Considerations During Glaucoma Drainage Implant Procedure


Dr. Paul A. Sidoti, USA


Dr. Steven J. Gedde, USA


Dr. Sirisha Senthil, India


Dr. Christopher C. Teng, USA


Dr. Davinder S. Grover, USA


Dr. Joseph F. Panarelli, USA


Dr. Arsham Sheybani, USA


Dr. Sonal Dangda, USA

The decision to choose between various glaucoma surgical procedures involves weighing the risks and benefits to the patient. Although preferred practice patterns vary among glaucoma specialists, evidence based medicine in the form of several multi-center clinical trials helps guide glaucoma surgeons to make the best possible decision for their patients. The landmark trial of Tube versus Trabeculectomy (TVT) study compared the two most commonly performed glaucoma filtration procedures in patients with previous intraocular surgery. This trial helped glaucoma specialists to understand the effectiveness and safety concerns of either procedure and take a better informed decision. At 5 years, although both procedures were associated with similar intraocular pressure (IOP) reduction and use of supplemental medical therapy, additional glaucoma surgery was needed more frequently after trabeculectomy with MMC than tube shunt placement. The latest Primary TVT study is a way forward in the same direction and will provide valuable information regarding these two procedure in patients with medically uncontrolled glaucoma and no previous intraocular surgery. In PTVT at one year, trabeculectomy with MMC has been reported to have a higher surgical success rate but more frequent serious complications producing vision loss or requiring reoperation than tube shunt surgery. Similarly, trials between the valved Ahmed glaucoma implant and the non-valved Baerveldt implant have given valuable data about surgical success and safety concerns of each device. In India, the advent of Aurolab Aqueous Drainage Implant (AADI) which is a based on the prototype Baerveldt 350mm^2 implant, has widened the options that we can offer to our patients. As we look at the results of these trials and see what's new on the horizon, it is essential to understand how these clinically impact our patient care and decision process. We asked a panel of imminent glaucoma specialists about their decision-making process, as regards glaucoma drainage implants (GDI) in the various subtypes of glaucoma and the operative considerations with each device.

(PAS): Dr. Paul A. Sidoti, *MD, Professor of Ophthalmology,* Icahn School of Medicine at Mount Sinai; Site Chair, Department of Ophthalmology, New York Eye and Ear Infirmary of Mount Sinai; Director, Glaucoma Service, Mount Sinai Health System, New York City, NY, USA.
(SG): Dr. Steven J. Gedde, *MD, Professor of Ophthalmology,* Bascom Palmer Eye Institute, Miami, Florida, USA.
(SS): Dr. Sirisha Senthil, *MS, FRCS, Consultant and Head,* VST Centre for Glaucoma Care, L V Prasad Eye Institute, Kallam Anji Reddy Campus, L V Prasad Marg, Hyderabad, India.
(CT): Dr. Christopher C. Teng, *MD, Director, Glaucoma, Associate Professor of Ophthalmology and Visual Science,* Yale University School of Medicine, New Haven, CT, USA.
(DG): Dr. Davinder S. Grover, *MD, MPH, Attending Surgeon and Clinician*, Glaucoma Associates of Texas Dallas, Texas, USA.
(JFP): Dr. Joseph F. Panarelli *MD, Associate Professor of Ophthalmology,* Icahn School of Medicine at Mount Sinai, Associate Residency Program Director, Glaucoma Fellowship Director, New York Eye and Ear Infirmary of Mount Sinai, New York City, NY, USA.
(AS): Dr. Arsham Sheybani *MD, Assistant Professor of Ophthalmology,* Advanced Anterior Segment and Glaucoma Surgery, Washington University School of Medicine, St. Louis, Missouri, USA.
(SD): Dr. Sonal Dangda *MS, DNB, FICO. Research Fellow (Glaucoma)*, New York Eye and Ear Infirmary of Mount Sinai, Icahn School of Medicine, New York City, NY, USA.

SD: How often in your clinical practice do you perform a GDI procedure?

PAS: This is the most common surgical procedure performed in my glaucoma specialty practice. Many of my referred patients have advanced glaucoma and have often undergone prior surgical procedures for glaucoma and other ophthalmic conditions.

SG: Placement of a GDI is one of the most common surgical procedures I perform in my tertiary referral glaucoma practice.

SS: I do 3-4 GDI procedures per week.

CT: I have a referral glaucoma practice, with many complex and advanced glaucoma cases. I would estimate that approximately 40% of my glaucoma surgeries involve a glaucoma tube implant.

DG: I typically perform GDI several times a week. However, the frequency that I need to depend on tube shunts have substantially decreased following the evolution of angle surgery and other minimally invasive subconjunctival filtration procedures.

JFP: 5-7 per week.

AS: 3-5 cases per week.

SD: What is the patient profile you prefer for GDI procedure over Trabeculectomy?

PAS: My choice between trabeculectomy and GDI has shifted in the direction of GDI during my 25 years in clinical practice. This has as much to do with my clinical experience as well as the results of several well-designed clinical trials. I still prefer trabeculectomy as a primary glaucoma procedure in phakic or pseudophakic patients who require a very low postoperative IOP such as those with advanced disc damage or low-tension glaucoma (LTG). Additionally, phakic patients with an anterior chamber angle that is compromised by peripheral anterior synechiae (PAS) (leaving inadequate room for safe tube placement) and without a visually significant cataract are often better candidates for a trabeculectomy than a GDI.

SG: I prefer to use a GDI over trabeculectomy in those patients who are at increased risk of filtration failure. This includes patients with high risk secondary glaucoma, (i.e., neovascular glaucoma (NVG), uveitic glaucoma, iridocorneal endothelial syndrome (ICE), and fibrous/epithelial ingrowth) and eyes with conjunctival scarring from prior ocular surgery, trauma, or cicatrizing diseases (i.e., Stevens Johnson syndrome (SJS) and ocular cicatricial pemphigoid). I also favor GDI surgery in patients with severe posterior blepharitis and contact lens (CL) wear, because of the increased risk of bleb-related infection with filtering surgery in these groups. Additionally, the TVT Study provides strong evidence to support the use of GDIs in eyes with prior cataract extraction and/or failed filtering surgery, a lower risk population than has traditionally had GDI surgery.

SS: Majority of my indications for GDI are secondary glaucoma eyes, specially those with multiple previous intraocular surgeries or scarred conjunctiva. In eyes with primary glaucoma, failed primary trabeculectomy or failed repeat filtering surgery is an indication for GDI.

CT: There are various considerations for me in electing to perform GDI over trabeculectomy. I consider patient's age, ethnicity, glaucoma disease level, IOP, prior incisional surgery history, social situation, ability to take eye drops, ability to return for postoperative visits, distance residing from my office, etc. If the patient is elderly and lives independently, has difficulty coming for postoperative visits, or cannot instill eye drops, I may consider a GDI over a trabeculectomy. I try to tailor my decisions for each patient's situation, and make the best informed decision for them. Before choosing a surgery, I think, what would be the best for this patient?

