Trabeculectomy - revisited

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Evolution of the procedure

The seminal importance of the intraocular pressure in pathogenesis of glaucoma led to a wide variety of surgical procedures being devised to reduce the intraocular tension. These procedures evolved over a period of time to the trabeculectomy, which has stood the test of time the longest. William Mackenzie, in 1830, suggested a sclerotomy to relieve tension. By 1854 he preferred using a paracentesis. Luis de Wecker, pupil of the great Von Graefe, first suggested the idea of a filtering cicatrix and developed the anterior sclerotomy (using a Von Graefe knife puncture counterpuncture and an incomplete Von Graefe ICCE incision leaving a bridge of conjunctiva at the superior limbus – effective temporarily till healing occurred). Col. Robert Henry Eliot, superintendent of the Madras Eye Hospital - the present Regional Institute of Ophthalmology, Chennai, developed and popularized his corneoscleral trephine, further improving on the filtering scar concept. Felix Lagrange in 1907 combined a sclerectomy with an iridectomy and established a more permanent filtering scar. Cairns in 1968 described a new concept of partial thickness filtering procedure – trabeculectomy. Thus it took one and a half centuries for the basic concept to evolve. Further refinements are still being developed.

Type of surgery and mechanism of action

It is a guarded filtration procedure. This means that a partial thickness scleral flap lends resistance to flow of aqueous from the anterior chamber to the sub conjunctival space (Figure1). There is a basal peripheral iridectomy to deal with any pupillary block component and more importantly prevent the underlying iris from plugging the trabeculectomy osteum by excising it. Quite often the surgical osteum is anterior or includes more than just the trabecular meshwork and hence the term filtering surgery is more accurate in description. But the good old name has stuck.

Indications

The only real indication is medically uncontrolled glaucoma. The target intraocular pressure for that patient is not achieved with medications that the patient can tolerate and can afford for chronic therapy.

In Chronic angle closure glaucoma with more than half the angle closed by synechiae used to be an indication, but now with more options among medicines for IOP reduction one can put in a PI and try medical therapy for IOP reduction. Having said this I know that medical
therapy fails and we have to opt for surgery more often in angle closure and secondary glaucomas when compared to primary open angle glaucoma.

**Procedure**

The patient is worked up as for any intraocular procedure and informed consent obtained. The anaesthesia can be monitored local anaesthesia or general anaesthesia depending on age and patient's ability to cooperate.

Preparation and draping is as for any intraocular procedure. Superior quadrants are preferred for trabeculectomy as inferior quadrant filtering blebs are notorious for infections. Exposure is obtained by a speculum and a traction suture (a Superior rectus bridle suture or a 5-0 silk corneal limbal suture). A clear corneal paracentesis is done slowly to prevent a supra choroidal haemorrhage if IOP is high, both to decompress the globe and for ease of entry later to reform the AC. The conjunctival incision can be limbal (fornix based flap) or 7-8mm behind limbus (limbus based flap) to expose sclera of 5mm square. If antimitotic is to be used, one can use the same in a sponge at this stage. Light cautery is used for haemostasis and a one third to half thickness scleral flap is fashioned in a shape of the surgeon's choice (Square or triangle) till clear cornea is reached in the bed of the flap where a rectangular window is cut out (anatomically this would be at the limbus anterior to Schwalbe's line). A basal peripheral iridectomy is done via this osteum to prevent iris tissue from blocking it. Now apposing sutures are put at the apices of the scleral flap to close it lightly (not tightly). The conjunctiva is closed.

**Factors determining IOP after surgery**

As any glaucoma surgeon will swear, the post operative IOP after glaucoma surgery is determined mostly by factors beyond our control (even supernatural). But then there are a few factors we can use to our advantage to adjust resistance to flow of aqueous and thereby the IOP.

**Lateral overlap**

The overlap of the flap from the edge of the excised block is usually less to the side than to the flap's posterior edge (Figure 2). Thus the resistance to flow of aqueous is less laterally than to the posterior edge. This distance therefore determines the resistance to filtration. Most surgeons who use triangular flaps also excise rectangular blocks in the bed. Here the least resistance would be determined by the distance from the apex of the block to the side of the triangle. Thus if one uses a 4mm wide rectangular scleral flap and a 3mm block excision the lateral overlap would be the same as a 3mm flap and a 2mm block excision i.e., half a millimetre on either side. Theoretically both should have the same resistance to flow of fluid. (In practice the bigger scleral flap has a slightly higher resistance).

**Flap Thickness**

If the flap is thinner the filtration is more. Ideally the flap should be one third to half scleral thickness. Less than this and the flap will overfilter through it like a sieve. And a thicker flap will snugly fall back in the depression from which it was dissected and seal the wound fully.

