Pediatric Cataract Surgery

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Several aspects of cataract surgery in children differ from adults. Ocular anatomy, cataract morphology, exaggerated response to surgical trauma, and the need for amblyopia therapy are major concerns in pediatric cataract surgery. Moreover, intraoperative differences such as location and type of incisions, management of anterior and posterior capsules and need for anterior vitrectomy are other important issues to be considered. Achieving a successful result depends on adhering to all the pre-, intra- and post-operative considerations and their proper management.

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INTRODUCTION

Despite recent advances in microsurgical techniques, pediatric cataract surgery remains a challenging issue.[1] Over the past 15 years, intraocular lens implantation has become more popular in pediatric cataract surgery.[2] The problems inherent in the treatment of pediatric cataracts are related to surgical technique, the exaggerated response to surgery and post-operative visual rehabilitation.[3] Although the role of the surgeon in achieving an optimal visual outcome is undeniable, the management of pediatric cataracts requires team work. Experience in this field, as well as awareness of the differences between pediatric and adult cataract surgery is the cornerstone for achieving successful results.[4] Pediatric cataract is still an important issue in developing countries; this is due to difficulties in surgical technique, expensive equipment and the associated economic and social burden.[5]

In this article, we describe the anatomical characteristics of the pediatric eye and then discuss differences between children and adults at each stage of cataract surgery. Other aspects related to childhood cataracts such as diagnosis, preoperative evaluation and intraocular lens power calculation are not discussed here.

ANATOMICAL CONSIDERATIONS

Although the pediatric eye is small, it is not a miniaturized adult eye. It has its own specific anatomical and physiological characteristics. Pediatric cataract surgeons must be familiar with these differences to better manage the condition, achieve superior results in each phase of surgery, optimize the overall outcomes of the procedure and competently handle postoperative complications.

Ocular dimensions continue to grow until adolescence.[6] The sclera is thinner, more vascular and elastic in children as compared to adults with greater tendency for hemorrhage, and collapse leading to high vitreous pressure during surgery.[7] The crystalline lens is smaller in children: the equatorial diameter measures

approximately 6.5 mm at birth and increases to about 9-10 mm in adulthood.[8] The anterior capsule is thinner and more elastic in children compared to adults which makes a continuous curvilinear capsulorrhexis more difficult.[9] The lens material is soft but gummy making aspiration more time-consuming and difficult.[4] The iris is thicker, more vascular and tenacious in children resulting in more postoperative inflammation and fibrinous reaction.[10] The vitreous is usually more viscous in young children and the hyaloidolenticular ligament (attachment between anterior hyaloid and posterior capsule) is still strong, making posterior capsulorrhexis troublesome. Remnants of the anterior vitreous in children serve as a scaffold for fibrous membrane overgrowth and opacification.[11] During cataract surgery in children, macular and retinal phototoxicity due to the intense illumination of the operating microscope must be prevented.[12]

ANESTHESIA

Almost all types of pediatric operations including cataract surgery are performed under general anesthesia whereas topical, retrobulbar and peribulbar anesthesia are usually applied in adult cataract surgery. Children are 3 to 8 times more vulnerable to complications of anesthesia particularly respiratory failure. In pediatric patients, cataracts may be associated with other systemic conditions which may complicate general anesthesia.[4,7] The anesthesiologist in charge must have adequate knowledge and experience with pediatric anesthesia.

In contrast to adults, bilateral cataract surgery may be considered in infants who are at high risk for anesthesia. Deep anesthesia is necessary during pediatric cataract surgery and inadequate anesthesia is associated with problems such as extraocular muscle contraction and intraocular pressure rise resulting in radialization of a continuous curvilinear capsulorrhexis, activation of Bell's phenomenon or problematic intraocular lens implantation.[13] Owing to recent advances in pediatric anesthesia, pediatric cataract surgery may be con-

sidered an outpatient procedure with less frequent need for postoperative hospitalization.

