Assessing and Treating Glaucoma in Children of the Developing World
Assessing and Treating Glaucoma in Children of the Developing World

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This document is for those who wish to learn more about how to deal with the pediatric glaucomas and whose resources may not always be at the highest level. The authors’ aim is to inform and to encourage eye doctors to deliver the best level of care possible for these children, but we also recognize everything advised here may not be possible to accomplish in their location. Any equipment limitations should not discourage doctors from using all resources available to them, to the best of their abilities.
**INTRODUCTION**

Glaucoma in children or even young adults cannot be looked upon in the same way as glaucoma in the adult. Diagnostic and treatment methods used primarily in adults may not be appropriate for the pediatric glaucomas. Children are not small adults so their disease must be assessed and treated accordingly. Diagnosis and treatment of pediatric glaucomas must take into consideration the age and developmental status of the child, other systemic signs, family history, the family psychosocial situation, and, in particular; the availability of follow-up and ongoing care. For those with internet access, a model for support and education for families can be found through the Pediatric Glaucoma and Cataract Family Association (www.pgcfa.org). Assistance for doctors treating children with glaucoma is available through Orbis Telemedicine, Cyber-Sight at [www.cybersight.org](http://www.cybersight.org).

For glaucoma treatment, there is an inherent assumption that “success” is achieved in the patient who lives life with useful vision. More specifically, this might be called the purpose of treatment for the pediatric glaucomas. In children, life span may be many years past the initial diagnosis (life expectancy 37.2 years in Zambia and 83.2 years in Andorra); thus, the expected series of examinations and therapies through those years must address a number of issues and challenges that are not seen generally in an adult population.

**OVERVIEW**

**Basic Principles for Management of Glaucoma in Children**

- The initial treatment may not be successful for the lifespan of the patient. A plan for the child must be formulated, or at least appreciated by the first as well as subsequent doctors, so as to utilize ALL options in a logical & optimal sequence.

- Procedures done early should be planned not to interfere with, nor compromise the potential success of subsequent procedures.

- It must be recognized that each surgical intervention may have accompanying or potential future complications, many of which may not be apparent for months to years afterward (e.g. retinal detachments, macular edema, endophthalmitis, etc). The extended life expectancy of the pediatric glaucoma patient will mean that these events, which might not be seen in adults, are more likely to appear over an extended time period. Short-term studies (< 5-10 years), therefore, may not be as useful in planning longer or lifetime surgical options.

- A significant part of treating pediatric glaucomas is awareness of the need for timely diagnosis and appropriate treatment of strabismus, refractive amblyopia and media opacities (cornea and lens). Even in successfully treated cases of pediatric glaucoma, these factors have a profound impact upon the degree of vision loss and therefore should not be overlooked.
Many pediatric glaucomas are associated with other conditions and diseases, which must be considered during diagnosis and treatment (e.g. retinoblastoma, cataracts in rubella, corneal decompensation in aniridia, proptosis in neurofibromatosis, developmental delay in Lowe syndrome, etc.).

Pediatric glaucoma is a family disease, which can affect other members directly by genetic transmission and indirectly by the demands of follow-up and care.

One principle that is in common with both childhood and adult glaucoma is the importance of early detection and appropriate intervention!

Problems & Purpose
The ophthalmologist who is responsible for these children and young adults with glaucoma must inform the patients and their parents about the numerous potential problems associated with pediatric glaucoma. This includes emphasizing the importance of lifelong supervision and watchfulness for eye problems both from the disease, and from possible complications following surgery or medical therapy. In the most serious cases, one hopes to help a patient have sufficient vision to allow successful completion of their schooling so they have the social tools to survive in their own culture. If this is not possible, the price to the patient in quality of life, to his/her family in effort and expense, and the loss to their society can be extremely high. One study of developing world children found a dramatic decrease in life expectancy from suicide in those who were blind. The loss of income and status of a blind person, the dependency of the blind individual on family and society, and the loss of support that the patient might otherwise provide for elderly parents are considerable!!

Long Term Resource Planning
To help pediatric glaucoma patients, particularly those in the developing world, a number of problems must be identified and overcome:

- A critical number of ophthalmologists must be trained to not only perform surgery on children with glaucoma but also participate in the diagnosis, long-term follow-up, and planning mentioned above, in order to maximally benefit affected children and their families. Major centers should ideally have one or more surgeons who are designated as “specialists” in the field of pediatric glaucoma providing significant expertise and experience for the benefit of the community.

- Instruments and supplies must be made available to put such an effective plan into action. The costs for early treatment are small compared to those of advanced disease: a good reason to identify the disease and intervene successfully earlier!

- Parents and health planners must be made aware of their responsibilities for surgical follow-up and ongoing medical care.
Doctors, nurses, and other primary health care workers in the patient’s local area should be made aware of the subtleties of glaucoma diagnosis and the need for immediate referral of these patients if definitive treatment is not available locally. The same people should then be made aware of the support needed for families and patients in the local area when patients return home from a treatment center.

Anesthesia for pediatric patients must be available for children of all ages. Often anesthesiologists lack the experience or skills to attend children of less than 2 - 6 years of age. Absence of this support at an early age can mean guaranteed blindness in pediatric glaucoma patients who could be denied the benefits of timely surgery. Capacity for childhood anesthesia is necessary for both the assessment and the treatment of glaucoma. This includes the need for proper intra-operative and post-operative supervision, facilities, and personnel in both the tertiary care center and the local health facility that will supervise the child upon returning home.

**General Characteristics**

**Causes of Childhood Glaucoma**

Glaucoma in the pediatric age group can be divided into roughly 3 subtypes: primary infantile (22%), those with associated systemic conditions (46%), and secondary pediatric glaucoma (32%). Examples of the secondary group are uveitic, post infantile cataract surgery, tumor-related (e.g. retinoblastoma), and angle closure (e.g. retinopathy of prematurity, PHPV). The associated pediatric glaucoma group includes such conditions as Sturge-Weber syndrome, neurofibromatosis (NF-1), Axenfeld-Rieger spectrum, and many other disorders with systemic involvement (Table1)

![Primary congenital glaucoma](image1) ![Patient with Sturge-Weber](image2)
### TABLE 1. CHILDHOOD GLAUCOMAS