**Sutures**

The next determinant for IOP would be the scleral flap closure. Sutures at the apex / apices of the flap, i.e., the corner sutures, are more effective in closure than subsequent sutures. If these are too tight they work as efficient sutures closing the flap tightly and the IOP will rise. Subsequent sutures, in between, have less of an effect on filtration in comparison to the apical sutures. So if a releasable suture is used or if a suturolysis is done it should be an apical suture to achieve reasonable pressure adjustment.
IOP in immediate post op

If in the immediate post op period the IOP is low then the aqueous inflow is decreased by the ciliochoroidal detachment. This means less fluid goes through the trabeculectomy osteum to maintain the bleb in the immediate post op period. This would cause the bleb to heal into a small or flat bleb. Eventually, when the aqueous inflow picks up the IOP would go up and out of control.

Healing

Healing or fibrosis is the biggest determinant in late post operative IOP. Sub scleral flap and subconjunctival fibrosis cause the resistance to flow after a trabeculectomy (Figure 3). Of these two the subconjunctival fibrosis contributes maximally. To maximally control this we need to understand the factors that contribute to increased fibrosis.

Factors contributing to increased tissue fibrosis

Tissue Priming

Conjunctiva can be primed to react more to injury by long term topical therapy. Though pilocarpine and adrenaline are the most notorious, beta blockers are not exempt. Drop preservatives are also blamed in reduction of goblet cells and other changes in fibroblast phenotype that cause exaggeration of healing response. Thus very early treatment of glaucoma may actually compromise the result of surgery performed a couple of decades down the line.

Tissue damage

During surgery if there is excessive crushing (by forceps), burning (by cautery) and bleeding (torn tissue), these factors lead to tissue breakdown products being released. This leads to inflammation that ultimately causes fibrosis. So gentle handling of tissue rather than speed is to be preferred.

Ring of steel

This is a relatively new concept (Figure 4). This phenomenon came into being after the advent of wound modulation using antimitotic agents. Antimitotic agents kill dividing cells (in the subconjunctival area this reads as Fibroblasts). So when mitomycin is placed over a limited area of sclera all the fibroblasts there are killed and no fibrosis can occur here. The edge of this zone has less effectively killed or partly killed cells. These cells release tissue breakdown products for a long time (months to almost a year). This again incites inflammation that attracts viable fibroblasts from surrounding areas (not affected by the antimitotic) causing an exaggerated fibrosis than what would have occurred without use of antimitotics. This fibrosis causes a “ring of steel” that delimits the bleb posteriorly. Now we have an avascular thin walled (bubbles like) bleb with congested edges. This bleb can have a high IOP if the wall is thick enough or it can extend anteriorly and overhang onto
the cornea or dissect into it. Sometimes the wall is so thin that fluid “weeps” or exudes out through its surface (now it is a time bomb for blebitis).

To prevent this from happening, it has been suggested that the antimitotic be used over a wider area surrounding the bleb rather than the area of scleral flap alone.

Wound modulation in Filtering surgery

The logical answer to fibrosis is to knock out the fibroblasts by inducing their apoptosis. There are a few options explored for this:
1. Antimitotic drugs - Mitomycin C, 5 Fluorouracil
2. Anti transforming growth factor β2
3. Gene therapy - insert antiproliferative gene using adenovirus carrier
4. β irradiation of conjunctiva - 1000 rads.
5. Photodynamic therapy - Carboxy fluorescein, Blue light radiations

Of all these, the only one widely used now is the antimitotic drugs. The two drugs in use are worth comparing. Mitomycin is about a hundred times more potent, gram to gram, when compared to 5-fluorouracil. It penetrates deeper and acts for a longer time. The accelerated apoptosis of fibroblasts continues for a year with mitomycin explaining the late postoperative hypotonies seen in children and young adults. Both are water soluble and diffuse out of the sponge fast.

<table>
<thead>
<tr>
<th>Drug</th>
<th>5 – FU</th>
<th>MITO C</th>
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<tbody>
<tr>
<td>Efficacy</td>
<td>1 X</td>
<td>100 X</td>
</tr>
<tr>
<td>Solubility</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Penetration</td>
<td>Shallow – does not go past sclera</td>
<td>Deep – diffuses upto ciliary body</td>
</tr>
<tr>
<td>Diffusion</td>
<td>Fast - out of sponge in 3 minutes</td>
<td>Fast - 68% out of sponge in 1 minute</td>
</tr>
<tr>
<td>Concentration</td>
<td>50mg/ml</td>
<td>0.2-0.4mg/ml</td>
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Both the drugs can be used for per operative application sub conjunctivaly (with such fast diffusion it makes little difference if placed sub scleral flap) for 2 – 4 minutes as is decided depending on age of patient, chance of fibrosis and inflammation. Applications over one minute to be effective need change of sponge to compensate for diffusion loss from the sponge. Excess drug is washed off with balanced salt solution after application. And the surgery proceeded with.