DG: Despite the MIGS (minimally invasive glaucoma surgery) revolution, GDI and trabeculectomy surgeries are not going away. However, we are able to depend on these two surgeries less often to treat surgical glaucoma. There are a several patient profile where I believe GDI are essential. First, GDI are a tremendous help in patients with a pro-inflammatory environment, such as NVG, Uveitic glaucoma and traumatic glaucoma. Second, in patients with prior corneal transplant surgery (full or partial) ideally with the GDI in the sulcus or far away from the endothelium. Third, in patients that are younger where angle surgery has failed and I am concerned they will have a very active subconjunctival fibrotic reaction. Fourth, in patients who have failed a prior trabeculectomy. Fifth, in patients that are aphakic and at high risk for a suprachoroidal hemorrhage (SCH). In these patients, I will perform a GDI with a rip-cord to allow complete control over when I want the tube to start functioning. Sixth, in patients who do a lot of outdoor work or recreation with a lot of dirt or dust that would put them at high risk for a blebitis. Seventh, in patients who need to return to physical activity very quickly. Again, in these patients, I will perform a GDI with fenestrations and a ripcord. This approach will allow the patient to return to work within a week and then schedule time off in 2-3 months where we can open the tube in clinic. Eighth, in patients with ICE syndrome, posterior polymorphous dystrophy (PPMD) or epithelial down growth. In these group of patients, I am careful to keep the tube away from the cornea and keep the tube relatively long. This is not intended to be an all inclusive list of patient scenarios but more a general guide one when I feel GDI are best indicated.

JFP: Nearly all! I prefer trabeculectomy in patients who are in need of a very low IOP like, those progressing with Normal tension Glaucoma (NTG) or phakic patients with chronic angle closure glaucoma (CACG) who need a lower IOP and do not have a visually significant cataract.

AS: The patient profile I prefer for GDI is IOP > 21mmHg on maximum medications on presentation, prior failed trabeculectomy or tube, those travelling from long distance, and patients with poor compliance, uveitis and NVG.

SD: Do you consider primary GDI procedure as the first option in patients with primary glaucoma, both open (POAG) and closed angle (PACG) cases?

PAS: Primary GDI surgery is a consideration in patients with all varieties of primary and secondary open-angle glaucoma. I use this more commonly in patients who require low postoperative pressures because of moderate to advanced disease and have significant risk factors for failure of trabeculectomy due to episcleral scarring. Young patients, darkly pigmented patients, patients who have undergone prior intraocular or conjunctival-incising surgery, and those with complex secondary glaucoma such as neovascular and uveitic would be included in this group.

I also consider a GDI as a primary glaucoma surgical option in pseudophakic patients with CACG, assuming there is adequate anterior chamber depth for anterior chamber tube placement well away from the cornea. If high PAS preclude safe tube positioning in the anterior chamber, placement in the ciliary sulcus is a consideration in some patients. For phakic patients with CACG and no prior incisional ocular surgery, I prefer a trabeculectomy as an initial glaucoma surgical procedure.

SG: I generally prefer trabeculectomy over GDI surgery as an initial incisional glaucoma procedure in patients at low risk for surgical failure, including eyes with POAG and PACG. However, I favor initial GDI surgery in patients who are poorly compliant with medical therapy and follow-up, even if they have primary glaucoma. The success of trabeculectomy critically depends on the use of postoperative topical steroids and frequent follow-up visits in which laser suture lysis (LSL) and 5-FU injections are commonly performed. A patient who is unlikely to seek prompt medical attention in the setting of a bleb-related infection is a poor candidate for trabeculectomy. I will recommend placement of a GDI if the patient had a poor outcome with trabeculectomy in the fellow eye (e.g. bleb-related infection or hypotony maculopathy). I avoid trabeculectomy in patients who are dependent on CL because of the associated risk of bleb infection, and GDI surgery is a desirable alternative.

SS: I do not prefer GDI over trabeculectomy in eyes with primary glaucoma. In eyes with primary glaucoma with associated co-morbidities like severe ocular surface disease or lid pathology, I would avoid trabeculectomy, hence if there is a need for incisional surgery in these eyes, GDI would be the choice.

CT: I have certainly performed GDI as a first line option in many patients and do consider it to be an effective first line option. Given the many innovative and new options in performing glaucoma surgery, there are many considerations that have to be made when choosing a glaucoma surgery. One consideration is the level of disease. For a mild to moderate case, there may be better options than a GDI.

DG: In certain situations, yes. In angle closure, my first priority would be to remove the lens and open the patient's angle to see if we can enhance their native outflow pathways before creating a new one. If patients with both POAG and PACG have some of the features as the patients described above, I will consider a primary tube. However, the results of the 1-year PTVT study have really caused me to re-assess my surgical decision-making prior to placing a GDI in POAG patients without prior surgery.

JFP: I will perform a "primary" GDI in patients with all types of POAG, especially if they have a high starting IOP. For PACG patients who have not had primary incisional ocular surgery, I prefer to start with a trabeculectomy though I have recently begun using the Xen Gel Stent in select cases.

AS: I consider primary GDI in POAG cases if the IOP $\geq$ 21mmHg and PACG only if angle is still closed after phacoemulsification.

SD: Has the TVT study changed your acceptability of the GDI procedure as a primary surgery?

PAS: For me, the TVT study provided good evidence for the relative efficacy and safety of GDI surgery over trabeculectomy in patients who have undergone limited prior intraocular surgery. It confirmed my clinical impression regarding outcomes of GDI surgery versus repeat trabeculectomy in patients with prior failed trabeculectomy. It also provided good evidence for the relative safety and effectiveness of GDI surgery in pseudophakic patients who have not undergone prior glaucoma surgery. For both of these patient groups, the information provided by TVT has made me more likely to pursue GDI surgery over trabeculectomy.

SG: The TVT Study found that GDI surgery had a higher rate of surgical success compared with trabeculectomy with MMC in patients with previous cataract and/or failed filtering surgery. The TVT Study supports the use of GDIs in a less refractory population than had historically undergone this procedure. However, it is important to note that all patients in the TVT Study had undergone prior ocular surgery, and study results cannot be extrapolated to dissimilar patient groups (i.e. previously unoperated eyes). The Primary Tube Versus Trabeculectomy (PTVT) Study is an ongoing multicenter randomized clinical trial (RCT) that is similar in design to the TVT Study, but enrolled patients without prior incisional ocular surgery. In contrast to the TVT Study, the PTVT Study found a higher success rate with trabeculectomy with MMC compared with GDI after 1 year of follow-

up. However, trabeculectomy with MMC also had a higher rate of early postoperative complications and serious complications producing vision loss or requiring reoperation.

SS: The results of TVT Study have not changed my practice pattern in primary glaucomas or pseudophakes with no prior conjunctival surgeries. Trabeculectomy is still my preferred first surgery in these eyes. However, in eyes with primary glaucoma with early failure of trabeculectomy or pseudophakes with conjunctival scarring or disturbed anterior segment (synechiae, variable AC depth, misaligned IOL), I prefer GDI.

CT: TVT is an important study that demonstrated that tube shunt surgery with a Baerveldt had a higher success rate compared to trabeculectomy with MMC, in patients who had previous trabeculectomy and/or cataract extraction with IOL implant (CEIOL). In these subset of patients at 5 years of follow up, the IOP was similar, as were the number of glaucoma medications. The failure rate was higher in the trabeculectomy group as were the number of reoperations. While the TVT study did not directly study GDI as primary surgery, I feel it has had influence on the increase in the number of GDIs being performed in relation to trabeculectomy.

DG: I think both the TVT and the PTVT studies have had a major impact on how we treat surgical glaucoma patients with open angle glaucoma. Overall, we are less reluctant to place a GDI, as a primary procedure if we think the surgery is best for the patient. Prior to the results of the TVT and PTVT, many surgeons were reluctant to place a GDI unless the patient had failed multiple incisional glaucoma surgeries (multiple trabeculectomies in most cases). Now, thanks to the hard work and dedication of Dr. Steven Gedde and the entire TVT and PTVT research teams, surgeons can place these GDI in specific patients as a primary procedure with confidence in the long-term safety and efficacy of tube shunts.