#### Developmental Glaucomas
1. Primary congenital glaucoma (PCG)
   - Newborn primary congenital glaucoma
   - Infantile primary congenital glaucoma
   - Late-recognized primary congenital glaucoma
2. Juvenile open-angle glaucoma (JOAG)
3. Primary glaucomas associated with systemic diseases
   - 8q23.3 deletion S
   - 9p deletion syndrome
   - Aicardi-Goutieres syndrome
   - Androgen insensitivity, pyloric stenosis
   - Brachmann-deLange syndrome
   - Caudal regression syndrome
   - Cranio-cerebello-cardiac (3C) syndrome
   - Cuts marmorata telangiectatica congenita
   - Diabetes mellitus, polycystic kidneys, hepatic fibrosis, hypothyroidism
   - Epidermal Nevus syndrome (Solomon S)
   - Fetal hydantoin syndrome
   - GAPO syndrome
   - Glaucoma with microcornea and absent sinuses
   - Hepatocereboreal syndrome (Zellweger)
   - Infantile glaucoma with retardation and paralysis
   - Kniest syndrome (skeletal dysplasia)
   - Linear scleroderma
   - Marfan syndrome
   - Michel's syndrome
   - Moyamoya S
   - Mucopolysaccharidosis
   - Nail-patella syndrome
   - Neurofibromatosis
   - Nonprogressive hemiatrophy
   - Oculocerebrorenal syndrome (Lowe)
   - Oculodentodigital dysplasia
   - Phakomatosis pigmentovascularis(PPV)
   - Proteus syndrome
   - Rieger syndrome
   - Roberts' pseudothalidomide syndrome
   - Robinow syndrome
   - Rothmund-Thomson syndrome
   - Rubinstein-Taybi syndrome
   - SHORT syndrome
   - Soto syndrome
   - Stickler syndrome
   - Sturge-Weber syndrome
   - Trisomy 13
   - Trisomy 21 (Down syndrome)
   - Warburg syndrome
   - Wolf-Hirschhorn (4p-) syndrome
4. Primary glaucomas with associated ocular anomalies
   - Aniridia
     - congenital aniridic glaucoma
     - acquired aniridic glaucoma
   - Axenfeld- Rieger anomaly
   - Congenital anterior (corneal) staphyloma
   - Congenital hereditary endothelial dystrophy
   - Congenital iris ectropion syndrome
   - Congenital microcoria
   - Congenital ocular melanosis
   - Idiopathic or familial elevated venous pressure
   - Iridotrabecular dysgenesis (iris hypoplasia)
   - Peters' syndrome
   - Posterior polymorphous dystrophy
   - Sclerocornea

#### Secondary (Acquired) Glaucomas
1. Traumatic glaucoma
   - Acute glaucoma
     - Angle concussion
     - Hyphema
     - Ghost cell glaucoma
   - Glaucoma related to angle-recession
   - Arteriovenous fistula
2. Glaucoma with intraocular neoplasms
   - Aggressive iris nevi
   - Juvenile xanthogranuloma (JXG)
   - Iris rhabdomyosarcoma
   - Leukemia
   - Medulloepithelioma
   - Melanocytoma
   - Melanoma of ciliary body
   - Mucogenic glaucoma with iris stromal cyst
   - Retinoblastoma
3. Glaucoma related to chronic uveitis
   - Angle-blockage mechanisms
     - Synechial angle closure
     - Iris bombe with pupillary block
   - Open-angle glaucoma
   - Trabecular meshwork endothelialization
4. Lens-related glaucoma
   - Phacolytic glaucoma
   - Spheroophakia with pupillary block
   - Subluxation-dislocation with pupillary block
     - Axial-sulubexation high-myopia syndrome
     - Ectopia lentis et pupillae
   - Homocystinuria
   - Marfan syndrome
   - Well-Marchesani syndrome
5. Glaucoma following lensectomy for congenital cataracts
   - Infantile aphakic open-angle glaucoma
   - Pupillary-block glaucoma
6. Glaucoma related to corticosteroids
7. Glaucoma secondary to ruberosis
   - Coats' disease
   - Familial exudative vitreoretinopathy
   - Medulloepithelioma
   - Retinoblastoma
   - Subacute/chronic retinal detachment
8. Angle-closure glaucoma
   - Central retinal vein occlusion
   - Cicatrical retinopathy of prematurity
   - Ciliary body cysts
   - Congenital pupillary iris-lens membrane
   - Laser therapy for threshold ROP
   - Microphthalmos
   - Nanophthalmos
   - Persistent hyperplastic primary vitreous
   - Retinoblastoma
   - Topiramate therapy
9. Malignant glaucoma
10. Glaucoma associated with increased venous pressure
    - Cavernous or dural A-V shunt
    - Orbital disease
    - Sturge-Weber syndrome
11. Intraocular infection related glaucoma
    - Acute herpetic iritis
    - Acute recurrent toxoplasmosis
    - Endogenous endophthalmitis
    - Maternal rubella infection
12. Glaucoma secondary to unknown etiology
    - Iridocorneal endothelial syndrome (ICE)
13. Secondary glaucomas associated with hereditary ocular conditions
    - Ectopia lentis disorders
    - Primary angle-closure glaucoma
    - Nanophthalmos
    - Retinoblastoma
**Childhood Glaucoma: Signs, Age of Onset, Prognosis**

Any glaucoma appearing before 3 years of age may produce enlargement of the cornea and globe (buphthalmos) and often causes clouding of the cornea and photophobia. After age 3 years, the eye will typically not enlarge, but corneal edema or increased cupping may occur and may be the only signs of glaucoma aside from a decrease in functional vision. Most patients with primary infantile glaucoma will present within the first year. Glaucoma presenting at birth has a poorer prognosis with about 50% of children being legally blind in spite of treatment. Glaucoma developing between 3 and 12 months and receiving successful treatment have up to a 90% chance of obtaining good vision. But, glaucoma can present at any age. Later presentation (e.g. juvenile open angle glaucoma, complicating chronic uveitis) may occur in patients up to 35 years of age or beyond, although it may be confused with adult glaucoma at that point.

Glaucoma associated with Sturge-Weber syndrome, neurofibromatosis, and aniridia may be congenital or present later in childhood or early teens. A thorough knowledge of the natural history of these diseases is necessary to alert the eye care team about the potential onset of glaucoma.