INSTRUMENTATION

Removal of the soft lens materials in children can usually be achieved with any irrigation-aspiration device (automated or manual); ultrasound is rarely necessary for emulsification. A guillotine-style vitrector-aspirator is needed to perform a well controlled anterior and posterior capsulectomy and anterior vitrectomy which are accepted steps in pediatric cataract surgery.[14] The availability of a vitrector-aspirator probe facilitates removal of the child's gummy lens material. In cases of traumatic cataracts with possible posterior capsule tears and admixture of vitreous and lens material, alternate switching of vitrector-aspirator probe between vitreous cutting and aspiration modes facilitates the procedure.[15]

LOCATION AND CONSTRUCTION OF THE INCISION

Superior circumlimbal incisions are preferred due to the protection provided by the upper lid and superior orbital rim. By activation of Bell's phenomenon, the globe is elevated and the wound is covered with the eyelid in the trauma-prone child. A clear cornea sutureless approach (e.g., temporal) as performed in adults is less applicable in children because of the high rates of wound dehiscence and iris incarceration.[1] Although this approach is easy and the induced astigmatism is low,[16] the higher risk of trauma to the incision and its consequences make it less attractive for children.

In eyes undergoing lensectomy alone, two small keratotomies for introducing the automated vitrector-aspirator probe and a blunt irrigation needle are adequate. If there is no contraindication to an anterior approach such as microcornea or disorganized anterior segment structures, keratotomies may be performed with a 20-gauge microvitreoretinal (MVR) blade in clear cornea. The MVR blade can also

be used for making sclerotomies with pars plana or pars plicata approaches.[17] Conjunctival peritomy is mandatory for limbal or scleral tunnel incisons.[18]

Some pediatric cataract surgeons prefer scleral tunnel incisons.[7] These incisions are less trauma-prone, prevent iris prolapse intra-operatively and provide faster and more secure wound healing postoperatively. The sclera is thinner and less rigid in children which must be taken into account when making scleral incisions to prevent uveal trauma, premature entrance, anterior chamber collapse and the possibility of vitreous loss. In adults, scleral tunnel incisions are easier to perform with less risk of hemorrhage than children.[19]

ANTERIOR CAPSULE MANAGEMENT

An opening in the anterior capsule is necessary for removal of cataractous lens material. Continuous curvilinear capsulorrhexis (CCC) has gradually become the method of choice in adult cataract surgery since the early 1990's.[20] Capsulorrhexis can be performed more easily and with greater control in adults due to a thicker anterior capsule, greater scleral rigidity and lower vitreous pressure. The anterior capsule is thinner and more elastic with more tendency to tear radially in children making capsulorrhexis more difficult.[21,22] An anterior capsulotomy without inadvertent radial tears is necessary for secure in-the-bag fixation of a posterior chamber lens.

Anterior capsulorrhexis can be performed using a cystotome, bent needle or forceps and must be started in a well formed and deep anterior chamber to flatten the anterior capsule and decrease zonular tension. It is better to start the rhexis from the center of the capsule with smaller than intention size. A high molecular weight dispersive viscoelastic also helps control the capsulorrhexis.[23,24] Another technique which can be considered for younger children is vit-rectorrhexis as proposed by Wilson.[25] Anterior capsulotomy using the vitrector-aspirator probe produces a round capsulotomy with low risk of radial tear. This technique is less often required

in adult patients. The can-opener capsulotomy which is less frequently used nowadays in both adult and pediatric cataract surgery, cannot ensure long-term in-the-bag intraocular lens (IOL) positioning and may result in asymmetric bag-sulcus fixation, decentration and pupillary capture.[26,27] High frequency endodiathermy (Oertli, Switzerland) can also be used to create a continuous curvilinear capsulorrhexis. The instrument can be used for capsulorrhexis in both adult and pediatric cataract surgery.[28] The size and shape of capsulotomy can be adjusted by setting the handpiece tip. The procedure is performed under viscoelastic and the edge of the capsular flap tends to roll up resulting in a slightly larger capsulorrhexis than initially attempted.

Although all the above-mentioned techniques of capsulotomy have been used in children, manual CCC and vitrectorrhexis are most commonly used. Vitrectorrhexis is well suited for use in infants and young children, whereas manual CCC is best used beyond infancy and produces the most stable edge.[29] Capsulorrhexis is more difficult in eyes with white mature cataracts. To enhance visualization, capsular staining with indocyanine green[30] or trypan blue[31] may be used.