JFP: The TVT study showed us that we can achieve lower IOPs in patients that are at lower risk for failure. The biggest change for me is with my pseudophakic patients who have not had prior glaucoma surgery. Though many would still perform a trabeculectomy here, the data shows that GDI is associated with greater success.

AS: It has not. PTVT has patients with IOP > 21mmHg and I favor GDI over trabeculectomy in these patients.

SD: Between the valved Ahmed glaucoma implant (AGV) and the non-valved Baerveldt glaucoma implant (BGI), which is your primary preference? What are the patient characteristics which tilt your decision in favour of one as compared to the other? Have the Ahmed-Baerveldt comparison studies influenced your decision in the above regard?

PAS: I prefer the AGV model FP-7 in a few select groups of patients who are at risk for chronic hypotony due to aqueous hyposecretion. Specifically, for patients over the age of 75 years with pseudoexfoliative glaucoma (PXG), NVG or Uveitic glaucoma, I now routinely use this device. I also use the AGV in most patients over the age of 80 years. For younger patients who may also be at risk for aqueous underproduction, I prefer to use a BGI with a relatively small end plate (model BG103-250; 250 mm^2). For most other patients in whom I am using a GDI, I prefer the 350-mm^2 BGI.

SG: The Ahmed Baerveldt Comparison (ABC) Study and Ahmed Versus Baerveldt (AVB) Study are landmark randomized clinical trials comparing the safety and efficacy of the AGV and BGI. These trials have provided valuable information to guide implant selection. The design and results from both trials are remarkably similar, allowing each study to validate the other. The BGI was more effective in lowering IOP, but the AGV had a more favorable safety profile. I prefer a 350-mm^2 BGI in patients with advanced glaucoma and those who are poorly compliant or intolerant of medical therapy, given its ability to achieve lower IOP with fewer medications. I favor the AGV in patients with marked IOP elevation, as the implant reliably produces immediate IOP reduction. I also select the AGV for patients with Uveitic glaucoma and eyes that have undergone prior cyclodestruction/ cyclophotocoagulation (CPC), as the valve helps to prevent postoperative hypotony in patients at higher risk for this complication.

SS: Valved shunts achieve an immediate IOP drop and have less risk of postoperative hypotony. However, they are associated with higher percentage of hypertensive phase, need for glaucoma medications and long-term failure. While, with non-valved implants, the postoperative course is slightly more complex. Initial high IOP needing medications in the early postop, hypotony after the ligature suture dissolves with its attendant complications if not recognized and treated appropriately, hence needing close and frequent follow ups. However, they have less hypertensive phase, less need for antiglaucoma medications and better long-term success. AGV is my preferred choice in most cases. Specifically, I would prefer AGV in eyes Post keratoplasty, vitrectomized eyes, high myopes, very old patients, uveitic patients, PXF, poor follow up, if other eye had hypotony with non-valved device, nanophthalmos, post Keratoprosthesis (K-Pro) eyes and those needing early IOP control. Baerveldt implant was not available in India and hence our experience with non-valved implants is limited. Since the availability of the Aurolab Aqueous Drainage Implant (AADI) which is similar to the BGI, over 4 years, our indications for non-valved implants have slowly evolved from eyes with failed AGV to considering them more often in refractory childhood glaucomas and adult glaucomas. Apart from the indications mentioned, I would prefer a non-valved implant only if postoperative follow-

up is possible for the patient with us or any other local glaucoma specialist and in those eyes with severe allergy to anti-glaucoma medications (as post-AGV we may still need medications in the long term which they may not be able to use). The other consideration is definitely the cost, as the AADI is available at close to ¼ the cost of AGV.

CT: There are many nuances to both valved and non-valved surgeries. I have been using the valved implants more often. The decision depends on similar characteristics as I mention above, such as pathology of disease, IOP, social situation, etc. If a patient lives far away or live independently, I typically choose a valved implant because I find that there may be fewer postoperative interventions needed. These patients may not be able to come for frequent follow ups, and the techniques used in non-valved implants to restrict flow typically would involve more visits to tailor the IOP. These could involve pulling a ripcord, lasering a ligating stitch, or waiting for the ligating suture to dissolve. Once one of these steps is performed, the patient may follow up visit a few days later to check the result. In a non-valved implant, hypotony is a serious consideration that I make sure to follow up on once the tube is opened. For valved implants, no manipulations are needed, though patients may be more susceptible to hypertensive phase, where there is a rise in IOP, and may need to be on glaucoma medications during that time. I have been fortunate to participate in humanitarian projects, and in these settings, if a patient needs a glaucoma implant, I perform a valved implant, because there may not be adequate follow up, and I can be more confident in an early term uncomplicated course. ABC study showed that the BGI may have a lower failure rate, and lower mean IOP in the long run, but had a higher risk of hypotony.

DG: I think the Ahmed-Baerveldt studies were a great addition to the literature and further gave doctors evidence regarding decision making in glaucoma surgery. I applaud and am grateful to all the authors involved in both of these studies (ABC and AVB as well as the combined study) for providing us high quality evidence to help us make better decisions for our patients. We are seeing more and more tube associated hypotony, especially in older patients. My tube of preference, if I can control the IOP for a reasonable amount of time in my young patients would be a 350 BGI and in my patients over 75 years old would be a 250 BGI. If the IOP is very elevated and I know that I cannot watch the IOP for the next 4-6 weeks, I will then place an AGI FP7. In patients that need an AGI FP7 (eg. NVG patients who typically have a very high IOP), I will tell them that they may need another surgery to control their IOP once the eye is more stable. I depend heavily on low energy CPC/Diode laser after a first tube to provide better IOP control. Since I have incorporated this approach into my practice over the past 5 years, it has dramatically decreased the number of second tube shunts that I place in an eye.

JFP: I prefer the AGI in patients with NVG, PXG, and Uveitic glaucoma. For all other cases I prefer a BGI, either with a 250mm^2 or 350mm^2 endplate, depending upon the age of the patient. For older patients, I prefer the smaller implant.

AS: I perform a Molteno implant. Our data show similar IOP and medication reduction compared to BGI-350, which we are publishing soon. I choose AGV in patients with increased chances of hypotony though my preference is non-valved implants.

SD: What are the operative considerations during placement of the GDI plate?

PAS: Posterior placement of the GDI plate is critical to optimal functioning of the device and limiting complications. I prefer to place the plate at least 10 mm posterior to the limbus in the superotemporal and inferotemporal quadrants and 9 mm posterior to the limbus inferonasally. This positions the plate well posterior to the rectus muscle insertions. Placement of the end plate in this location enhances function by allowing for better capsule development and aqueous flow and minimizes complications associated with anterior plate positioning such as strabismus, discomfort and conjunctival erosion.

SG: The quadrant for GDI placement is generally made preoperatively, but occasionally intraoperative findings (e.g. extensive conjunctival scarring or scleral ectasia) may direct the surgeon to a different quadrant. I generally prefer the superotemporal quadrant for GDI implantation, but the inferonasal quadrant is my second choice. However, in eyes with silicone oil, I will place the tube inferiorly in case oil migrates into the anterior chamber. In the presence of scleral thinning, the end plate can be attached with tissue glue or sutured to the rectus muscle insertions to avoid scleral sutures. The tube should be positioned away from the corneal endothelium. If I'm not satisfied with the tube position intraoperatively, it's easy to create a new needle track adjacent to the first one.

