Management of Primary Angle-Closure Glaucoma

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Abstract: Primary angle-closure glaucoma (PACG) is a progressive optic nerve degeneration and is defined as a glaucomatous optic neuropathy with associated characteristic enlargement of optic disc cupping and visual field loss that is secondary to ocular hypertension caused by closure of the drainage angle. Angle closure is caused by appositional approximation or adhesion between the iris and the trabecular meshwork. The main treatment strategy for PACG lies in the reduction of intraocular pressure, reopening of the closed angle, and possible prevention of further angle closure. There is no universally agreed best surgical treatment for PACG. Trabeculectomy, goniosynechialysis (GSL), glaucoma implant, and cyclodestructive procedures are effective surgical options. Each of them plays an important role in the management of PACG with its own pros and cons. Accumulating evidence is available to show the effectiveness of visually significant and visually nonsignificant cataract extraction in the treatment of PACG. Trabeculectomy and GSL are often combined with cataract extraction, which may offer additional pressure control benefits to patients with PACG. This review article will discuss laser peripheral iridotomy, argon laser peripheral iridoplasty, and surgeries such as GSL, phacoemulsification, and phaco plus glaucoma surgeries that lower intraocular pressure and also alter the anterior segment and/or drainage angle anatomy. Currently, glaucoma implants and cyclodestruction are mainly reserved for PACG patients who have failed previous filtering operations. Their role as initial surgical treatment for PACG will not be discussed.

Key Words: surgery, primary angle-closure glaucoma

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Primary angle-closure glaucoma (PACG) is a major cause of blindness in Asia and throughout the world. It is a multifactorial optic nerve degeneration and is defined as a glaucomatous optic neuropathy with associated characteristic enlargement of optic disc cupping and visual field loss that is secondary to ocular hypertension caused by closure of at least 180 degrees of the drainage angle. Angle closure is usually the result of apposition or adhesion of the peripheral iris to the surface of the pigmented trabecular meshwork, thus blocking aqueous access to the filtering trabeculum. Blockage can be appositional (intermittent) or synechial (permanent). When a sufficient proportion of the drainage surface of the trabecular meshwork is blocked, the intraocular pressure (IOP) begins to increase. When extensive drainage angle is closed, the rise in IOP can be substantial. The natural course of the disease progresses at variable rates from primary angle-closure suspect (angle closure without increase in IOP) to primary angle closure (angle closure with increased IOP) and finally PACG. Because the pathogenesis of PACG is caused by a relative anatomical derangement of the anterior segment, treatment strategies aim at reconstruction of the anatomical defect and IOP control. Medical treatment can hardly achieve the 2 targets, and surgery becomes the mainstream of treatment.

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SURGICAL TREATMENT OF PACG

Unlike primary open-angle glaucoma, PACG often requires laser and/or surgical treatment in the early stage of the disease because medical treatment can hardly achieve a long-lasting widening effect on the drainage angle. The main objectives of surgical treatment in PACG are (1) reduction of IOP to prevent progression of the glaucomatous optic neuropathy, (2) reopening of the closed angle, and (3) prevention of progressive angle closure or reclosure. Various surgical procedures have different roles to play to meet these objectives.

LASER PERIPHERAL IRIDOTOMY

Pupillary block is a major angle-closure mechanism in PACG. Therefore, all PACG eyes should have a peripheral iridotomy to eliminate the angle-closure force from pupillary block. Laser peripheral iridotomy (LPI) may be able to open an appositionally closed angle and results in reduction of IOP.[1–4] However, it may not be effective in opening angles with PAS closure. Laser peripheral iridotomy is in general minimally invasive.[5] There is no inherent risk of endophthalmitis and wound complications. However, LPI alone may not be sufficient in controlling progression of PACG. A proportion of patients with incomplete angle closure may still develop progressive angle closure after LPI.[6] This is because other angle-closure mechanisms such as plateau iris configuration and phacomorphic elements still exist after elimination of pupillary block with LPI.

ARGON LASER PERIPHERAL IRIDOPLASTY

Laser peripheral iridoplasty is a technique using low-energy contraction burns to mechanically pull open the angle by causing contraction of the iris away from the angle, thereby decreasing angle crowding, and thus reducing IOP in PACG. It has been shown to dramatically lower IOP, with opening of the closed angle, in patients with acute attack of PAC and in acute phacomorphic angle closure.[7–11] Besides lowering IOP, it also alters the configuration of the peripheral iris permanently because of contraction of the fibroblastic membrane. Argon laser peripheral iridoplasty (ALPI) has been found effective for mechanisms of closure other than pupillary block.[12] It is effective in eyes with PAS angle closure and plateau iris syndrome (PIS) that do not show an improvement after LPI.[13] It was observed that APLI opens the angle in PIS not only by contracting the iris stroma, but also by thinning the iris tissue at the crowded angle.[14] Like LPI, ALPI alone is effective in appositional angle closure but may not be as effective in extensive PAS closure cases. Although serious long-term complications on the cornea and the lens from ALPI have not been reported, its long-term effectiveness is unclear and it is not without sequelae such as an irregular dilated pupil causing photophobia.