**Infantile Primary “Congenital” Glaucoma**

This is the most commonly thought of diagnosis in the pediatric glaucoma group but it comprises slightly less than about 25% of pediatric glaucomas. It is an hereditary eye disease that usually has no associated primary abnormalities of the eye or body.
The incidence of primary infantile glaucoma is said to be about 1 in 10,000 live births and is more common in boys. It is usually, but not exclusively, bilateral.*

**Symptoms of pediatric glaucoma:**

Photophobia, tearing, reduced vision from cloudy cornea

**Signs of pediatric glaucoma:**

Enlarged corneas, corneal edema, tearing, photophobia, increased intraocular pressure (not obligatory during an examination under anesthesia (EUA), abnormal optic nerve cupping, breaks (tears) in Descemet’s membrane (Haab’s striae).

Children with any of the signs and symptoms listed above should be evaluated thoroughly in the clinical setting for glaucoma. As complete a history and examination as possible should be performed before taking the next step - an examination under anesthesia (EUA) - or if suspicion is low, a period of observation. This pediatric glaucoma examination should be carried out in a quiet-supportive atmosphere and with the assistance of parents to obtain as much information as possible.

Examination while the infant is feeding or under minimal sedation creates an environment making possible a more complete examination. Tonometry and several other steps found on the list mentioned below may be successful. However, when a diagnosis of glaucoma is made or even suspected, an EUA will be necessary. Although the natural tendency is to only take an IOP measurement with a tonometer, this alone is not sufficient to confirm or exclude the diagnosis of glaucoma in the child. Remember, glaucoma may also be only one aspect of a larger problem such as

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* Orbis experience in southern Ethiopia suggests a higher prevalence, not related to consanguinity, as evidenced by 16 cases of presumed congenital glaucoma being treated in children between age 3 months and 10 years in a 12-month period.
retinoblastoma, retinopathy of prematurity (ROP), uveitis, etc. In most cases, an EUA is needed to fully examine a child and to make a diagnosis. EUA is the cornerstone of diagnosis and management of children who are unable to allow a comprehensive awake examination.

The first part of the examination may be done in the office with a cooperative patient. This allows the examiner to assess: vision, the presence or absence of strabismus, refraction, and examination of the fundi with a dilated pupil. This will allow the child at the time of EUA to be examined more thoroughly for these parameters (excluding vision assessment) while avoiding the need for pupil dilatation and cycloplegia that would otherwise make surgery more difficult or impossible, if it were to be done at the time of the EUA. Refraction is an important part of the preoperative examination. It helps with the identification of an enlarging globe (increased axial length reflected as decreasing hyperopia or increasing myopia) due to elevated IOP in a distensible globe, and makes possible the prescription of appropriate glasses to optimize visual outcome.

**Infantile Aphakic Glaucoma**

Special mention about pediatric post-cataract patients should be made here. A large percent of infants who undergo cataract surgery will develop aphakic / pseudophakic glaucoma. The onset of this glaucoma may be early after surgery or occur later in childhood. The average age of onset is approximately 8 years after cataract surgery, but it can occur at any time. Children who undergo surgery for cataract in the first 6 months of life, represented by infants with microphthalmia, nuclear cataracts, or PHPV are at the highest risk. But any child after cataract surgery can develop open or closed angle aphakic glaucoma. These post-cataract patients should be frequently examined for glaucoma and on a regular schedule. Glaucoma screening should be part of every follow-up examination for the remainder of the lives of these children, even when IOP measurements are not possible. Early signs of glaucoma may include decreased aphakic refraction (reduced plus power from globe elongation), corneal clouding or enlargement (at an early age), or optic nerve cupping. Note of the optic nerve heads is a necessary part of any post-cataract examination in the office or in the operating room. As mentioned above the IOP is very important but the diagnosis of glaucoma initially or in follow up is best made from the optic nerve primarily with IOP as the main risk factor.

**Examination under Anesthesia (EUA)**

**General Considerations**

The examination under anesthesia (EUA) goals are to diagnose and to properly classify the type of glaucoma, identify any primary etiologies, set a baseline for future comparison, document findings necessary to develop a treatment plan, and monitor the
effects of treatment. A complete exam of the anterior and posterior segments is needed
to accomplish these goals. Also, the whole child should be examined for signs of orbital
changes, skin (neurofibromatosis, Sturge-Weber), or other organ involvement indicating
disease associated with glaucoma.

**Equipment for EUA**

Readers are reminded that not all of these pieces of equipment are absolutely
necessary but each instrument does add to the quality of examination. In short, do the
best you can with what you have.

- Calipers or ruler (ruler can also be used to check accuracy of the caliper scale)
- Direct ophthalmoscope
- Indirect ophthalmoscope with 20D condensing lens
- Retinoscope and loose refracting lenses or bars
- Goniolens for examination of the angle and perhaps the fundus - if it is a direct-viewing model, with fluid for lens-cornea contact
- Eyelid speculum (handy, but not essential)
- Hand-held slit lamp (shown) or operating microscope
- Tonometer (Schiotz, Perkins®, TONO-PEN® or other applanation device)
- Pachymeter (not essential, but very useful)
SEVEN STEPS IN THE CONDUCT OF AN EXAMINATION UNDER ANESTHESIA

In order to gain as much information as possible there is an efficient order in which parts of the EUA should be planned and carried out. Where possible, we recommend pharmacologic dilation of the pupil for the EUA after IOP is measured and the anterior segment is examined - *in those cases where surgery is not contemplated*. In cases where only one surgery is possible it is better to dilate the child in the office / outpatient department preoperatively so as to maintain a small pupil for possible surgery. It is helpful at each step to establish a routine in which the right eye is examined before the left eye and then the findings recorded in that order. This will help avoid confusion and error later when records are consulted. If the disease is unilateral, one should still examine in every case the normal, unaffected, eye as well for comparison. Also, remember that children who require ongoing EUAs, must also have periodic awake examinations to test vision, pupillary reactions (afferent pupillary defects), strabismus, and to monitor amblyopia treatment.
Step 1: Cornea and Anterior Segment

An operating microscope or hand-held slit lamp are essential pieces of equipment to examine for:

A. Cornea edema that is noted to be slowly disappearing may suggest that the intraocular pressure (IOP) was elevated moments before, and anesthesia may be lowering it. There may be epithelial edema alone or there may be stromal edema as well. When the stroma is cloudy, the hazy media may not be corrected by removal of the epithelium. There may also be localized and often linear edema, due to a new Haab’s striae. Also consider: glaucoma, Hurler syndrome, or CHED (congenital hereditary endothelial dystrophy). Other causes for corneal opacity are: keratitis (herpes, rubella), Peters’ anomaly, storage diseases, congenital corneal dystrophy, and forceps-related birth trauma.