SS: Based on the indication and the condition of the eye, I choose the type and location of implant placement. I prefer superotemporal mostly followed by inferotemporal location. I prefer limbal based conjunctival incision, 5-6 mm behind the limbus; this allows smaller conjunctival incision size of 5-6 mm, helps easy identification of the muscles, easy insertion and fixation of the implant, less dependent on an assistant for exposure and allows quick and easy conjunctival closure. I prefer plate fixation 9-10 mm from the limbus with 9-0 prolene suture. I prefer a scleral tunnel 3-4 mm from the limbus for tube insertion. The tube length if in AC is around 2 mm. If in sulcus it is longer and depends on the pupil size. If in the anterior chamber, I prefer the tube placement parallel to the limbus. However with sulcus placement, I prefer the tube perpendicular to the limbus so that the tube tip

is visible beyond the pupillary margin. The entire tube length is covered by the scleral patch graft. I use fibrin glue and additional 10-0 nylon sutures sometimes. The closure of conjunctiva is with 8-0 vicryl in a continuous fashion (I use 8-0 vicryl on a round bodied needle).

CT: Adequate dissection is important. I like to identify the muscle edges, which serve as a landmark for me to suture the plate. If doing a large plate that sits underneath the muscles, there must be good dissection, and the muscles must be isolated with a muscle hook. My placement of the plate is roughly 7-8mm posterior to the limbus, which is essentially at the edge of the muscle insertions. This allows for needling of the plate if needed later on. If the plate it too far back, it may be more difficult to access. Additionally, if the patient has a thick tenon's capsule, I will perform a tenonectomy, which I find will decrease the thickness of the capsule that forms over the plate.

DG: There are several considerations. The first, which has been previously answered above, is tube or no tube. Once we decide that a GDI is the best for the patient, the next immediate question is which one. The GDI's I currently use routinely are Ahmed valve (FP7 and FP8), Baerveldt 250mm^2 and 350mm^2, as well as the Molteno implant 185mm^2 and 245mm^2. If the IOP is very high and I do not think I can wait 4-6 weeks for the tube to open, I will consider an FP7. If I am concerned about long-term hypotony, I aim to use the smallest plate size possible (FP8 if IOP very high, BGI 250 or Molteno 185 if the IOP not too high). If I do not want to (or cannot) isolate the muscles during the surgery, for example in a patient with a previously placed scleral buckle, then I will use an implant that does not require muscle isolation (Molteno or Ahmed valve). Lastly, the patient's age is a key factor. We know that with age, the aqueous production slowly decreases and we are starting to see more and more tube associated hypotony (as stated above). I therefore will err on the side of the smallest plate possible in patients who are in their 80's or 90's.

JFP: I prefer that the muscles are cleanly dissected (with either implant) and the implant secured 10 mm posterior to the limbus. This encourages better flow and I believe decreases the incidence of strabismus.

AS: I make the traction suture centered along the planned peritomy. Ensure that you make the peritomy large enough to where you don't tear tissue. If placing a BGI 350, which goes under muscle at least 8mm back, the front of the plate should run parallel to the tangent of the limbus so that tube inserts without a significant bend.

SD: What are the operative considerations during tube placement in the anterior chamber (AC), sulcus and pars plana? What special precautions do you consider in post-corneal transplant patients?

PAS: For AC tube, placement just anterior to and parallel with the iris is ideal. While some contact with the iris is generally well tolerated, this should be avoided if possible. The tube should have an anterior bevel at its proximal tip and should lie between the pupillary margin and the limbus. Sulcus tubes should be positioned just anterior to and parallel with the intraocular lens (IOL). The proximal ostium should be beveled posteriorly to avoid iris incarceration and the tip should be seen at the time of insertion to ensure proper placement (above the IOL) and following pupillary dilation. Pars plana tubes should also be visualized at the time of surgery to ensure that there is complete insertion into the vitreous cavity and that the proximal ostium is not obstructed by residual vitreous gel. I prefer to bevel the tip posteriorly with pars plana tubes. For patients who have undergone prior PK, I prefer to place the tube deep in the AC making sure that the trajectory of the tube is parallel with the plane of the iris or angled slightly posterior. I prefer to keep the tube relatively short, with the tip extending no more than 2 to 3 mm from the limbus as visualized through the cornea. Sulcus placement is also a good option for some patients, although there is little evidence supporting the benefit of a sulcus tube over a well-positioned AC tube. Pars plana placement should be considered when concurrent pars plana vitrectomy (PPV) is required for other reasons or there is inadequate room or other contraindications to AC or sulcus positioning.

SG: I will generally insert the tube into the AC, as long as there is adequate space. If there are concerns that the tube may be positioned too close to the cornea in a phakic eye, concurrent lens extraction (especially with a visually significant cataract) will provide more AC space. In eyes with endothelial dysfunction or prior corneal transplantation, I position the tube as far away from the cornea as possible. This commonly involves sulcus placement in pseudophakic eyes. The tube is cut with an anterior bevel when inserted into the AC and with a posterior bevel when placed in the sulcus, which serves to prevent obstruction by iris. Alternatively, the tube may be inserted through the pars plana. However, a complete PPV with trimming of the vitreous base is required if the tube is placed in the vitreous cavity.

SS: I prefer the tunnel and tube entry with a 24 G needle, in few eyes with thin and stretched sclera (specially in children) I prefer 26 G needle entry. This prevents peri-tubular leak and snugly fits the tube entry hence preventing postoperative hypotony. I trim the tube after the needle entry and always trim bevel up. When tube entry is difficult, I tend to reverse the tube tip (bevel down) which helps in easy entry, once inside the eye I rotate it bevel up. Always do this only in vitrectomized eyes or else plan PPV with pars plana tube entry. In Post-PK/DSEK eyes, if the AC depth is good, I place the tube in the AC, prefer a shorter tube taking precautions not to place it closer to the graft. In virectomized eyes or eyes with with extensive

PAS or very shallow AC, a sulcus placement or pars plana tube is preferred.

CT: For AC, the angle of entry is important. The tube entry needs to be parallel to the iris, and not touching the iris or cornea. I teach my fellows to identify the entry point of the sclerostomy with the 23G needle, then look away from the microscope and at the surgical field, at a macro level view, in order to visualize the angle of entry. Due to rotation of the globe, the needle could be over or under tilted, and this may not be apparent when looking though the microscope. If this is the case, I ask them to make an adjustment to the angle of entry, and once the angle is noted to be parallel to the iris, then I instruct them to make the sclerostomy. For pars plana placement, I instruct fellows to not point the needle too radial. The entry should be slightly directed posterior but not radial. This is to ensure that after the surgery, the tube may be visualized readily at the slit lamp, so the doctor can check for patency and to ensure it is not plugged with vitreous. In corneal transplant patients, the tube would ideally be as far away from the cornea as possible. If the patient has had a corneal transplant and is pseudophakic, ideally the tube will be placed in the sulcus. Alternatively, a PPV may be performed and the tube may be placed in the pars plana.

DG: I do my best to keep the tube slightly long so that the tip is near the iris border. I also aim to try and place the tube as close to the iris (and as parallel to the iris) as possible. If I place the tube in the sulcus, I will often leave the tube in the visual axis and have never had a patient report that they can see the tube. In my patients with a PKP, I am very careful to keep the tube as far away from the cornea as possible and will often place the tube in the sulcus. In patients with corneal surgery, I also like to keep the tube slightly longer in case it is inadvertently cut during a repeat PKP or in case it needs to be redirected. Again, my first priority would be to keep the tube as far away from the cornea as possible. Unless there is a specific reason for me to place a tube combined with my retina colleagues (in the setting of a K-pro for example), I will not usually place the tube in the pars plana. In patients with NVG, I purposefully keep the tube long. These patients tend to have PAS and the iris is often traumatized during tube placement. If the tube is too short or just in the angle, one can often get a blood clot over the tube and a severely elevated IOP on postoperative day #1.