GONIOSYNECHIALYSIS

Goniosynechialysis (GSL) is a surgical technique to strip the PAS from the trabecular surface in the angle so that aqueous can regain access to the meshwork.[15] It is effective in opening closed

angle and lowering IOP in PACG with an overall success rate of 80%.[16–18] However, irreversible damage to the trabecular meshwork may have occurred in areas of synechial closure, with proliferation of iris or fibrous tissue into the intertrabecular space. The decreased aqueous outflow in these chronic cases may be secondary to widening and fusion of adjacent trabecular beams, together with the homogenous deposit enmeshing trabecular beams and spaces.[19] This may explain unsuccessful GSL in PACG cases of long duration. To be effective, GSL should be performed before there is irreversible histological change in the trabeculum. Furthermore, the angle-closure mechanisms must be eliminated by procedures such as LPI and ALPI to minimize the risk of recurrent angle closure. In eyes with minimal PAS angle closure but with high IOP, GSL may not be effective because trabecular function in these eyes may be poor. Goniosynechialysis is more suitable for eyes with a minimal to moderate degree of neuronal damage because the postoperative IOP profile may not be as clear cut as in trabeculectomy. Good visualization of the angle is the key to success in GSL. Over the years, angle visualization has been improved with the use of the Swan-Jacob lens and the Mori lens.

Lens-Based Glaucoma Surgery

Visually Significant and Visually Nonsignificant Cataract Extraction

Removal of a large cataractous lens from an eye with a crowded anterior segment will increase the aqueous outflow. Although large-scale randomized controlled trial data are not available at present, results from various case series provide evidence to show that cataract extraction with phacoemulsification reduces IOP, deepens the anterior chamber, and widens the drainage angle in PACG eyes.[20–26] Phacoemulsification alone is often used as the initial surgical treatment for PACG with coexisting visually significant cataract. The controversy arises when the lens is relatively clear without visually significant cataract. Removal of a functioning human crystalline lens may create anisometropia and problems with accommodation. The dilemma is whether to keep a normal functioning but anatomically abnormal crystalline lens in the anterior segment of the eye. Clinical research data on clear lens extraction in the management of PACG are sparse.[27,28] Although the role of cataract extraction in the treatment of PACG is becoming more affirmative, the challenge ahead is to predict which PACG eye will respond to removal of the cataract and the magnitude of response in terms of IOP reduction. Current studies emphasized the importance of the relative lens vault and its association with angle closure. Imaging modalities such as anterior segment optical coherence tomography have yielded valuable information on the lens thickness and lens vault[29–31] and their mechanical features in angle closure.[32,33] Subjects with angle closure had thicker lens and greater lens vault than normal controls.[29] However, the relative lens vault may be more closely related to angle closure than the absolute value of lens vault.[30] These data may be useful in predicting the effectiveness of lens extraction in the control of disease progression and as a guide to lens extraction in the management of PACG.

Phaco Plus Surgeries

In the presence of a visually significant cataract, combining phacoemulsification with other glaucoma procedures may provide more options for the treatment of PACG patients who are predicted to be poor or unsatisfactory responders to phacoemulsification alone. Primary angle-closure glaucoma cases with poor trabecular function or advanced glaucomatous optic neuropathy fall into this category. Glaucoma surgeries combined with phacoemulsification theoretically have a more profound IOP-lowering effect, and data on the magnitude of additional IOP reduction when glaucoma procedures are combined with phacoemulsification are emerging.