REMOVAL OF LENS MATERIALS

The ultimate goal of cataract surgery is clearing the lens capsule from opaque cataractous lens material and implanting a clear refractive intraocular lens. Lens material is soft and gummy in children which can usually be aspirated by an irrigation-aspiration or vitrectomy handpiece.[32] Even the cataractous fetal nucleus in children rarely needs phacoemulsification[33] which is in contrast to the adult nucleus which cannot be aspirated by irrigation/aspiration. Hydrodissection and hydrodelineation are commonly applied in adult cataract surgery but since cortical material is not strongly adherent to the lens capsule in children, it can usually be aspirated easily.[34] Nevertheless, hydrodissection prior to removal of lens material facilitates this step, saves time and decreases the risk of

posterior capsule opacification.[35] Addition of heparin to the irrigating solution during pediatric cataract surgery can decrease post-operative inflammatory and fibrinoid reactions and its related complications such as synechiae formation, pupil irregularity and IOL decen-tration.[36]

INTRAOCULAR LENS IMPLANTATION

The capsular bag is the best location for IOL implantation.[37] Asymmetric bag-sulcus fixation increases the risk of decentration and pupillary capture. Without a posterior capsulotomy and anterior vitrectomy, scleral collapse and posi-tive vitreous pressure cause obliteration of the capsular bag, making it difficult to implant the IOL in the bag.[34] Anterior vitrectomy decreases vitreous volume and facilitates stable in-the-bag IOL implantation and maintenance of media clarity.[38] Scleral rigidity in adult eyes is higher and vitreous pressure is less, therefore with the aid of viscoelastics, the capsular bag may be formed and IOL implantation into the capsular bag is not difficult.

An overall intraocular lens diameter of 12.0 mm guarantees long-term in the bag position in children. The ideal size for lens optic is considered to be at least 6.0 mm. A larger optic prevents symptomatic glare and monocular diplopia even if slight IOL decentration occurs due to asymmetric capsular contraction or asy-mmetric bag-sulcus fixation.[37]

Heparin or fluorine surface-modified IOLs, polymethylmetacrylate (PMMA) and hydroph-obic acrylic posterior chamber IOLs (PCIOLs) have been used in children with excellent bio-compatibility and minimal adverse tissue re-actions.[2,9,39-43] There are also a few reports of silicone or hydrophilic acrylic IOL implantation in children. Ciliary sulcus fixated IOLs in child-ren do not seem to incur significant complica-tions in the short-term, however long-term consequences of contact between IOL haptics and the vascularized uveal tissue is not well known.[43-45] In situations where the IOL can only be placed in the sulcus, it is better to entrap the lens optic into an intact anterior

and/or posterior capsule opening to provide better centration and minimize the risk of pupil capture or IOL dislocation into the vitreous cavity.[46] This is in contrast to similar circum-stances in adults in whom sulcus fixation of a properly designed PCIOL, i.e. with 10-degree haptic-optic angulation, results in long-term stability with a low risk of complications. Modern rigid and foldable IOLs designed for adults produce variable degrees of capsule-rrhexis ovalization and capsular bag stretch in infants and children. Single-piece hydrophobic acrylic IOLs cause minimal ovalization of the capsulorrhexis due to their flexible haptic design.[47,48] Foldable acrylic IOLs have also been reported to be safe for secondary implantation in aphakic children.[49]

MANAGEMENT OF THE POSTERIOR CAPSULE

Media opacification and secondary membrane formation were common following pediatric cataract surgery until the early 1980s when Parks[50] proposed removal of the posterior cap-sule together with anterior vitrectomy. Primary posterior capsulotomy and anterior vitrectomy in adult cataract surgery increases the risk of cystoid macular edema (CME) and retinal de-tachment (RD); therefore, intraoperative pos-terior capsule rupture is often considered as a high-risk complication. Conversely, this event does not seem to entail the risk of the above-mentioned complications in pediatric eyes.[51-53]

Nd:YAG laser capsulotomy for manage-ment of posterior capsule opacification is sim-pler and requires lower energy in adults as compared to children. In children, due to the density of the opacified membranous posterior capsule, repeat laser applications are required to possibly achieve success. This higher energy increases the risk of RD, CME, and damage to the IOL.[54] Furthermore children may not always be cooperative for such laser treatment. The upper age limit at which posterior capsule removal is necessary remains controversial.[55]

