ABSTRACT
Secondary angle closure glaucomas are a distinct entity from primary angle closure glaucoma (PACG). Unlike PACG, secondary angle closure glaucoma’s have an identifiable contributory factor/s for angle closure and obstruction of aqueous flow which is usually unrelieved by iridotomy. The treatment of each type of secondary angle closure glaucoma is varied, so identification of the primary cause aids in its effective management.

Keywords: Pupillary block, Neovascular glaucoma, Iridocorneal endothelial syndrome, Aqueous misdirection syndrome, Ciliary body swelling.

INTRODUCTION
In secondary angle closure glaucoma, the underlying cause can close the angle directly by local iris and angle factors or by acting to move the crystalline lens forward causing pupillary block (secondary pupillary block). This is important since some of these patients with secondary pupillary block will respond to laser iridotomy. They are common causes of glaucoma and can produce high elevations of intraocular pressure (IOP) and ocular morbidity. This review will discuss the risk factors, signs and symptoms, pathophysiology, imaging and the treatment modalities of secondary angle closure glaucomas.

Secondary angle closure glaucoma’s can be categorized by the existence of pupillary block or not though some overlap can be seen (Table 1).

Aqueous Misdirection Syndrome
The aqueous misdirection syndrome is a form of secondary angle closure glaucoma occurring postsurgery with raised intraocular pressure (IOP), shallow or flat anterior chamber (AC) in the presence of a patent peripheral iridectomy (PI) (Figs 1A to C). It is unresponsive to miotic or filtering surgery. It can occur after filtering surgery,2 cataract3/combined surgery, surgical peripheral iridectomy, following suturelysis,4 glaucoma drainage device implantation5 or even after laser iridotomy.6 The predisposing factors are pre-existing angle closure glaucoma, shallow anterior chamber due to wound leak or overfiltration.

The pathophysiology is not completely understood, but is believed that the primary mechanism is a blockage of anterior aqueous flow at the level of the ciliary body combined with an inherent impermeability defect in the anterior hyaloid.7 Recently, choroidal expansion has been proposed as a contributory factor as evidenced by ultrasound biomicroscopy (UBM) studies showing fluid in the suprachoroidal space in some patients with ciliary block glaucomas.8

Clinical Features
It is seen in the postoperative period anytime from the 1st day to weeks, sometimes months later. The features are axial shallowing of AC, high IOP or normal IOP in case of functioning blebs, patent PI, closed angle on gonioscopy and ciliary processes can be seen rotated forward pressing against the base of the iris in case of choroidal effusions. UBM shows anterior rotation of ciliary processes pressing against the lens equator (or anterior hyaloid in aphakia).9

The principles of treatment are to relieve the obstruction of aqueous flow and restore normal intraocular pressure by medical therapy, to surgically correct the block to aqueous flow, re-establish a normal aqueous flow pathway and drain the aqueous from its abnormal location.

Medical Therapy
Rule out pupillary block by verifying or creating a patent iridectomy/iridotomy. Start mydriatic-cycloplegic therapy consisting of 1% atropine and 5% phenylephrine twice a day in phakic and pseudophakic eyes. This tightens the lens–zonular diaphragm to resist the force from behind and also dilate the ciliary body ring to move the ciliary body away from peripheral anterior hyaloid. Fifty percent success rate has been noted with this therapy. Additionally, topical steroids, aqueous suppressants are used to reduce inflammation and IOP. Osmotics help to lower the IOP as well as to reduce the vitreous volume. Conservative treatment is advised for 5 days to see for resolution.

YAG hyalidotomy disrupts the anterior hyaloid face allowing aqueous to drain out of the vitreous. It’s an elective
In cases of medical and laser therapy failure, vitreous surgery almost always cures this condition. The surgery is intended to establish an opening through the anterior hyaloid membrane and the vitreous body for aqueous humour to escape forward to the posterior and anterior chambers. Pars plana vitrectomy is done in pseudophakic and aphakic eyes and IOP control is achieved in 67 to 100% of cases. Vitrectomy in phakic eyes was studied in 5 phakic eyes, the preliminary vitrectomy was limited to core vitrectomy to debulk the vitreous, the residual vitrectomy, zonulohyaloidectomy and peripheral iridectomy was performed to create a free communication between the anterior and posterior chambers. Cyclodiode laser photocoagulation has also been proposed in patients with failed medical therapy to break the cycle of aqueous misdirection and prevent future recurrences. YAG PI done preoperatively in occludable eyes can reduce aqueous misdirection. In patients with increased risk like in decompression related shallowing of the anterior chamber, using viscoelastics during surgery, tighter closure and cycloplegics after surgery prevents aqueous misdirection. It must be remembered that recurrence can occur so vigorous follow-up and chronic atropine drops may be necessary. The fellow eye is also at a high-risk for aqueous misdirection.