B. Horizontal diameter (white to white) may be increased when the onset of glaucoma is before 3 years of age. This measurement can be done with calipers or with a ruler held close to the eye.

An enlarged cornea may be found in congenital megalocornea. This condition is always bilateral and present in boys (x-linked recessive). It is often associated with iris transillumination defects, pigment dispersion on the lens, angle structures, and cornea. The enlarged anterior segment in megalocornea is not associated with an enlarged antero-posterior globe length evident on ultrasound or refraction. The eye pressures are normal.

C. Corneal & iris structure. These include breaks in Descemet’s membrane [Haab’s striae]. Other findings should be noted including: peripheral opacification and pannus in aniridia in older children, posterior embryotoxon in Axenfeld-Rieger, and Lisch nodules in neurofibromatosis (NF). (Note: Lisch nodules are very rare in infants with NF and very rare in eyes with glaucoma secondary to NF; look for them in the fellow eye). In neurofibromatosis, an ectropion uvea is frequently present as well as an hypoplastic iris. It is also an important sign of the iris ectropion syndrome, a condition frequently complicated by childhood glaucoma. Although the anterior chamber cells of uveitis are very hard to see without a standard awake slit lamp examination, keratitic precipitates
(KP) can be seen on the corneal endothelium and synechiae may be seen also. If available, pachymetry will help to interpret the relative values of IOP. The iris is often thin and hypoplastic in Axenfeld-Rieger’s abnormality and associated with irregular pupils but this may not appear until a number of months post-natally.

**Step 2: Intraocular Pressure (IOP)**

In order to minimize changes to the cornea from tonometer trauma IOP measurements are done carefully. In the case of scarring of the cornea, an attempt to determine the IOP is best done using the clearest and most normal appearing part of the cornea. Any tonometer (Schiotz or applanation) may be used by the same type should be used for every examination as slight variations may be introduced otherwise. If no tonometer is available, or the cornea is unsuitable for IOP measurement (from scarring, band keratopathy, etc.), use finger tension to estimate IOP. Some surgeons advocate early IOP determination before corneal examination so as to decrease the effect of anesthesia-induced reduction of the IOP.

Sources of artifact in determining IOP include:

- **Falsely low IOP:** Halothane and related inhalation agents, corneal epithelial edema, if using Perkins – too much fluorescein on the eye surface causing large mires, hyperventilation with low end tidal CO2, poor systemic hydration, thin corneas.

- **Falsely high IOP:** patient not fully asleep, pressure from mask, pressure from speculum, ketamine, intubation (up to 5 minutes after intubation), malfunctioning Tonopen (try replacing batteries), hypoventilation with high end tidal CO2, small thickened cornea

**Step 3: Posterior Segment**

Detailed examination and documentation of the optic nerve head (ONH) and surrounding retina should be made for purposes of diagnosis and for future comparison. Examination with a 20D lens and indirect ophthalmoscope may not give enough detail to draw an accurate depiction of the ONH. An exact image of the ONH can be obtained using a portable camera with good quality output. On the other hand, direct ophthalmoscopy will provide details of the neuroretinal rim width, size of optic nerve head, and blood vessel pattern which, when drawn accurately, are excellent for follow-up. The remainder of the retina is also examined for associated pathology – mainly tumors, abnormal tissue, or malformations.

Another useful technique is to apply a smooth-domed direct gonioscopy lens to the cornea in conjunction with a direct ophthalmoscope that is used to view the fundus through the goniolens and an undilated pupil. This magnifies the optic nerve head by about 10-15% and allows extended examination without drying the cornea.
Step 4: Gonioscopy

A direct (Koeppe-style) goniolens with a hand-held slit lamp or tilting operating microscope or an indirect goniolenscope (Goldmann, Sussman, or Zeiss) with the operating microscope can all be used equally well. The newborn or infantile angle is immature and different from the adult angle. There is often a high insertion of the iris in newborns with glaucoma. Increased opacification of the angle tissues is characteristic of infantile primary congenital glaucomas. Signs of neovascularization from tumors or cicatricial ROP may be recognized. This is also an opportunity to assess the angle for future or previous angle surgery, or for trauma. In the case of a central corneal opacity, gonioscopy may be the only way in which the anterior segment can be seen.

Step 5: Supplemental Examination

An ultrasound examination determines the axial length and, where media opacities prevent a good view of the posterior or anterior segments provides some useful information. It is also beneficial for those children who have crowded orbits (mainly Asians) and are being considered for tube implant surgery. The implant plates can be difficult to insert in a crowded orbit so planning with ultrasound results may be helpful before performing this type of surgery. Similar to monitoring corneal diameter, monitoring the axial length of young children’s eyes provides examiners with an objective measure of IOP control over time. If one eye is noted to be increasing in axial length at a significantly greater rate compared to the other eye, or from established guidelines for normal growth; it can be assumed that the IOP of the elongating eye is too high. This can also be ascertained indirectly by refraction, as evidenced by increasing myopia or decreasing hyperopia.

If pachymetry is available it should be done as the last stage of the EUA to avoid corneal distortion.

Step 6: Diagnostic Paradigm

With information gained during the EUA, a great deal of information is available, but what “weight” should be given to each of the findings and to them as a whole in trying to arrive at a working diagnosis? What is most important for assessing the child’s condition and planning treatment? We know IOP is affected by many variables (see above). From this, we can assume that while IOP determination is important, it is not the best single criterion for diagnosing glaucoma without other more reliable parameters. Making a diagnosis of glaucoma is like fitting together the pieces of a puzzle. To do the job right, all of the parts must fit. For example, it is not uncommon for a newborn infant with glaucoma to have a low applanation IOP. The status of the cornea (size, edema, appearance of [new] Haab’s striae) and the ONH are more reliable for determining the initial diagnosis and the continuing status of the eye. Detailed drawings or pictures done at each EUA of the optic nerve and Haab’s striae, for example, are useful for assessing changes in the condition. Imitators of glaucoma
must be ruled out. Remember congenital megalocornea (usually X-linked recessive with iris transillumination and no Descemet's breaks); birth trauma from forceps (these may cause breaks in Descemet's membrane that are vertical and straight unlike the scalloped multidirectional Haab's striae), coloboma of the optic nerve, optic pits, and other conditions can be confusing when attempting to arrive at a final diagnosis of glaucoma.

