduced exposure rates in some studies, although assistance from a pars plana clip remains controversial.[4]

The type of GDD has not been established as a risk for tube exposure, based on the Ahmed Baerveldt Comparison Study[4] and a 2010 meta-analysis. Tube exposure was recorded in 37/1,419 eyes with an Ahmed valve versus 8/759 eyes with a Baerveldt.[5] However, the type of patch graft may be an important factor. Current options include human pericardium, sclera, and split-thickness corneal grafts.[2,4] Despite these efforts, there is no current consensus on a gold standard for patch grafts.

Scleral tunnels, an alternative to patch grafts, have been used in primary GDD surgery. Single or multiple partial-thickness scleral tunnels are made parallel to the limbus. These tunnels allow for passage of the tube through the sclera prior to entry into the globe. In a retrospective study of 79 eyes, erosion rates were 2.5% for scleral tunnels versus 7.9% for pericardial patch grafts over 46.7 ± 19.4 months.[6]

Another consideration is concomitant surgeries. Cataract surgeries are commonly performed in combination with GDD surgeries because of the possibility of cataract progression. Two studies reported an increased risk of tube exposure in patients with combined GDD surgeries (cataract and pars plana vitrectomy).[4] In contrast, Hoffman and colleagues reported no cases of tube exposure over an average of 15.4 months in a study of 33 eyes that had combined cataract and Baerveldt implantation.[7]

Complications

Initial presentation of tube exposure can be asymptomatic, but symptoms, when present, include vision loss, pain, redness, tearing, and hypotony, which can be signs of endophthalmitis.[4] Although a rare complication of GDD surgery, endophthalmitis is significantly increased by tube exposure.

Given that tube exposure has been documented up to five years after GDD surgery,[4] patients should have ongoing follow-up to evaluate the state of the plate, tube, and graft; signs of endophthalmitis; and health of the overlying conjunctiva.

Repair of Tube Exposure

Assessment and options. If tube exposure has occurred, an algorithm devised by Lun and colleagues recommends consideration of 1) the presence of concomitant infection, 2) functionality of the GDD, and 3) health of the underlying tissue. These three factors can aid in surgical timing and planning.

In the presence of endophthalmitis, a vitreous sample should be obtained and intravitreal antibiotics initiated. The consensus is that surgical intervention is required; however, timing of GDD removal is controversial.[4] Lun and colleagues suggest that in the absence of infection, spontaneous healing of small defects over the tube can be achieved with topical antibiotic ointments, and careful observation may be considered.[4] Subsequently, the functionality of the GDD should be determined based on the clinical presentation, IOP, and status of the anterior chamber.

The health of the surrounding conjunctiva also dictates whether supplementary techniques are required during closure. The first step involves undermining the surrounding conjunctiva and determining if sufficient healthy conjunctiva is present.[3] Figure 1A shows the site of tube exposure, and 1B shows mobilization of surrounding conjunctiva. Once the conjunctiva has been sufficiently mobilized, significant cautery or dissection of all exposed and undermined sclera must be completed to remove any epithelialized tissue that can lead to repeat exposure.

Management options then include repositioning the implant, patching with a graft, or removing it with or without reimplantation elsewhere.

Removal. In cases of major plate exposure or significant re-exposure risk, complete removal may be advisable. When a GDD tube is removed, the ostomy is often self-sealing. However, if a brisk leak is noted from the site, suture closure, with or without a patch graft, is suggested.[4]

Repositioning or rerouting. In cases of a functioning GDD that will not be removed, tube repositioning has been suggested to avoid surrounding necrotic tissue and to change mechanical vectors that contributed to the original tube exposure.[8] Repositioning options include pars plana placement with concurrent pars plana vitrectomy or sulcus placement. The ciliary sulcus can be expanded with viscoelastic, and the tube introduced 4 mm posterior to the limbus, parallel to the iris, trimmed in a bevel-down configuration.[9]

Alternatively, Nardi and colleagues recommend altering the original track of the tubing. To accomplish this, the surgeon uses a 19-G blade to create a new scleral tunnel 45 degrees oblique to the central axis of the implant plate.[1] A 23-G needle is used to enter the anterior chamber, and the tubing is directed into the new tunnel.[1] The authors hypothesize that the major bending radius reduces the vector forces perpendicular to conjunctiva.[1] Alternatively, to achieve the same effect, the tube can be sutured to the underlying sclera to flatten the curvature of the tube and reduce any mobility and subsequent mechanical rubbing.[4] Huddleston and colleagues recommend use of nylon rather than polyester (e.g., Mersiline) sutures, which increased tube re-exposure rates (via mechanical friction or immunological reaction).[3] Tube extenders are available if tube length is insufficient for repositioning.[8]

Scleral tunnels. Unlike the case of primary GDD surgery, the use of scleral tunnels in secondary surgery may be difficult if the underlying sclera is thinning (e.g., scleromalacia or high myopia) and is not advised.[4]

Patch grafting. Studies show that if a secondary patch graft is not used, there is a twofold increase in rate of subsequent exposure.[4] Some authors hypothesize that using a different type of patch graft from that of the initial surgery eliminates any immune response to the graft that could have contributed to the initial failure.

Once a secondary patch graft is applied, conjunctival closure is required. An intraoperative decision may be needed to determine closure technique in cases of conjunctiva-deficient tube exposure. In order of invasiveness, the options include primary closure, pedicle flap and pull down, conjunctival autograft, and buccal mucosal graft. In 15 eyes that had forniceal conjunctival pedicle flap repair, no recurrence of tube exposure was noted during a mean four-year follow-up period.[3] Alternative options include use of synthetic material such as Ologen[4] or amniotic membranes.[3] Our center uses 7-0 Vicryl suture for final closure.

Conclusion

Given the recent increase in GDD implantation, surgeons should be well versed in managing GDD tube exposure. Every case of tube exposure is the result of a unique interplay of multiple factors, and the surgical repair should be targeted at these factors. Despite best efforts, however, the risk of re-exposure following repair remains 44% at 36 months based on some studies.[10] As such, patients with tube exposure require long-term follow-up and early, aggressive intervention to prevent devastating outcomes such as endophthalmitis.

1 Nardi M et al. *Eur J Ophthalmol.* 2021;31(2):778-781.

2 Bains U, Hoguet A. *Semin Ophthalmol.* 2018;33(1):1-10.

3 Huddleston SM et al. *J Glaucoma.* 2013;22(6):433-438.

4 Lun KW et al. *Clin Exp Ophthalmol.* 2022;50(7):781-792.

5 Stewart WC et al. *Eur J Ophthalmol.* 2010;20(1):124-130.

6 Kugu S et al. *Semin Ophthalmol.* 2015;30(1):1-5.

7 Hoffman KB et al. *Ophthalmology.* 2002;109(10):1916-1920.

8 Liu WW et al. *J Glaucoma.* 2020;29(7):604-606.

9 Kang JM et al. *Case Rep Ophthalmol Med.* 2020;2020:6878025.

10 Bouris E et al. *J Glaucoma.* 2023;32(6):489-496.

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