Primary removal of the posterior capsule during cataract surgery may be accomplished

with an automated vitrector or by performing posterior capsulorrhexis with a forceps under tamponade by a high molecular weight viscoelastic substance e.g. Healon GV (Advanced Medical Optics, USA). The Kloti radiofrequency bipolar cautery with or without indocyanine green staining is another alternative.[56] Anterior vitrectomy can be performed immediately after posterior capsulotomy using an automated vitrector before or after implantation of the IOL.[57,58] Gimbel[58] believes that removal of the posterior capsule and optic capture of a PMMA PCIOL without anterior vitrectomy can prevent secondary media opacification and membrane formation.[59] Other reports however, have shown that posterior capsulorrhexis with optic capture alone cannot prevent this complication and that anterior vitrectomy is necessary to prevent secondary membrane formation.[11,60] Trans-limbal or pars plana removal of the posterior capsule and anterior vitrectomy can be performed with similar long-term outcomes.[61-64] According to one study, primary posterior capsulotomy together with anterior vitrectomy was not a predictive factor for RD. Although RD is infrequent in pediatric eyes, more myopia (less hyperopia) than the age adjusted aphakic norm can be predictive of this complication.[65]

IRIDOTOMY–IRIDECTOMY

The uveal tract is thicker and more reactive in children as compared to adults and intraoperative manipulation can increase the risk of sterile postoperative uveitis which may lead to pupillary block.[66] Iridotomy or iridectomy can prevent this complication. Because of significant iris vascularity in children, hyphema is not a rare event during surgery.[7,67] In modern adult cataract surgery, in-the-bag IOL implantation keeps the optic border away from the pupillary margin, reducing the risk of capture, synechiae formation and pupillary block. Therefore, iridectomy is only indicated in complicated cases following anterior vitrectomy and implantation of an appropriate IOL in the sulcus or anterior chamber. Iridectomy in children, if needed

(e.g., in cases of persistent hyperplastic primary vitreous, juvenile rheumatoid arthritis, other types of uveitis and trauma) is best performed as small and peripheral as possible to prevent the risk of monocular diplopia.[68]

WOUND CLOSURE

As mentioned previously, sutureless cataract surgery is not appropriate in pediatric patients. Greater physical activity and less attention and protection are associated with an increased risk of trauma to the operated eye in children predisposing to wound leakage and dehiscence, uveal or vitreous prolapse, endophthalmitis, PCIOL extrusion and anterior chamber collapse with consequences such as peripheral anterior synechiae and glaucoma.[6,67,69] It is best to repair the surgical wound with separate 10-0 monofilament sutures with low reactivity such as nylon, Prolene or polygalactic acid (Vicryl).[33,70] Vicryl sutures have the advantage of being absorbable which eliminates a second anesthesia for suture removal. The surgeon must ensure the adequacy of wound closure, suture tension and absence leakage before ending the operation. On the other hand sutures must not be over-tightened to avoid high astigmatism. Since wound healing is faster in children, earlier suture removal can be considered to prevent permanent induction of astigmatism.

POSTOPERATIVE COURSE AND MANAGEMENT

One of the largest differences between pediatric and adult cataract surgery is the postoperative course. The postoperative period in adults most often follows an uneventful course. In children however, high uveal reactivity is the major cause of certain postoperative complications such as uveitis and fibrinous reaction, synechiae formation, pupillary block and attacks of glaucoma. These complications are less common in adults. The incidence of postoperative open-angle glaucoma in aphakic children seems to be much higher than adults and corneal edema must be considered as a warning

sign of glaucoma.[71-73] Strategies for follow-up and management of any complication are different in children and adults. Limited cooperation for examinations, need for earlier correction of refractive errors, risk of amblyopia, higher rates of complications and low compliance in children mandate team work to address the range of postoperative issues.

CONCLUSION

Pediatric cataract surgery is not analogous to operating on a miniaturized adult eye. Preoperative evaluation, the surgery itself and postoperative considerations and care are totally different in children. The pediatric cataract surgeon, as the pivot of the team, must be familiar with the details mentioned above. Being familiar with these differences results in superior surgical and visual outcomes with lower complications in pediatric cataract surgery. Children who need cataract surgery have longer life expectancy than adults; these patients need clear vision for experiencing, learning and living for a lifetime.

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