JFP: For AC tubes, I prefer the tube deep in the AC, resting just above the iris. For sulcus and pars plana placement, I always make sure I can see the tip clearly before I close the conjunctiva. In fact, for sulcus placement, I prefer to touch the tube tip with a cannula to be sure it is in the proper spot (Not the pars plana!). For post PK patients, I prefer sulcus placement of a GDI. Whether I place an AGV or BGI, I try to leave the eye fairly well pressurized at the conclusion of the case to avoid postoperative bleeding. Often a precipitous drop in IOP will lead to significant bleeding from the needle track and this can result in early tube occlusion and obstruction. Pars plana placement is a reasonable option for these patients but it does require more surgery and if the patient becomes hypotonous, it is much harder to manage given the posterior location of the tube. Injections of viscoelastic to re-pressurize the eye are not as helpful in these cases.

AS: We still place it in the AC but the goal is to be posterior. Sulcus placement is not as consistent as some report and there is a risk of bleeding if you hit the ciliary body.

SD: What are the special considerations with GDI procedure in glaucoma post-vitreoretinal (VR)? How do you plan the shunt placement in cases with a scleral band/buckle (SB)?

PAS: For eyes that have undergone prior PPV, placement of the tube through a pars plana scleral fistula is a reasonable option. If the prior PPV was not performed with the intent to place a tube in this location at a later date, careful preoperative evaluation should be performed to determine whether additional vitrectomy is required at the time of tube insertion. Removal of the posterior hyaloid membrane (which often detaches following PPV) and additional trimming of the anterior vitreous base may be required to prevent postoperative occlusion of the tube. Ocular hypotony (as often occurs following tube ligature release with non-valved GDIs) can be more difficult to manage with a tube placed in the posterior segment. Injections of viscoelastic to re-pressurize the eye are less effective in these patients as the viscoelastic does not have direct access to the tube tip and adds less to tamponade of the tip and resistance to aqueous flow as it does with AC tubes. For eyes that have an encircling band, I position the end plate over the band and secure it directly to the band with 8-0 nylon sutures as the band generally sits 10-12mm posterior to the limbus. I use a BGI in these situations as the lower profile of this device (compared with the AGV) facilitates insertion and conjunctival closure with less risk of postoperative erosion. When using a 350-mm^2 BGI, I attempt to dissect scar tissue and place the wings of the device beneath the muscles. If this is not possible (as is more common with wider encircling bands), I place the wings over the muscles. For patients where silicone oil cannot be removed, AC placement of the tube is required. If the pupil is large and the eye is aphakic, it is best to place the tube inferiorly to minimize the risk of contact with the anterior silicone meniscus. In pseudophakic patients with a relatively intact iris diaphragm and small pupil, the tube can be placed superotemporally, leaving the intraocular portion long to reduce the risk of emulsified silicone oil draining into the tube.

SG: Eyes that have undergone a PPV may have tube insertion though the pars plana. However, a complete vitrectomy is needed because any residual

vitreous may lead to tube obstruction. I prefer the BGI in eyes with a retinal band/buckle, given the low profile of the device. If a radial element is present, this quadrant should be avoided. Sufficient posterior dissection is performed between the sclera and Tenon's capsule to allow the implant to seat comfortably over the rectus muscles. In cases where the band is located anteriorly, the end plate can be sutured to the band. If the band is positioned more posteriorly, the implant is placed over the band. I excise the capsule overlying the band in the quadrant of GDI implantation. This may allow contiguous encapsulation of both the encircling band and Baerveldt plate. Studies suggest that the degree of IOP reduction is proportional to the surface area of the capsule.

SS: Special considerations in these eyes are conjunctival scarring, thin sclera, limited space, silicon oil in eye and predisposition to recurrent retinal detachment (RD). In eyes with multiple previous VR surgeries and scarred conjunctiva, trabeculectomy may not be possible and GDI with posterior subconjunctival drainage have a definite role to play. Placing an implant in these eyes is technically challenging due to the space constraint. The preoperative planning includes choosing the location for the implant placement and selection of implant type. The extent, position and height of the buckle need to be identified to decide the site of placement of the GDI. It is ideal to avoid the quadrant where the buckle is anteriorly placed due to the difficulties in fixing the plate. In an anteriorly located belt buckle, GDI can be fixed 8 mm from the limbus, behind the buckle. In posterior buckle, the implant can be placed over the encircling band and sutured to the capsule or directly to the buckle. In the presence of segmental buckle, it is better to choose a quadrant where the scleral band is absent. If the conjunctival scarring is extensive, a pediatric implant is chosen or an adult implant can be trimmed appropriately to ensure adequate and free conjunctival closure. It is better to avoid dissection in areas with thin sclera and also to avoid excising the buckle or disturbing the buckle. Also preoperatively, adequate IOP control is mandatory to avoid sudden decompression. In cases of silicone oil filled eyes, inferior implant placement would be preferred. In case of eyes post-silicone oil removal, or floating bubbles, one can choose any site as appropriate. In these eyes I prefer a pediatric AGV (FP8) which is safer in a space constrained situation to avoid implant exposure and its related complications.

CT: In a patient with a scleral buckle, the plate can typically be sutured to the encircling element, which serves as a nice suturing platform. One consideration is to check to be sure the patient does not have lagophthalmos prior to the GDI placement, because putting a plate over an encircling element could worsen it and lead the patient to have cornea exposure. If the patient has some lagophthalmos, then I recommend an inferonasal placement of the GDI. If a patient with silicone oil in the eye has elevated IOP and the oil is unable to be removed, then I recommend inferior placement of the tube. This is because if the oil migrates from the pars plana into the AC, it will rise, and if the tube is placed in the superior position, it may become blocked with oil. If the tube is inferior, the oil will rise within the AC and the tube will not get occluded.

DG: Eyes with prior PPV are at increased risk for SCH when the tube opens. I therefore tend to change my technique in these eyes when performing non-valved implants and place a rip cord (4-0 nylon through the tube, tucked in the inferior subconjunctival space and tied off near the plate with a 7-0 prolene suture). This technique allows me to use fenestrations to temporarily lower the IOP but more importantly, it allows me to have complete control over when I open the tube. The tube opens when I want it to open. I can therefore open the tube in clinic, place a drop of atropine in the eye and have the patient sit in the waiting area for an hour. I sometimes inject viscoelastic into the AC at the slit lamp if the IOP is too low and I am very concerned about developing a SCH. I also make sure the patient limits their activity strictly for the first week once the tube opens. This approach theoretically allows me to further decrease the chance of a SCH and maximize safety outcomes. In eyes with a prior scleral buckle, I suture the plate to the buckle and do not attempt to isolate the muscles. I usually place a Molteno implant (the largest possible, depending on the anatomy) knowing that if I need further pressure lowering, I can always follow up with a low energy CPC/Diode.

JFP: For eyes that have an encircling band, I prefer to use a BGI (often 250 mm^2 due to tight space) and I will routinely secure the implant to the SB if it sits 10-12mm from the limbus. This requires extensive dissection but often leads to better long-term results with less chances of erosion. Due to the high profile of the AGV, I find it challenging to place above the SB and safely close the conjunctiva. I also find the AGV tend not be as successful in these patients due to the higher risk of encapsulation with additional hardware on the eye. For eyes with or without a SB that have silicone oil which cannot be removed, I will use an AGV. To ensure that the oil stays back, I will fill the eye with Healon GV and I prefer the AGV in these cases as it will filter the viscoelastic more easily than a BGI that relies on a wick or fenestrations to lower the IOP in the early postoperative period.

AS: With a buckle, we use a BGI-250 and sometimes cut the plate to size. If there is significant scarring, consider placing the tube from a tube extender into the fibrotic band around the buckle.