In short, the emphasis should be on ONH and cornea findings as objective signs of disease or its progression. IOP is important but is not as objective. IOP is important if it is extremely high and no extraocular reason is found for it. It must be remembered that once surgery is done on a child the child is automatically labeled as “glaucoma”, thus the responsibility is on the first surgeon to properly assess and diagnose the disease, determine its etiology, and to document its initial findings.

**Step 7: EUA Summary**

At the end of the EUA, and using the paradigm described above, a diagnosis of glaucoma should be possible or at least suggested in appropriate cases and a baseline for treatment and future follow-up established. The criteria for diagnosis in primary infantile and other pediatric glaucomas may include typical changes in the cornea, gonioscopic abnormalities, and optic nerve head cupping along with elevation of the IOP. Other findings include increased axial length, increasing myopia, photophobia, and family history. The examiner’s experience and awareness of all of the possibilities will help with the assessment of these patients. In those cases where associated pathology is found, appropriate steps should be taken to deal with the primary problem, but the glaucoma may have to be treated even in the face of such disease. After these seven steps have been completed, one can then proceed with surgical intervention or with medical treatment.

**Medical Treatment of the Pediatric Glaucomas**

Although discussion of this subject is not the main purpose of this paper, medical therapy is indicated and necessary for at least part of the treatment in many cases of pediatric glaucoma. A short overview will therefore be given describing those circumstances where medical therapy is indicated. These indications will deal mainly with secondary or associated glaucomas (with notable exceptions), and in those cases where children are too sick from other diagnoses to withstand a surgical procedure. Generally, surgery is the preferred treatment of choice for primary infantile glaucoma. Most other forms of pediatric glaucoma should be managed initially with a course of medicine. Moreover, after a surgical procedure has been done, medical management should be tried before proceeding to the next surgery. *The exception to this rule is goniotomy or trabeculotomy where a second procedure, after a suitable post-operative time period, should be attempted.*
The main concern with medical therapy is toxicity from various agents. But, it is fortunate that most anti-glaucoma medications are tolerated far better in children than in adults. The one exception is the alpha-2 agonists (brimonidine and to a lesser extent apraclonidine), which may cause hypotension, bradycardia, and apnea. These agents cross the blood-brain barrier and should never be used in the first year of life and should be avoided in most other pediatric cases. They may cause sleepiness even in older children or those with small-body-mass. Adverse drug reactions in children are mainly related to drug dose-to-weight ratios. In the first year of life and for the same reason in older children, it is best to use 0.25% beta-blockers rather than 0.5%. Where practical, parents of particularly small or young children should be instructed in the technique of punctal occlusion when using these drugs. Other drugs including topical carbonic anhydrase agents and prostaglandins are well tolerated by children. Prostaglandins can even be used in children with uveitis but may not be as effective as in adults. Pilocarpine is not a very effective drug for pediatric glaucoma and headaches and myopic shift may be greater in children. Oral carbonic anhydrase inhibitors are surprisingly well tolerated and effective in children. However, when they are used it is important to monitor weight and height because these children so treated may suffer from failure-to-thrive.

**SURGICAL TREATMENT OF THE PEDIATRIC GLAUCOMAS**

**General Considerations**

There are a number of surgical options available for treatment of the pediatric glaucomas including: goniotomy, trabeculotomy, trabeculectomy, trabeculectomy-otomy, tube implants, and cyclodestructive procedures. These should always be used with the understanding that a child is being treated, not an adult. The least destructive and minimally distorting surgical procedures should be done initially. This will minimize the potential for complications while making available other needed surgical procedures to be performed later for the child suffering from this “lifelong disease”. Just because a surgeon is able to perform a given procedure should not be the main criterion for choosing it over one that could be more beneficial in a given situation. In such a case, it would be beneficial for the most effective procedure to be done by another surgeon. One of the compelling reasons to establish 1, 2, or more recognized pediatric glaucoma surgeons in a center is that they are more likely to have a series of surgical options at their disposal and not just one or two.

**Goniotomy**

Not many surgeons perform goniotomy, but with proper training, it is relatively simple to do under good conditions. It is the least invasive, most effective procedure for most infantile glaucomas. Goniotomy has a relatively high degree of success and few complications. When complications do occur they include: cyclodialysis, iridodialysis, synechiae, and in rare cases when the blade disrupts the lens capsule, cataract.
Goniotomy is comparable to trabeculotomy in success rate, although trabeculotomy has the disadvantage of causing much more tissue distortion and scarring. Goniotomy has the advantage of being a “low technology” procedure requiring just a few relatively low cost instruments and for that reason can be readily introduced to a community with limited resources. Unfortunately, some cases of pediatric glaucoma, especially those that present in an advanced state, are not amenable to goniotomy because this technique requires a relatively clear cornea for safe and effective application. This downside may be particularly problematic in developing countries where access to care is more difficult and patients frequently present later and with more advanced stages of disease.

Equipment
1. Although commonly done with a microscope, goniotomy may be done with 2-3x loupes and a co-axial headlight. If done with a microscope, the head of the scope must be able to tilt to 30-45 degrees, although the angle of maximum advantage between the child’s eye and the microscope may be attained by simply tilting the patient’s head away from the surgeon.
2. An operating goniolens for goniotomy (e.g. Swan-Jacob with handle (Ocular Instruments Item # OSJAG) or Barkan operating lens.)

3. A 25-gauge needle on a syringe (0.5-2.0 cc) – with viscoelastic, if possible. Ringer’s lactate, Balanced Salt SolutionR (BSS) or hydroxymethylcellulose are alternatives.

4. Two locking fixation forceps of your choice (e.g. Elschnig-O’Connor) to fixate the eye (non-locking forceps can be used by the assistant, but they make it more difficult to sustain constant pressure for longer times.)

**Procedure**

Goniotomy can be done immediately after an EUA or as a specifically scheduled procedure. But for safety and a better view of the angle, it should be performed with a non-dilated pupil. Bilateral surgery may be done in one sitting, but a complete re-scrub of the patient and surgical team and re-draping of the patient is required. In addition, a second set of instruments should be used or the first set of instruments should be re-sterilized. These steps are required to decrease the possibility of cross-contamination with resulting endophthalmitis that could lead, in the worst case, to bilateral blindness.