Post operative top up by subconjunctival 5 fluorouracil can be done with 5 mg in 0.1ml sub conjunctival injections (these are effective in the first 3 weeks). These injections can be given daily in the inferior fornix for up to 7 injections. The appearance of punctuate erosions on the corneal epithelium is a contraindication for further injections (figure 5).

An encysted bleb can be needled and a 0.1 ml injection of either 50mg/ml 5 FU or 0.2mg/ml mitomycin subconjunctivaly away from the trabeculectomy osteum can be given to salvage a trabeculectomy in the immediate post op (works till about 3 months).

Complications

Intra Op

Conjunctival button hole or perforation can occur and a meticulous microsurgical repair is to be done.

The scleral flap can be amputated. Here if the inner osteum is not yet fashioned, the best option would be to start again in another quadrant. If the inner osteum is already made a meticulous reapproximation of the flap will need to be done.

Haemorrhage into the subconjunctival area can compromise filtration by fibrosis but nothing much can be done about it. Hyphema can be washed out. Sudden decompression can trigger a suprachoroidal haemorrhage with sudden flattening of the anterior chamber with rise in IOP and a change of glow in the pupil to dusky red. This needs to be identified and the flap sutured down tightly (before it proceeds to become an expulsive haemorrhage).
Choroidal effusion and malignant glaucoma can rarely develop intra operatively (management described later). One can also injure other intraocular tissues inadvertently. The PI can become a CI. One can injure the lens capsule or the zonules while doing a PI and caused vitreous loss. The pull on the iris root or an entry behind the scleral spur during the trabecular block excision can result in a cyclodialysis cleft.

**Immediate Post op**

Ocular hypotony develops due to excessive filtration or ciliary shutdown (or inadvertent continuation of antiglaucoma medications!). Excess filtration would have a large diffuse bleb if there is no conjunctival edge leak. If on the Siedel test there is a leak then the conjunctival edge needs to be tacked down with horizontal mattress sutures at the limbus and additional sutures elsewhere. One can use large diameter bandage contact lenses for small leaks (Often the hypotonous globe infolds and the contact lens falls off!).

Hypotony soon develops into shallow anterior chamber as choroidal detachment develops. Here the shallow AC is uniformly shallow and not an iris bombe as in pupillary block.

Hypotony $\rightarrow$ ciliochoroidal detachment $\rightarrow$ apposition of lens equator to the ciliary processes $\rightarrow$ misdirection of aqueous behind the vitreous face $\rightarrow$ now IOP goes up $\rightarrow$ this pressure on the vitreous now dehydrates it and makes it less permeable to water, thus trapping fluid behind it $\rightarrow$ IOP rises drastically with a flat AC $\rightarrow$ MALIGNANT GLAUCOMA.

Another reason for a flat AC with high IOP is a late suprachoroidal haemorrhage.

Medical treatment of shallow AC is atropine drops. It works for pupillary block, helps in ciliochoroidal detachment and often controls malignant glaucoma. If it fails we proceed to perform the Chandler’s **three step diagnostic and therapeutic procedure**.

This procedure deals with diagnosis and management of post operative shallow anterior chamber.

**Step 1:** Peripheral iridectomy, to rule out and treat pupillary block. In a trabeculectomy we make sure the PI is patent and not bound down by synechiae.

**Step 2:** Sclerotomy. In the inferotemporal quadrant after limited peritomy and cautery a 3mm radial sclerotomy is fashioned centred 3.5 mm from the limbus (so as to be anterior to the vitreous face and behind the lens equator). This would drain a ciliochoroidal effusion as clear fluid and supra choroidal haemorrhage as blood and the AC can easily be formed via the paracentesis. If the sclerotomy is dry a presumptive diagnosis of malignant glaucoma is made and we proceed to step 3.

**Step 3:** Deep vitreous surgery. Chandler used a Wheeler knife (sharp on both sides like an MVR knife) to go into the vitreous at 3.5 mm from limbus aiming for the “centre of the globe” for 12mm and sweep the knife to incise the vitreous face. This was followed by aspiration of fluid using a 26 G needle. In this day we can go in with a vitrectomy cutter 3.5 mm form the limbus and do an anterior vitrectomy to achieve the same end. With these 3 steps we have definitive diagnosis and would have treated the concerned condition.