SD: What are the special considerations in patients with Uveitic and Neovascular glaucoma?

PAS: Given the concern with compromised ciliary body function in ischemic eyes with NVG or in eyes with chronic uveitis, my preference is to use a 250-mm^2

BGI. In patients with more severe disease or over the age of 75 years, an AGV may be preferable due to the presence of a flow-restricting mechanism at the distal end of the tube and the smaller surface area of the end plate. These features provide additional protection against hypotony in the early and late postoperative periods, respectively. Good control of the underlying disease is important in these patients. For patients with NVG, adequate panretinal photocoagulation (PRP) and treatment with anti-VEGF agents prior to GDI surgery is recommended. Control of uveitis with topical, intraocular and systemic steroids and other immune-modulating agents prior to glaucoma surgery is critical. Ongoing postoperative management of ischemic retinal disease and uveitis in appropriate patients is essential.

SG: I prefer to use an AGV in patients with Uveitic glaucoma and NVG. Patients with uveitis are more prone to hypotony, and the flow restrictor in this valved implant minimizes the risk of postoperative hypotony. NVG is frequently associated with marked IOP elevation, and a valved implant reliably provides immediate IOP reduction. The rate of progression to No Light Perception (NLP) vision was twice as high in the Baerveldt group compared with the Ahmed group in the ABC Study, providing compelling evidence to support the use of an AGV in patients with NVG.

SS: Valved implants are preferred in these cases. There are no other special precautions. Meticulous surgery is needed to avoid trauma to the iris and to avoid bleeding and inflammation.

CT: I frequently see patients with NVG. Often, they also have advanced cataracts. In these situations, I almost always perform a cataract surgery and valved implant. At the end of these cases, I leave a moderate amount of viscoelastic in the AC to guard against potential hypotony and potential for hemorrhage. In these cases, when the IOP goes from a preoperative very high level to postoperative low level, there is a possibility of choroidal effusions and potential for hemorrhage. I find that retaining viscoelastic in the AC guards against this. In uveitic cases, I favor valved implants to guard against the possibility of hypotony in the long term.

DG: These patients tend to have severely high IOP and are at very high risk of developing hypotony afterwards. I typically will place either an AGI FP7 or a small non-valved implant (Molteno 185) if I can, depending on the preoperative IOP. In some patients with aggressive inflammation, I may consider even placing an AGI FP8.

JFP: For both of these cases I prefer an AGV. For uveitic, the only consideration I have is to ensure that they are on the proper steroid regimen as dictated by their uveitis specialist. For NVG patients, I try to have their retina specialist inject an anti-VEGF agent 3 days prior to tube shunt placement. During the surgery, I am especially careful to keep the tube off the iris and preform a more anterior placement if necessary. Any contact with the iris, whether it is with the 23G needle used to create the tube entry site or the tube itself, can result in bleeding. I will leave the eye with a full viscoelastic fill at the completion of the case and inject Kenalog (triamcinolone) into the sub-tenon's space to limit the amount of postoperative inflammation.

AS: Caution should be taken in a patient with active neovascularisation or a hyphema, we prefer diode CPC here as there is a significant risk of a larger hyphema if the IOP drops after a tube shunt. In uveitis, we inject dexamethasone in the sub-conjunctival space.

SD: Do you routinely use patch grafts to cover the tube? If so, what is your preferred choice of graft material and how much portion of the tube do you cover?

PAS: I routinely use a patch graft to cover the anterior portion of a GDI tube and the limbal (or pars plana) insertion site. This is done to minimize the risk of conjunctival erosion with exposure of the tube. My preferred patch graft material is VisionGraft human corneal allograft (Tissue Banks International) oriented with its long axis parallel with the path of the tube to cover the anterior 5 to 6 mm of the tube. The clarity of this tissue permits visualization of the underlying tube and allows LSL of the tube ligature if positioned beneath the graft.

SG: A low incidence of tube exposure has been reported with tube insertion through a long scleral tunnel without a patch graft. I insert the tube through a 4-5 mm scleral tunnel, but I also place a patch graft over the limbal portion of the tube to further minimize the risk of tube exposure. I generally use cornea as the patch graft material because it is transparent and cosmetically superior to sclera or pericardium. It is particularly important to use a corneal patch graft with inferior GDI placement, as the lower lid covers less of the graft compared to the upper lid with superior GDI implantation.

SS: Yes, I do use patch graft in all cases. I prefer preserved donor sclera. I use it cover the entire subconjunctival tube length including anterior to the tube entry up to the limbus. I use fibrin glue to fix it and also supplement with 10-0 nylon suture anteriorly, if needed. In all children supplemental sutures are given. I use half thickness corneal patch graft in very limited cases like, in young patients if they have a cosmetic requirement.

CT: I routinely use a cornea patch graft to cover the tube. I use a half portion of cornea to cover the tube and it typically covers about 5mm of the tube course.

DG: I routinely use partial thickness corneal tissue to help avoid tube erosions as I feel it is very durable and also is much more cosmetically appropriate than sclera or pericardium. There are more and more studies showing very good success when placing the tube through a long scleral tunnel and under a scleral flap, thus avoiding the need and

expense of a patch graft. I think patch free approach is very attractive but have not incorporated it into my practice as I still feel that in the United States, using a patch graft is considered the standard of practice. Moreover, I know that it is helpful and is very unlikely to be harmful. Additionally, I still place the tube through a 3mm scleral tunnel and aim to enter the AC as close as I can get to the 12 o'clock position. I feel lid coverage helps decrease the risk of tube exposure.

JFP: I use VisionGraft to cover all of my tubes and orient it in a "D" fashion to cover as much of the tube as possible.

AS: Yes, I use tutoplast sclera. We cover the portion from the limbus to just beyond the insertion into sclera.

SD: What is your preferred technique for tube occlusion during the early postoperative period in non-valved (BGI) implants? What measures do you consider for IOP control during that time? Would you prefer to add oral carbonic anhydrase inhibitors (CAIs) for IOP control postoperatively in these patients?

PAS: My preference for tube occlusion at the time of BGI implantation is a single, external, 7-0 polyglactin suture. I position this ligature 5 to 6 mm anterior to the front edge of the end plate so that it is easily visualized for release postoperatively (following encapsulation of the end plate), using an argon or green diode (532 nm) laser. In my hands, a single fenestration through both walls of the tube using a 10-0 polyglactin suture needle and leaving a segment of suture through the fenestration to act as a stent has proven to be the most consistent technique for achieving some aqueous egress and IOP reduction in the immediate postoperative period. Topical medications are generally used to supplement IOP reduction while the tube is ligated. Oral CAIs are sometimes used, despite their side effects, to optimize for IOP control during this period.

SG: Unlike valved implants, non-valved implants require a temporary restriction of aqueous flow with tube ligation or occlusion until encapsulation of the end plate occurs. This serves to minimize the risk of postoperative hypotony. I ligate the tube with a 7-0 polyglactin suture near the tube-plate junction, and I place 1-3 fenestrations just anterior to the tube ligature using a TG-140 needle (Ethicon). I have found that tube fenestration is an effective way of providing IOP reduction in the early postoperative period. However, fenestrations generally begin failing a few weeks after surgery, and I frequently will need to add glaucoma medications prior to opening of the tube. An oral CAI is a viable option if topical glaucoma medications are not sufficient, although there is an added risk of significant hypotony with tube opening. An orphan trabeculectomy at the time of GDI placement is an alternative approach for early IOP control. If I need reliable, immediate IOP lowering in the setting of markedly elevated IOP, I will generally choose a valved implant.