### Neovascular Glaucoma

Neovascular glaucoma (NVG) arises in response to retinal ischemia, the common predisposing factors being central retinal vein occlusion and diabetic retinopathy. An NVG patient requires a broad diagnostic workup to determine the underlying cause and also a predisposed patient requires careful monitoring to detect NVG in its earliest stages.

The pathogenesis of NVG is retinal ischemia which produces angiogenic factors (VEGF, angiogenin, PDGF, TGF-α, β, TNF-α) which in turn causes new vessel formation on the iris and angle leading to formation of fibrovascular membrane which eventually contracts to form peripheral

### Table 1: Classification of secondary angle closure glaucomas

<table>
<thead>
<tr>
<th>With pupillary block</th>
<th>Without pupillary block</th>
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<tbody>
<tr>
<td>Aqueous misdirection</td>
<td>Neovascular glaucoma</td>
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<tr>
<td></td>
<td>Iridocorneal endothelial syndromes (ICE)</td>
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<td>Inflammatory glaucoma</td>
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<td>Ciliary body cysts, tumors</td>
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<td>Scleral buckling and postvitreoretinal procedures</td>
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<td>Ciliary body swelling secondary to:</td>
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<tr>
<td></td>
<td>a. Central retinal vein occlusion (CRVO)</td>
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<td></td>
<td>b. Panretinal photocoagulation (PRP)</td>
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<td></td>
<td>c. Drugs or inflammation</td>
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### Surgical Therapy

In cases of medical and laser therapy failure, vitreous surgery almost always cures this condition. The surgery is intended to establish an opening through the anterior hyaloid membrane and the vitreous body for aqueous humour to escape forward to the posterior and anterior chambers. Pars plana vitrectomy is done in pseudophakic and aphakic eyes and IOP control is achieved in 67 to 100% of cases. Vitrectomy in phakic eyes was studied in 5 phakic eyes, the preliminary vitrectomy was limited to core vitrectomy to debulk the vitreous, the residual vitrectomy, zonulohyaloidectomy and peripheral iridectomy was performed to create a free communication between the anterior and posterior chambers. Cyclodiode laser photocoagulation has also been proposed in patients with failed medical therapy to break the cycle of aqueous misdirection and prevent future recurrences.
management of secondary angle closure glaucoma

Management of Secondary Angle Closure Glaucoma

Anterior synchiae (PAS) and ultimately complete closure of the angle. VEGF levels are elevated to 40 to 100 times normal in aqueous and vitreous of patients with rubeosis and NVG.14

The clinicopathologic course and treatment may be described in the following stages.15

Rubeosis Stage (Preglaucoma)

Neovascularization is typically first seen in the pupillary border;16 however, gonioscopy should be done in all patients under the risk to look for angle neovascularization, since it can precede iris neovascularization.17 The IOP is usually normal, rubeosis is seen as fine randomly oriented vessels near pupillary border or may be first seen in the angle in diabetic and CRVO patients.18 Pan retinal photocoagulation (PRP) is indicated which decreases the retinal oxygen demand, thereby reducing the stimulus for release of angiogenesis factors.19

Open-angle Glaucoma Stage

The rubeosis is more florid in this stage with elevated IOP and open angles with intense neovascularization of the angle. PRP can reverse IOP elevation in this stage. Aqueous suppressants, topical corticosteroids and atropine are used.