Blebs can cause dellen formation. Uveitis, hyphema and cataract can develop post op. And of course infection. In advanced cases with macular split fixation on fields, there is a ten percent risk of wipe out or snuff out of vision after surgery, due to either a spike in IOP or a macular haemorrhage due to hypotony. This should be informed to the patient prior to surgery and consent obtained.

**Late**

Bleb infection or blebitis is definitely the most disastrous complication in this group. These are very difficult to cope with. It is essentially a corneal ulcer starting with a perforation already in place. Treatment is as for any post op endophthalmitis though results are poorer than with post cataract scenario. And if the eye is saved the trabeculectomy invariably fails thanks to the inflammation.

Cataract tends to mature faster after glaucoma surgery. Cataract surgery should be undertaken as late as possible and an interval of one year reduces chances of failure of the trabeculectomy.

Bleb leaks can occur late now with use of antimitotics (cellular apoptosis goes on for a year with use of mitomycin). These late leaks are best managed with a
conjunctival autograft over a wide area (if conservative
treatment with acetazolamide fails to close the fistula
by reducing flow through it).

Scleral staphyloma and sympathetic ophthalmia are also
described as complication after trabeculectomy.

Hypotony with diffuse bleb can be treated by autologous
blood injections peribleb. If this fails in 2 weeks, the
blood is injected intrableb. Blood and its breakdown
products encourage fibrosis. If these measures fail, one
can incise conjunctiva radially to limit the bleb and
suture it down with absorbable continuous suture onto
sclera to incite fibrosis to limit the bleb.

Thus though trabeculectomy is the most widely used
glaucoma surgery, it is still not the final solution. It has
its advantages and definitely its limitations. Quite often
the bigger skill is not in the surgery but in deciding
“when” and “when not” to operate.

References


Peter Roget and his Thesaurus

Prof. Padmaja Krishnan, Kozhikode

All of us are familiar with dictionaries where words are arranged in alphabetical order with their correct pronunciation, meanings, derivation and usage.

Not so well known perhaps is a thesaurus, a book of synonyms and antonyms. Here a word is listed according to its meanings and distinctions are drawn between similar words and their opposites. In both Greek and Latin the word literally means a "treasure or storehouse". The thesaurus helps writers choose the right word and use it in the right context. For those who use it regularly, it is as important a reference book as the Bible or Webster’s Dictionary.

The first of its kind, Roget's Thesaurus, was published on 26th April 1852. The first edition had 15,000 words and is still preserved in the Karpeles Manuscript Library in the USA along with Roget's autobiography. The thesaurus has never gone out of print and each new edition has been larger.

Peter Mark Roget, born on January 18th 1779 in London, was an English doctor, writer, inventor and theologian. His father was a Swiss clergyman who died young. After his father's death, Roget went to Edinburgh University to study Mathematics and Medicine. He was a naturally gifted child who became a doctor in 1798 when he was just 19 years old.

He inundated the scientific establishment with numerous inventions and papers, including those on Tuberculosis and on the effects of Nitrous Oxide. In 1814 he invented a slide rule to calculate the roots and powers of numbers. This formed the basis of slide rules that were common currency in schools and universities until the age of the calculator. Later in life, he attempted to construct a calculating machine. He wrote a paper on how the kaleidoscope could be improved as also on a wide range of other topics, contributing to encyclopaedias of the day.

Roget worked in Bristol and Manchester and for a time was a private tutor, travelling with his charges to Europe. In 1808, he moved to London, where he continued to lecture on medical topics.

He was made a Fellow of the Royal Society of Medicine and served as its Secretary from 1827 to 1848. In 1840 Roget effectively retired from medicine and spent the rest of his life on the project that has made his name, 'Roget's Thesaurus of English Words and Phrases'. As early as 1805 he realised the need for a book to find meanings and opposites of words easily. He started compiling, for his own use, a small indexed catalogue of words which he used to enhance his prolific writing. This was two years before Webster started on his dictionary. For a period of 47 years Dr. Roget used it as his personal, secret, treasure trove.

After he left his job in the Royal Society, he found the leisure and the time for his life’s work and improved upon his catalogue of words. However, only at the age of 73 did he decide to reveal and publish this great manuscript. Roget's contribution to Ophthalmology was his demonstration of persistence of vision. On December 9, 1824, Roget presented a paper entitled "Explanation of an Optical Deception in the Appearance of the Spokes of a Wheel when seen through Vertical Apertures". In it he proved that the image of an object is held on the retina for approximately 1/16th of second after the object actually disappears - TV and movies rely on this illusion to produce apparent ‘reality’ on screen.

He died on September 12th 1869 while on holiday and is buried in St. James' Church in West Malvern, Worcestershire.

Interestingly, ‘Amarakosam’ in Sanskrit probably quite unknown to Peter Roget, was perhaps the first ever Thesaurus in the world.