SS: Double ligature with 6-0 vicryl suture and ensuring complete tube blockade is my preferred technique. I use postoperative anti-glaucoma medications (AGM) including oral CAIs for IOP control (if they can tolerate). I also use tube fenestrations proximal to the tube ligation for early postoperative IOP control in non-valved devices.

CT: For BGI, I use a tube ligation with a 7-0 vicryl. I fenestrate the tube with 3-4 passes with the 7-0 needle to provide a slow flow until the suture dissolves, typically in 5-6 weeks. If the IOP is elevated during the period before suture dissolution, I find that topical glaucoma medications work sufficiently. In rare cases, an oral CAI may be needed. Occasionally, I will ligate the tube with a 7-0 prolene, which can be lasered at the slit lamp. This enables a more controlled opening of the tube that the doctor can dictate. Prior to lasering the suture, I place 1 drop of atropine. Using a Ritch lens and an argon laser, the prolene can be lasered. One consideration in doing this is that it is important to tie the suture knot on the underside of the tube. This can be achieved by turning the implant upside down, then tying the suture. This will ensure that the argon laser goes through a single line of prolene, rather than a dense knot. Additionally, if the IOP is too low after the laser opening, viscoelastic may be injected at the slit lamp, to protect against hypotony.

DG: In my routine cases, I tie the tube off near the plate with a 7-0 vicryl suture. I then perform 3-6 fenestrations with the needle on the 7-0 vicryl suture. In patients who are on blood thinners, have undergone a PPV, come from a long distance away, or those that need to get back to work as soon as possible, I will consider using the ripcord technique that I have described above. Using a rip cord approach gives me complete control over when the tube opens and maximizes safety in this high risk group of patients. If needed, I will use an oral CAI, however, my goal is to avoid starting my patients on oral medications. If the patient has a severely elevated IOP and I am concerned that I may not be able to keep the IOP controlled with aggressive fenestrations during the immediate post-op period, I am much more likely to consider a valved implant.

JFP: I occlude the BGI with a 7-0 polyglactin suture. For early IOP control, I use a 10-0 polyglactin suture on a cutting needle to make a fenestration and leave a strip of suture material going through the fenestration to act as a stent to allow for aqueous to egress out.

AS: I use a vicryl suture. We do prefer 1-2 slits but this is not very titratable as others describe. Around 4-5 weeks if the IOP is dangerously high despite all medications we can consider LSL. For early severe IOP elevations we can create slits through the tube at the slit lamp using 7-0 vicryl needles.

SD: What measures do you consider during tube opening in BGI? How often do you encounter hypotony post-tube release and how do you prefer to manage it?

PAS: I feel that it is best to release the tube ligature in a planned fashion so that measures can be taken to minimize the occurrence of hypotony and its related complications that frequently follow initiation of flow into the drainage reservoir. It is generally safe to release the ligature between the 3rd and 4th postoperative week as adequate capsule formation has occurred by that time. If the IOP is well controlled, I will frequently wait until the 5th postoperative week to release the ligature. After week 5, the risk of spontaneous release of the 7-0 polyglactin ligature increases significantly. Depending on the IOP level, I ask the patient to discontinue some or all of their glaucoma medications 2 to 3 days prior to ligature release so that the aqueous suppressant effect begins to dissipate before the tube is opened. Immediate, profound reduction of the IOP frequently occurs following ligature release as fluid from within the eye fills the reservoir of the BGI. If the IOP drops below 8 mm Hg, especially in patients at high risk for SCH, I prepare the eye with 5% betadine and administer an AC injection of a cohesive viscoelastic agent via a 30 gauge needle at the slit lamp. This viscoelastic maintains the AC depth, elevates the intraocular pressure and provides some temporary resistance to aqueous flow through the tube. All glaucoma medications are discontinued and, in phakic patients, 1% atropine is added twice daily. I also increase the frequency of topical corticosteroid as an increase in intraocular inflammation, sometimes with fibrin formation, generally accompanies ligature release. The patient is asked to return to the office within 48 hours. Occasionally, the viscoelastic injection needs to be repeated to allow the eye more time to equilibrate at a lower IOP level.

SG: I have found that a 7-0 polyglactin suture ligating a tube will reliably lyse about 5-6 weeks postoperatively. A sudden drop in IOP increases the risk of SCH, and I instruct the patient to avoid bending, lifting, and straining during this period. I follow patients closely around the time a tube is expected to open. I will occasionally open a tube with argon LSL (laser settings: 50 microns, 500 mW, 0.02 seconds) when the IOP is significantly elevated and/or the patient is using multiple glaucoma medications, as it is beneficial to know the exact time of tube opening. A visible separation of the suture is not seen (as with LSL of a nylon flap suture following trabeculectomy), but the eye will become noticeably softer when the suture is successfully cut and a bleb will form over the end plate.

SS: Close follow up in the early postoperative period until about 3 months. I stop oral Diamox by 5 weeks and topical AGM by 5-6 weeks based on the level of IOP. I also step up the topical steroids and cycloplegics during the time the ligature is likely to open (by 5-6 weeks) to treat the inflammation and prevent hypotony and its associated complications. Hypotony is common but not all develop hypotony related problems. I see this in close to 30% of eyes and majority resolve with topical medications. I have had to intervene for prolonged hypotony in about 5% of eyes with tube stenting using 3-0 or 4-0 nylon. Hypotony induces inflammation which further worsens hypotony, hence that vicious cycle needs to be broken.

CT: Hypotony certainly may occur after suture dissolution. I prepare the patient for this by having them stop the IOP drops at week 5, and I tell them that they may feel a sensation in the eye, indicating the tube opening. I have them come back at week 6, and if the tube is open and the IOP is in the low single digits, then I may start cycloplegics to protect the eye from developing choroidals. If there is a shallow AC with or without choroidals, then I will consider anterior chamber reformation at the slit lamp with viscoelastic.

DG: My goal is to keep the tube closed for as long as possible, especially when using the rip-cord technique. When I tie off the tube with a vicryl suture, I see the patient around the time that I think the tube will open and place a drop of atropine in the eye. I also will taper and eventually stop all glaucoma drops around the time that I expect the tube to open. During this phase, I still have the patients on topical steroids at least 4 times a day. In the case of persistent hypotony after the tube opens, I usually put the patient on atropine at least BID. I also keep the patient on topical steroids 4-6 times/day. If the patient has significant hypotony with large choroidal detachment (CD) or tube corneal touch or lens-corneal touch, I will reform the eye, at the slit lamp, with a viscoelastic. If the choroidals are persistent despite this conservative treatment, I will consider draining the choroidals in the operating room. In extremely rare cases, I have to revise or remove the tube shunt.

JFP: I will release the polyglactin ligature in the office at postoperative week 4-5 for high-risk cases (previous hypotony in the other eye, high myopia, aphakia, etc.) and fill the eye with a cohesive viscoelastic right after to ensure that the IOP does not drop and remain too low. For all other cases, I follow the patient weekly after week 4 and will begin to remove any topical IOP medications that the patient is on if the IOP allows. For certain phakic patients, I will begin Atropine as well. If the IOP is low but the eye is stable, I will not intervene. When the IOP is low and either the AC shallows or choroidal effusions begin to develop, I will inject viscoelastic into the AC to slow the flow though the tube (works better for AC or sulcus tubes). If the IOP remains low and the effusions worsen despite multiple viscoelastic injections, I will return to the operating room to drain the effusions. Re-ligation

of the tube with downsizing of the implant is rarely needed but I will do this if the patient does not appear to have adequate encapsulation as evidence by B-scan ultrasonography.

AS: Hypotony can be transient in most cases but 5% can have a prolonged course. Treatment is usually conservative with atropine unless there is lens endothelial touch. In those cases we fill with cohesive viscoelastic, the amount varies based on the hypotony and AC depth.