Angle Closure Glaucoma Stage

PAS formation can eventually close the angle with ectropion uveae formation resulting in severe glaucoma requiring surgical intervention. PRP is still useful in this stage to reduce IOP if synechial closure is less than 270°20 and even if the angle is closed for more than 270° PRP is useful in reducing anterior segment neovascularization before any surgical intervention.21

Filtering surgery is rarely successful because of the risk of bleeding and postoperative progression of fibrovascular membrane. In a study in NVG patients, mitomycin C (MMC) augmented trabeculectomy yielded success rates of 62.6, 58.2 and 51.7% at 1, 2 and 5 years respectively.22 Modified trabeculectomy can be performed with intraocular bipolar cautery of peripheral iris and ciliary processes to prevent bleeding.23 Intracameral Bevacizumab (avastin)24 has been tried in NVG patients resulting in rapid regression of the iris and angle neovascularization and could act as an adjunct in the surgical treatment of these patients. Preoperative intravitreal bevacizumab combined with mitomycin C augmented trabeculectomy has been studied to be a safe and effective method for controlling IOP in NVG, though long-term effects are not known.25 Even comparative studies between combined intravitreal bevacizumab (IVB) and trabeculectomy with MMC verses trabeculectomy with mitomycin C alone concluded that IVB significantly reduces postoperative hyphema and controls early postoperative IOP with no difference in long-term results.26

GDDS have gained wide acceptance as a primary procedure for NVG patients because the tube bypasses the fibrovascular membrane. The aqueous tube shunts have reported success rates of 22 to 97% in these patients.27,28 Molteno tube shunts29Ahmed glaucoma valve30 and Baerveldt glaucoma implants31 have shown comparable success rates. Successful IOP control was achieved with combined pars plana vitrectomy and glaucoma drainage implant in selected patients with refractory NVG.32

In eyes with little or no visual potential, treatment is mainly with topical cycloplegics, steroids and aqueous suppressants. Ablation of the ciliary body is undertaken in cases of symptomatic patients. Bloom et al reported a mean IOP reduction of 53% in 25 patients with diode laser for refractory glaucoma.33 However of note is the study by Ramli et al34 that underlying NVG was a significant risk factor for hypotony post transscleral cyclophotocoagulation. A less aggressive energy setting and a more limited treatment was advised to prevent hypotony.

Iridocorneal Endothelial Syndromes

Iridocorneal endothelial (ICE) syndrome is a spectrum of ocular diseases characterized by corneal endothelial abnormalities, unilateral glaucoma and iris stromal abnormalities.35 They include progressive iris atrophy, Chandler syndrome and Cogan-Reese syndrome (Figs 2A to C). They may be regarded as different manifestations of the same disease process. It is caused by an abnormal corneal endothelium which forms a membrane (ICE membrane) over the anterior surface of the iris and the angle structures, which on contraction distorts the iris, forms peripheral anterior synchiae and closes the angle leading to glaucoma.36 Half of all the patients of ICE syndrome develop glaucoma.37

Management of glaucoma in ICE syndromes is difficult and medical therapy is restricted to aqueous suppressants which is often unsuccessful.38 The success rate of filtering surgery is also lower than most other forms of glaucoma.39,40 A study of surgical outcome of trabeculectomy with MMC in 10 ICE syndrome patients showed 8 of 10 patients having adequate IOP control after filtering surgery with mitomycin-C, with a mean follow-up of 14.9 months. The results of their study suggested that trabeculectomy with adjunctive mitomycin-C may offer better intermediate-term success than trabeculectomy alone or trabeculectomy with 5-fluorouracil.41 Failure of filtering surgery is often due to the continued growth of the endothelial membrane over the filtration site.
the tube should be left long in the anterior chamber away from the potential source of ICE cells and entry through pars plana can be used in pseudophakic vitrectomized eyes.

Cyclophotocoagulation is indicated in eyes with refractory glaucoma who have failed trabeculectomy or shunt surgery.

**Inflammatory Glaucoma**

Glaucoma is a potentially devastating complication of uveitis and remains a therapeutic challenge despite availability of new modalities of treatment in both the conditions.\(^{43}\)

Inflammation can produce secondary angle closure glaucoma with pupillary block mechanism due to posterior synechiae formation or without pupillary block due to inflammatory peripheral iris swelling, exudates in the angle contracting to form PAS or due to forward rotation of the ciliary body. PAS form easily in eyes with shallow anterior chamber and in eyes with chronic inflammatory processes.

Inflammatory glaucoma can occur after trauma, surgery, idiopathic inflammatory condition or due to specific uveitic entities.