The steps of goniotomy are shown in A-D
The nasal angle is normally done first simply because it is technically easier. The surgeon sits temporal to the eye and the assistant sits opposite, on the other side of the patient. The patient’s head is rotated away from the surgeon making it easier to visualize the nasal angle. Now, the goniolens is placed on the eye to ensure that the nasal angle can be viewed. The inferior rectus is then grasped at its insertion with one forcep and the eye depressed to allow easier access to the superior rectus, which is now fixed with the second forceps. The surgeon usually places these forceps. A speculum is not recommended because it can interfere with the forceps and other instruments. Usually, sufficient exposure is obtained without one. The forceps are handed over to the assistant who handles the forceps carefully so as to not obstruct the surgeon’s view. It is important to have the assistant practice rotating the eye, while keeping the iris plane steady and parallel to the planned entry and path of the goniotomy blade across the anterior chamber. This will make it easier for the surgeon who has a limited depth of focus and very little room between the cornea and iris.

With the lens on the cornea, the angle is checked for visibility. If the angle is not seen well, the corneal epithelium may be scraped off using a blade or rubbed off after applying sterile glycerin. The epithelium just anterior to the limbus should be left undisturbed and in cases of aniridia, the epithelium should never be scraped off. The syringe-needle unit is grasped like a pen and is oriented to make it parallel to the iris. With the angle in view and the eye securely fixated, the 25-gauge needle, bevel-up on the air-free syringe, enters the anterior chamber through peripheral clear cornea at the temporal side (3 o’clock right eye and 9 o’clock left eye) under direct vision. Once the needle is 1/4 - 1/3 across the AC, the lens is moved slightly toward the surgeon making it possible for him / her to follow the tip of the needle into the angle under direct vision. The angle structures to identify are blood vessels in the angle that loop upward and then backward to the iris root stroma. A cut in the filmy tissue just anterior to the loop of the blood vessels is ideal positioning. If blood vessels are not seen, the cut is made into the filmy tissue just anterior to the iris root stroma. Short sweeps of the needle in one direction or the other will commonly produce a white line on the sclera as the iris drops backward. The 25-gauge needle should be inserted no further than one quarter of the bevel length. At no time should the surgeon feel resistance on the needle as the cut is made. Technical evidence of a successful goniotomy is visual and not tactile. A gritty feeling at the needle tip in primary glaucoma indicates that the tip of the needle is too deep and may result in bleeding. In Axenfeld-Rieger, and in uveitis some grittiness may be felt as the needle knife is cutting tissue in the angle. The goniolens technique will enable about 4 clock hours of goniotomy (2 to the right and 2 to the left) before the eye is rotated one way, and then the other, by the assistant. Access to additional clock hours in the angle is accomplished with a smooth and slow rotation of the eye by the assistant – maintaining proper iris plane stability at all times. While the assistant is rotating the eye, the needle should be removed from the angle, but remain over the nasal iris.

When the procedure is completed, withdrawal of the needle is done swiftly to avoid any touch of the iris or crystalline lens. Viscoelastic or other fluid in the syringe may be injected prior to needle withdrawal, or it can be done if the AC shallows during surgery.
Fluid may also be inserted after the cutting instrument is removed from the eye. The AC usually shallows or becomes totally flat after goniotomy, and then spontaneously reforms in about 15-30 minutes. This should be prevented or minimized when doing surgery on a Sturge-Weber patient in order to prevent bleeding. Steroid and antibiotic ointment can be instilled at the conclusion of surgery and the eye is patched and a shield is placed.

The patient should be seen on the first postoperative day and then every few days for a week or two according to availability. Post-op care is routinely with steroids and antibiotic drops, but if no inflammation is encountered steroids may be omitted. Drops rather than ointment are easier to instill in the awake infant. Special care should be exercised to avoid trauma to the eye during the immediate post-operative period. Patients can demonstrate a variety of responses in the first few days to weeks. One to two months after surgery an EUA may be done to check for results including: clearing of the cornea, stable or reduced cupping of the optic nerve, and reduction in the IOP. In small children, reversal of the cupping is often seen. A second (temporal or inferior) goniotomy may be performed later to further improve the eye pressure. This is done if any of the criteria mentioned earlier indicating need for surgery are noted, showing no or little success with the first surgery or if there are signs of progression of the disease.

The white line indicates successful goniotomy with the iris plane falling back exposing the angle.
Goniotomy is used for primary infantile glaucoma but may also be used for late-onset infantile glaucoma, congenital rubella syndrome, neurofibromatosis, Sturge-Weber syndrome, uveitic glaucoma, aphakic glaucoma with goniodysgenesis, and some juvenile glaucomas with varying degrees of success. The success rate of goniotomy is remarkable but, like all other medical and surgical options for this disease, results may not be life-long. Success is highest with infantile glaucoma treated between 3 months and 1 year and is between 70-90% effective after 1-2 procedures. In neurofibromatosis and newborn primary infantile glaucoma the success rate is poor.


**Trabeculotomy**

This procedure is the equivalent of goniotomy in success rate, but it differs from goniotomy in that it destroys or alters more tissue than a goniotomy. However, trabeculotomy does offer an alternative to goniotomy in the case of a cloudy cornea or where the surgeon is uncomfortable in performing goniotomy.

**Equipment**

A simple set of instruments and supplies are required as for trabeculectomy. These include:

- A sharp, pointed knife to cut down on the canal of Schlemm
- A rounded knife that might be used in trabeculectomy e.g. #15 or better
- A set of trabeculotomes (right and left)

Right and left trabeculotomes
Procedure

The conjunctiva is opened at the limbus employing a fornix-based flap of conjunctiva. Before this, fixation is achieved using a superior rectus bridle or peripheral corneal suture. An inferonasal or inferotemporal self-sealing paracentesis is recommended to deal with potential anterior chamber (AC) collapse that could occur part way through the procedure. Dissection of Tenon’s and episclera should be carried out to expose bare sclera. Assessment of the bare sclera at the limbus will help in finding the Canal of Schlemm (CS), but this is often difficult to identify using the location of blood in the CS. Aqueous veins, with half blood and half clear aqueous may suggest the CS location viewed from the scleral surface.

A half-thickness scleral flap of about 4x4 mm is then dissected, hinged at the limbus. If in doubt, a longer posterior dissection from the limbus may be needed to have access to a CS that has been displaced more than expected due to globe enlargement. This will reveal the “blue zone” between cornea and sclera. About 1 mm behind this zone is where the CS may be found.