SD: How can we identify and manage the hypertensive phase? Is it seen with both valved and non-valved implants?

PAS: The "hypertensive phase" commonly occurs with both flow-restricted and non-flow-restricted devices. It is defined by elevation of the IOP despite aqueous flow into the capsule of the GDI. B-mode echography can be useful in distinguishing this phenomenon from IOP elevation due to occlusion of the tube. I have found that the hypertensive phase tends to be more frequent and greater in magnitude with the AGV as compared with the BGI. Regardless of the device, management should be directed at aqueous suppression to reduce the IOP, thereby reducing surface tension on the fibrous capsule surrounding the end plate which is an important stimulus to increased fibrosis, capsule thickening and reduced permeability to aqueous outflow. In fact, I have found that early aqueous suppression following endplate encapsulation and ligature release is helpful in minimizing the occurrence and magnitude of hypertensive phase IOP elevations. I will start topical aqueous suppressant therapy when the IOP rises to between 12 and 14 mm Hg after ligature release in patients with a BGI, especially if they have advanced disc damage. I maintain topical corticosteroid therapy.

SG: A hypertensive phase is commonly seen after GDI surgery and usually develops a few weeks postoperatively. In this condition, the capsule surrounding the end plate is less permeable to aqueous humor resulting in IOP elevation despite tube patency. The hypertensive phase after GDI surgery is felt to be analogous to the encapsulated bleb phase often observed after trabeculectomy; both are treated with aqueous suppressants and frequently resolve over time due to tissue remodeling as part of the wound healing process. Early initiation of treatment with aqueous suppressants has been shown to reduce the likelihood of a hypertensive phase and improve surgical success with GDI surgery. A hypertensive phase may occur with valved or non-valved implants, although the incidence appears to be higher with valved implants. Aqueous humor rich in inflammatory mediators is delivered to the end plate immediately after surgery with valved implants, while non-valved implants have a delayed drainage of aqueous humor to the end plate after ocular inflammation has subsided. This has been offered as an explanation for the higher rate of hypertensive phase with valved implants compared with non-valved implants.

SS: Hypertensive phase is more commonly seen with valved implant in 50-60% eyes (in my cases). This problem can be significantly decreased by starting topical aqueous suppressants in the early postoperative period. We typically start aqueous suppressants when the IOP is around 8-10 mmHg. Hypertensive phase is not common with non-valved implants and in our experience it is seen in around 27-30% eyes. We do not use prophylactic AGM in non-valved implants, as it is short lived, and treat cautiously with aqueous suppressants for limited time of 3-4 weeks during which time the hypertensive phase resolves. In my experience, I have seen delayed hypotony when hypertensive phase is treated aggressively in eyes with non-valved implants, hence shorter duration AGM along with topical steroids are preferred with close monitoring of IOP. I prefer to stop the glaucoma medication once the hypertensive phase resolves except in less than 10% eyes where it may need to be continued.

CT: Hypertensive phase may be seen in both types of implants. Typically, the IOP rises above goal, in which IOP lowering drops should be started to blunt the increase. The etiology may be continued wound modulation at the plate. This phase will typically pass once the patient is restarted on IOP lowering drops. If the IOP is elevated and sustained, then a plate needling with 5-FU injection can be performed at the slit lamp.

DG: The hypertensive phase is definitely seen in both valved and non-valved implants. In valved implants, I start the patient on timolol 0.25% usually around the 2-3 weeks point, which typically coincides, with the point in time when the IOP is slowly starting to increase. In non-valved implants, I will start timolol typically 2 weeks after the tube opens. I think the hypertensive phase is related to aggressive steroid use but feel that steroids are essentially to control inflammation and allow the eye to recover appropriately from surgery. I only consider tapering the steroids when the AC is completely quiet after the tube has opened.

JFP: This is commonly seen with both AGV and BGI implants. Once the IOP goes above 16 mm Hg, I will begin topical IOP lowering medications. I do not alter my steroid regimen but treat depending upon the degree of inflammation present.

AS: I treat IOP > 12mm Hg with medications. After tubes open, they can still have a hypertensive phase. Both implant types can get it.

SD: What is the routine postoperative medication regimen you consider? Is the duration of anti-inflammatory medications same in both procedures?

PAS: Following GDI surgery, I start my patients on 1%

prednisolone acetate 8 times/day or difluprednate 6 times/day and maintain this through the period of ligature release (for BGIs) or plate encapsulation (for AGVs). I then taper these medications based on the degree of intraocular inflammation with the goal of discontinuing by 3 months after the surgery. For patients in whom I am concerned about the possibility of excessive inflammation or the ability to comply with the postoperative eye drop regimen, I administer a posterior sub-Tenon's injection of 40 mg of triamcinolone acetate at the conclusion of the surgery. I also use a topical antibiotic for the first 3 postoperative weeks. In phakic patients and those at high risk for hypotony-related complications, I use 1% atropine eye drops until the tube is functional and the IOP has stabilized.

SG: My standard postoperative medical regimen after GDI surgery consists of a topical antibiotic 4 times daily for 1 week and a topical steroid 4 times daily for approximately 2 months, followed by a steroid taper over the subsequent month. An increased AC reaction is universally seen when a non-valved implant opens, so I usually do not begin a steroid taper until after tube opening. Glaucoma medications are used depending on the postoperative IOP level, and the frequency of steroid administration may be modified based upon the inflammatory reaction observed.

SS: For AGV, I give topical steroids for 3-4 weeks, cycloplegics for 2-3 weeks, AGM (aqueous suppressants) after 1st week. I step up the AGM during hypertensive phase. For AADI, early postoperative AGM need to be continued based on the IOP. Mostly low dose steroids and cycloplegics are needed. As the ligature opens up in AADI/ BGI around 5th to 6th week, the steroids are stepped up, cycloplegics are restarted (to treat the inflammation) and anti-glaucoma medications are stopped to avoid hypotony. Steroids are slowly tapered in eyes with non-valved implants over 2-3 months.

CT: I use prednisolone 4 times a day for at least 1 month; I begin to taper it off after then. Occasionally, for patients that may develop aggressive scarring, I may leave them on Prednisolone 1 drop a day for the long term. I use the same regimen in both valved and non-valved implants. I use cycloplegics as needed, and will use difluprednate if the the inflammation is severe.

DG: In valved implants, I leave a small amount of viscoelastic in the eye and place a drop of atropine on the eye after the surgery to protect against immediate postoperative hypotony. I aggressively treat with predisolone acetate 4-6 times a day depending on the case. I will sometimes give a subtenon's injection of 40mg of kenalog in the operating room as well. In non-valved implants, I fenestrate as much as I think is safe to help control the IOP until the tube opens. I place the patient on prednisolone acetate 4 times a day until almost a month after the tube opens. During this time, I treat the IOP as indicated. Around the time that I suspect the tube to open, I will place a drop of atropine in the patient's eye. I will usually taper the prednisolone down to once a day and may keep my patients on a topical steroid drop once a day for 3-6 months.

JFP: I often will give a sub-tenon's injection of kenalog at the time if surgery and begin difluprednate on postoperative day #1. I continue this 4 times a day for 3 weeks and then drop to 2 times a day for another 3 weeks. I will taper off over the next month depending upon the inflammation noted.

AS: I treat with steroids QID until the tube opens since it can cause a robust inflammatory reaction. Otherwise, I taper steroids after the vicryl sutures on the conjunctival closure absorb.

Compiled by:
Dr. Sonal Dangda
Research Fellow (Glaucoma),
New York Eye and Ear Infirmary of Mount Sinai,
Icahn School of Medicine,
New York City, NY, USA