**Principles of Management**

Usually control of inflammation alone leads to normalization of IOP. Management of inflammation is done by topical or systemic corticosteroids, mydriatics-cycloplegics and systemic immunosuppressives. Medical therapy to control IOP basically involves aqueous suppressants. Intracameral tissue plasminogen activator has been reported to be of use in impending pupillary block glaucoma due to acute fibrinous HLA-B27 uveitis.\(^{44}\)

YAG PI is done for pupillary block glaucomas, although fibrin can close small iridotomies in an inflamed eye.\(^{45}\) When this is unsuccessful surgical iridectomy is useful if less than 75% of the angle is closed by PAS.\(^{46}\)

If medical or laser therapy is unable to control the IOP then filtration surgery has to be considered. Trabeculectomy in uveitic eyes generally carries less success due to acceleration of wound healing by postoperative fibrinous and cellular responses.\(^{47}\) Antimetabolites like 5FU and Mitomycin C are used to increase the success of trabeculectomy in uveitic eyes (5FU, MMC). A success of 95% (IOP less than 21 mm Hg with 1 or no medication) was achieved with MMC augmented trabeculectomy.\(^{48}\) Aggressive anti-inflammatory therapy should be given before and after trabeculectomy in these patients.

All the three glaucoma drainage implants (Molteno, Baerveldt and Ahmed valve) have been tried with a success of 79% with Molteno implants,\(^{49}\) 94% with Ahmed valve\(^{50,51}\) and 91.7% with Baerveldt implant.\(^{52}\)
Glaucoma after Silicone Oil Injection

Silicone oil is used as a vitreous substitute for retinal tamponade. It can produce glaucoma by pupillary block, inflammation, synechial closure, neovascularization, migration of oil into anterior chamber or by open angle mechanism. Secondary glaucoma after silicone oil injection has been reported to be in 6 to 30% of eyes. Angle closure glaucoma can occur after silicone oil injection due to synechial closure. Overfilling of the oil in the eye has to be avoided to prevent secondary glaucoma. Inferior prophylactic iridectomy prevents pupillary block in pseudophakic and aphakic eyes. Medical therapy consists of aqueous suppressants, corticosteroids and cycloplegics. Postoperative closed iridectomies due to fibrin can be relieved by laser PI.

Silicone oil removal with or without concurrent glaucoma surgery has been performed to lower IOP, but oil removal carries some risk of retinal detachment. In patients with complete synechial closure silicone oil removal alone cannot be expected to lower IOP, rather glaucoma surgery is indicated in such cases and the decision to remove silicone oil or not depends on the relative risk of retinal detachment or silicone oil emulsification. If silicone oil remains in the eye, the GDD should be positioned in the inferior quadrant.

Cyclophotocoagulation by transscleral cytoto photocoagulation (TSC) or endo cytoto photocoagulation (ECP) can be used in refractory cases. Eyes with relatively intact central
visual acuity are appropriate candidates for ECP and can be combined with intraocular surgery.\textsuperscript{76}

**Ciliary Body Swelling**

Secondary angle closure glaucoma can occur due to ciliary body (CB) swelling secondary to vortex vein obstruction (venous stasis), drugs or inflammation. Vortex vein obstruction occurs secondary to extensive PRP or CRVO producing angle closure glaucoma similar to scleral buckling procedures. It is a self limiting condition and will resolve with or without medical therapy. Laser PI has no role in this condition.

Ciliary body swelling secondary to drug use is an idiosyncratic reaction causing relaxation of zonules, anterolateral rotation of the ciliary body leading to anterior displacement of iris—lens diaphragm producing induced myopia. Choroidal detachment and supraciliary effusions are frequently present detected by UBM. Sulfa-based drugs are associated with this type of secondary angle closure glaucomas like topiramate\textsuperscript{77} (Figs 3A and B), acetazolamide,\textsuperscript{78} hydrochlorothiazide and contrimoxazole. It presents as bilateral angle closure glaucoma. The management requires stopping of the drug, instituting aqueous suppressants and cycloplegics.\textsuperscript{79} Miotics, topical and systemic carbonic anhydrase inhibitors are contraindicated and laser PI has no role.

**CONCLUSION**

Secondary angle closure glaucomas require meticulous history taking, clinical examination, if necessary anterior segment imagings like UBM to identify the specific cause if possible and formulate a treatment plan to avoid ocular morbidity.

**REFERENCES**