Enlargement of the eye distorts normal anatomy so these hints may be very useful or not, as the surgeon looks for the CS. A radial incision in a dry field using a sharp-pointed blade under high magnification is then made in the scleral bed, scratching down carefully while spreading the incision walls until the circular scleral fibers near the CS are encountered. A small drop of aqueous indicates entrance into the CS. Under ideal circumstances, the concave inner wall of the CS will be seen reflecting back from the depths of the dissection. If the first attempt at finding CS fails, another radial incision can be attempted within the same scleral bed to either side of the first. Small circumferential cuts can be made to partially unroof the CS to the right and left of the incision. This is done to allow easier passage of the trabeculotomes into the CS.

Passage of one of the probes is attempted while stabilizing the globe. The probe is passed gently, parallel to the limbus. The fit of the probe in the canal is usually tight. This is normal. Extremely easy passage of the probe with no resistance may indicate a false passageway into the suprachoroidal space or AC. The probe improperly placed in this case will rotate freely posteriorly or into the AC where the probe can be rotated into view. With the probe fully inserted into the CS, it can be rotated into the anterior chamber while avoiding the iris root and Descemet’s. This is done by holding the tip firmly against the sclera. This will minimize the chances of disinserting the iris root or creating a Descemet’s tear. Slow rotation allows the tip to be just seen in the AC and at the same time be gradually withdrawn as the meshwork is torn to its greatest extent. Rotation of the trabeculotome should be only to about 70 degrees, retaining a small bit of tissue immediately in line with the scleral wound. This will decrease the chances of loss of the AC. If successful, the other probe can be passed in a similar fashion without need to refill the AC. If it does collapse, the AC can be refilled with fluid or viscoelastic. Care should be taken to avoid damaging the corneal endothelium with the probe tip. Withdrawal of the tip should be in a radial direction on both occasions. A hyphema may occur from either side of the angle that has been torn. This will resorb in a few days.
Some surgeons prefer to pre-cannulate the CS in both directions (to the right and to the left) with a small, 2-inch segment of a stiff suture, such as 6-0 Prolene. This allows one to confirm the correct location within CS. For example, if the suture appears in the AC, it is placed too far anterior. This maneuver also assists with identification of the CS if one should lose AC depth during the first half of the procedure as the initial trabeculotome is rotated into the anterior chamber.

It is also possible, using a longer piece of the same suture to perform a 360° trabeculotomy although this is more difficult for most surgeons. This is done by threading the suture for 360° degrees and then pulling the suture tight to incise the trabecular meshwork as the suture loop passes across the AC. A 360° trabeculotomy should only be attempted as an initial procedure and the tip of the suture should be blunted by application of light cautery to the tip. Attempting this technique in eyes that have had prior angle surgery may be more likely to create a false passage into the posterior chamber or sub-retinal space.

Repair of the sclera and conjunctiva is performed as in a trabeculectomy but, because this is probably being done in a child, an absorbable suture is preferred. The flap should be closed tightly. The radial incision used to identify CS may or may not be closed. The conjunctiva can be closed with 8-0 vicryl suture as well.
If the trabeculotomy is not successful, the procedure may be converted to a trabeculectomy. But if mitomycin or 5FU is not used, the result is likely to fail in the long term.

The procedure may also be combined as a trabeculectomy-otomy. Well-respected authors (Mandal AK and Netland PA) have written of this procedure and claim good results in their patients (2/3 “successful” IOP levels at 6 years) but as with other procedures, success is often not life-long.

The eye is dressed and post-operative care conducted as described above for goniotomy. In addition cycloplegic drops are used.


Surgeons who manage pediatric glaucomas should strive to become comfortable with both goniotomy and trabeculotomy surgery techniques. These are complementary procedures. Goniotomy requires a clear cornea and provides excellent access to the nasal and temporal angle structures. Conversely, trabeculotomies may be performed on cloudy or even opaque corneas and provide excellent access to superior and temporal angle portions of the angle. In cases of congenital or infantile glaucoma, it is preferable to open the entire angle prior to proceeding to other, less physiologic surgical interventions such as: tube implants, trabeculectomy, or cyclodestruction. Complete angle surgery employing goniotomy/trabeculotomy may require two or more separate surgeries to accomplish.

**Trabeculectomy**

As briefly mentioned above, the likelihood of success over the long-term with trabeculectomy is lower in aphakia and in infants / children due to scarring leading to a non-functioning bleb. The success rate has been reported as being higher in Indian patients, but in most other countries healing properties of children lead to failure in nearly every case due to scarring at the episcleral level.

Antimetabolites have been used with some success, but the fear of thin-walled blebs is always present. This occurs in 33 to 66% after 18 months using 0.2% or 0.4% mitomycin-C. This is a concern especially in countries where a large portion of the children live in an agricultural setting and where the chance of contamination/infection is high. As with most developing world countries, follow-up is unpredictable at best, and even when successful; most support staff in remote locations may not be able to assess post-operative eyes effectively. This may result in post-operative failure after uneventful and successful surgery due to unrecognized problems such as endophthalmitis, cataracts, corneal decompensation, or flat anterior chamber.
For most patients a fornix based conjunctival flap results in a broader and far superior drainage area and lessens the future incidence of bleb revisions for thinning blebs. Every effort should be made to apply the antimetabolite drug exclusively to the sclera posterior to the scleral flap in the hope of establishing aqueous flow away from the limbus. This will further decrease the chances of a thin-walled bleb. Parents must understand that observation of the eye is very important even years later, and peripheral support staff (doctors and nurses) must be consulted at any time if doubts exist about the eye status.

Tube Implant Procedures

If angle surgery is unsuccessful or if the child has a form of glaucoma that is not typically amenable to angle surgery (aphakic/pseudophakic glaucoma without goniodysgenesis, Axenfeld-Rieger with prominent iridocorneal strands); tube implant procedures may be necessary. Like trabeculectomy, tube implants provide an alternative outflow path that bypasses the CS, and implants also provide a bleb well posterior to the limbus. The procedure is easy to learn and is very effective at providing rapid and substantial lowering of IOP in children of all ages. Additionally, tube implantation does not require the application of antimetabolite compounds although excessive postoperative inflammation can lead to failure of bleb permeability and a rise in IOP unless the inflammation is specifically and aggressively suppressed.