Combined Phacoemulsification and Trabeculectomy (Phacotrabeculectomy)

Trabeculectomy, which is the surgical treatment of choice for primary open-angle glaucoma, is also effective for PACG.[34–36] Because cataract extraction has been shown to be effective in the treatment of PACG, trabeculectomy should logically be combined with phacoemulsification in PACG eyes with coexisting cataract. Trabeculectomy alone in these eyes has the disadvantage that future cataract extraction may result in loss of the functioning filter.[37,38] Nevertheless, trabeculectomy has a role in PACG eyes that have already undergone phacoemulsification and in eyes with clear lens. In the presence of a visually significant cataract, the surgical options to consider are phacoemulsification alone or combined phacotrabeculectomy. The decision is at present guided by the IOP level.[39,40] In medically controlled PACG, phacoemulsification alone suffices. In medically uncontrolled PACG, phacotrabeculectomy offers better control of IOP but with a higher rate of postoperative complications. This is an oversimplified guideline based indirectly on the IOP level. Whether IOP is medically controlled is very arbitrary. The fundamental determining factors are the adhesiveness of the PAS to the trabeculum and the trabecular function. If the PAS is tightly adhered to the trabeculum, phacoemulsification alone may not be effective in opening the angle to the extent that the re-established drainage is sufficient to keep IOP in the normal range. If the trabecular function is poor, IOP will not be normalized even though 360 degrees of the angle are reopened after phacoemulsification. The presence of either of the previous factors will require performing trabeculectomy combined with phacoemulsification. More research is needed to enhance our knowledge in this area to determine a more accurate prediction formula for the surgical outcome rather than crudely relying on the IOP level.

Combined Phacoemulsification and GSL

The effectiveness of GSL alone and GSL combined with phacoemulsification in the management of PACG has been reported.[15–18,41,42] Although cataract removal in PACG deepens the anterior chamber without significant lysis of the PAS, GSL breaks the PAS, resulting in a greater reduction in the iris-trabecular contact area, allowing aqueous access to the trabeculum.[42–44] Nevertheless, both phacoemulsification and GSL performed on their own have been shown to lower IOP, although the mechanisms are uncertain and may or may not be common to both procedures. Combining GSL with phacoemulsification has the advantages of noticeable visual improvement after surgery and the combined IOP-lowering effect of the 2 procedures. Furthermore, removal of the lens may decrease the possibility of recurrent angle closure. However, a comparative study reported no significant difference in the IOP-lowering effects and reduction of PAS between phacoemulsification and combined phacoemulsification and GSL (phacoGSL) in a group of medically controlled PACG patients with cataract.[45] A comparative study on phacoGSL versus trabeculectomy showed that both procedures had similar IOP-lowering effects.[46] However, the anterior chamber depth was markedly augmented and the angle closure decreased significantly in the phacoGSL group, but there was no significant alteration in the trabeculectomy group. Another comparative study reported the same efficacy between phacoGSL and phacotrabeculectomy in the treatment of PACG with coexisting cataract.[47] Larger-scaled randomized controlled trials are needed to reveal the

additional benefit, if there is any, of performing GSL combined with phacoemulsification in PACG.

CONCLUSIONS

The best surgical strategy for PACG is not yet clearly defined. However, because more and more high-quality clinical data from randomized controlled trials comparing different surgical modalities are emerging, there will be a paradigm shift in the near future when management of PACG is based on evidence rather than relying on a surgeon's expertise and preference. Besides comparative clinical trials, there is a need for research studies on the different angle-closure mechanisms. With the aid of advanced technology-driven imaging systems, the different angle-closure mechanisms will be more clearly delineated. Using data on the angle-closure mechanism(s) that is/are operating, the extent of angle closure, the lens clarity, and the stage of glaucomatous optic neuropathy, surgical treatment can be customized to individual PACG patients.

With the currently available published data, a low threshold for cataract extraction should be adopted. Removal of this largest intraocular structure will certainly offset the angle crowding effects of various angle-closure forces. With more available data, we should be able to predict which PACG patient will benefit from LPI, ALPI, phacoemulsification, angle reconstruction surgery, or filtration surgery alone and who will require phaco plus other surgeries. The aim is to use a minimum number of surgical procedures to achieve the best outcome in terms of IOP reduction, angle reconstruction, and optic nerve protection from further glaucomatous damage.

In summary, all PACG eyes should have peripheral iridotomy to eliminate the angle-closure force from pupillary block until the day when published clinical study results indicate that cataract extraction can replace LPI. Argon laser peripheral iridoplasty is a relatively noninvasive procedure in appositional angle closure caused by PIS on top of pupillary block. Goniosynechialysis should be considered in extensive PAS closure of short duration. In the presence of advanced visual field defects and/or advanced optic disc cupping that signify a long duration of angle closure and irreversible structural changes in the trabeculum, trabeculectomy is a more suitable option. Always remove the lens either as phacoemulsification alone or as phaco plus other procedures if there is cataract or suspicion of phacomorphic elements in angle closure evidenced by the iris configuration in indentation gonioscopy or a large relative lens vault.

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Without vision, even the most focused passion is a battery without a device.
— Ken Auletta