There are generally two types of tube implant: valved and non-valved. The valved form (e.g. Ahmed) offers immediate IOP reduction but obstructs free outflow from the device into the surrounding tissues thus maintaining physiological levels of IOP until the healing of tissues offers its own resistance to flow. If no valve were present, the IOP would be zero and hypotonous changes would inevitably occur in the eye. The non-valved devices (e.g. Molteno, Baerveldt) offer no resistance and therefore the tubes must be temporarily occluded usually by sutures, removed after a time, or until the suture dissolves. This usually takes about 3-8 weeks during which time the IOP may be elevated, thus requiring treatment until the tube opens. It is rarely necessary to open the tube surgically but it may be necessary in some cases. There are conflicting reports
that the non-valved devices lead to longer life for IOP reduction over those with valves. One must bear in mind the potential disadvantages of these implants. These include: opacification of cornea or lens if the tube tip lies in close proximity to these structures for a prolonged period of time. Also, erosion of the scleral patch graft and/or conjunctiva used to cover the tube, iritis, and if erosion occurs, endophthalmitis. Additionally, the expense of such implants may preclude their use in patients with limited resources. It is highly recommended to all surgeons that the tube be sutured loosely to the sclera with non-absorbable material, and donor sclera or other sources of tectonic grafts be used to reinforce the tube covering. This decreases the chances of erosion. Erosion and other complications associated with tube implantation procedures require surgeons to have a working knowledge of how to solve problems associated with the procedure.

**Equipment**

- Same instruments as for a routine trabeculectomy procedure
- A tube implant device
- Sclera from an eye bank or other source (screened for infectious diseases including HIV, other sexually transmitted diseases, and hepatitis) or other patch material
- A 22- or 23-gauge needle for introduction of the tube into the AC
- 6-0 to 8-0 non-absorbable suture for securing the plate to the sclera permanently
- 8-0 non-absorbable suture to secure the tube to the sclera
- 8-0 vicryl or other absorbable suture to repair conjunctiva and donor material

A valved tube implant (Ahmed); B non-valved tube implant (Molteno)
Procedure

Many different styles and sizes of tube implant devices exist but the basic implant technique is the same. A limbal peritomy is created, typically in the superior-temporal quadrant. Blunt dissection opens the potential space beneath Tenon’s capsule, taking care to avoid the rectus and oblique muscles. If the device is a “valved” implant, such as an Ahmed, it should be primed with Balanced Salt Solution® (BSS) or Ringer’s lactate to confirm that the valve is open. The tube plate(s) is then sutured in place using non-absorbable sutures, e.g. 6-0 black silk, so that the leading edge is 8-10 mm posterior to the limbus. Note that in children this may not be possible and distances of 5-7 mm are acceptable. In a microphthalmic eye, especially if less than 18mm in length, one must be careful that the plate does not touch the optic nerve. This can be accomplished by using a pediatric-sized device with anterior placement. Otherwise, adult size devices may be used. In some cases (e.g. Baerveldt), the implant plates can be trimmed to accommodate the smaller dimensions of some eyes or where retinal or other hardware complicates insertion.

A self-sealing paracentesis is always a good option so there is an alternative entry to the AC. The tube is then trimmed with bevel up so that when inserted it will extend 2-4 mm into the anterior chamber. A 22 or 23-gauge needle is used to enter the anterior chamber, just posterior to the limbus in a plane that is parallel to the iris. The tube is inserted through this opening such that it is touching neither the iris surface nor the corneal endothelium. If needed, air or viscoelastic may be used to reform the anterior chamber via the paracentesis, and may be left in the eye to help reduce the incidence of postoperative hypotony. As mentioned above, a means of occluding the tube in non-valved implants is mandatory. Most commonly this is done using a 6-0 vicryl suture. The tube occlusion must be confirmed with Ringer’s lactate in a syringe using a 30 gauge needle or cannula.

The tube should be covered with a 4 x 6 mm patch of processed sclera or cornea (or with tissue dissected from a donor eye at the same sitting), banked dura or pericardium. If this type of tissue is not available, the entry into the anterior chamber may be created under a partial thickness, limbus-based scleral flap similar to that used for a trabeculectomy or trabeculotomy. Alternatively, a partial thickness scleral patch can be dissected from an area adjacent to the tube placement and used to cover the tube. When sclera in the host eye is still attached at the limbus, the tube entry should be directed somewhat posteriorly as it will be canted anteriorly when the flap is sewn back into place. Pars plana tubes are an option for aphakic children but the formed nature of the pediatric vitreous will lower success rates unless a total vitrectomy has been performed previously or will be done at the same time as the tube is placed.

After instilling atropine, antibiotic, and steroid ointments the eye is patched and shielded. Daily postoperative follow-up is recommended for at least the first several days as hypotony due to overflow or leak around the tube or even high IOP may occur. Early complications may include iris or vitreous in the tube, corneal touch by the tube,
iritis, hyphema, conjunctival or scleral patch retraction, flat anterior chamber, or serous retinal detachment and choroidal effusion. The surgeon must be prepared to deal with these complications medically and/or surgically if they wish to undertake this procedure. Hypotony can often be managed by aggressive use of cycloplegics and simply waiting. Reformation of the AC using air or viscoelastic is sometimes needed. Removal of iris or vitreous from the tube can be delayed for 1-2 weeks while the tissues have a chance to heal.

**Cycloablation Procedures**

Whether using cryo or diode laser modes this is a choice of last resort. Success is quoted as being 30-45% per application but along with hypotony or poor control, long-term complications may be band keratopathy, corneal decompensation, cataract formation, and phthisis. Diode laser cycloablation seems to offer fewer complications than cryo.

Peribulbar anaesthesia is used here for postoperative pain. In some cases alcohol may be used to provide longer acting pain relief.

This type of procedure is usually done only on ½ to ¾ of the circumference of the limbus so as to decrease the chances of hypotony. In the case of cryotherapy the ice ball should be completely free of the probe tip before moving the tip. Only a small area of ice should go onto the cornea at the time of application. The center of the probe should be 1 ½ mm posterior to the limbus while in diode cycloablation, the probe edge is up against the limbus. The difference in locations is dictated by the radial application of the cryoprobe and the semi-tangential direction of the G-probe.

Cycloablative procedures - **A** cryotherapy; **B** external diode laser (using G-probe)
**Summary**

We have covered in some detail the general methods of assessing and treating a patient with pediatric glaucoma. There is a long history of anecdotal and “opinion-based” recommendations because few eye doctors have substantial long-term knowledge of either the eye diseases associated with glaucoma or the surgical experience with individual problems. Conditions encountered in the developing world make the treatment choices for an individual patient even more of a challenge. In addition to the suggestions and knowledge imparted here, the reader may want to read as much literature as available on these subjects. But there is no doubt that using this information you will be better equipped to take on that responsibility with more confidence and certainly with a more systematized way of thinking.

Good luck from all of us!