Chapter 25
Pediatric Cataract Surgery in the Developing World

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Recent public health initiatives have decreased the number of children who become blind from measles and vitamin A deficiency [1–3]. As a result, cataracts have become a leading cause of childhood blindness in the developing world. It is estimated that cataracts are responsible for 5–20% of pediatric blindness worldwide, with the prevalence of blindness due to childhood cataract being as much as 10 times higher in low-income economies compared with high-income economies [4–6]. Cataracts are a potentially curable form of blindness with timely identification, prompt surgery, and proper post-operative treatment of refractive error and amblyopia. However, limitations to obtaining timely surgery make cataracts a cause of irreversible blindness in children in the developing world.

The management of pediatric cataracts in the developing world has many unique considerations and challenges. The infrastructure needed to overcome these challenges is often very different from the developed world. Collaborative efforts from health-care providers and public health workers are needed to promote early detection, obtain cost-effective resources, and ensure proper post-operative follow-up. Surgical technique is often modified to adapt for limited surgical equipment and supplies.

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C. L. Kraus (ed.), *Pediatric Cataract Surgery and IOL Implantation*,
https://doi.org/10.1007/978-3-030-38938-3_25

Delayed Presentation

Early detection and timely surgery are critical for successful outcomes in childhood cataract surgery. An unobstructed visual axis is needed to stimulate visual development. A delay in clearing the visual axis can lead to untreatable amblyopia. Long travel distances and improper awareness of the urgency of a lens opacity create delays in developing countries. Mwende and colleagues found the mean time between recognition of the cataract by the caregiver and presentation to the hospital was 34 months in Tanzania [7]. Similar studies in India and China found a mean age at surgery for congenital cataract of 27.6 months and 48.2 months, respectively [8–9]. Long delays in presentation were found to be associated with having progressive cataracts, living far from the hospital, and low socio-educational status of the mother [7]. Congenital bilateral cataracts present with less delay as they tend to be more severe, and the associated nystagmus alerts the caregiver to the presence of a vision-related problem.

Red reflex screening programs for early cataract detection are not as widespread or reliable in developing countries. The cost and training of primary health workers make such programs difficult to implement and sustain. Key informants have been used as a cost-effective way to promote awareness and improve early detection. Key informants are respected members of a community trained to detect vision loss in children in their local population. They have proven effective in different areas of the world in identifying and referring children to appropriate surgical centers [10–12]. Despite efforts made in community awareness, delayed presentation continues to be an ongoing struggle preventing timely cataract surgery in children.

Facilities and Personnel

To address the problem of childhood blindness in the developing world, the World Health Organization and the International Agency for the Prevention of Blindness recommend that there be one Child Eye Health Tertiary Facility (CEHTF) per ten million people [13]. These facilities should be capable of treating complex pediatric eye conditions, including cataracts. Ideally, they should provide optical, low-vision, and pediatric anesthesia services. It is estimated that only about 28 of these facilities exist in sub-Saharan Africa, which has a total population of just over 1 billion [14].

Children typically travel long distances to reach these tertiary centers. As travel back and forth between the home and center is often not practical, children are typically admitted to an inpatient ward during the entire surgical process, including immediate post-operative care. The wards are staffed with ophthalmic nurses trained in pediatric eye care. Trained pediatric ophthalmologists perform surgeries while utilizing pediatric anesthesia services. Surgical staff with knowledge of assisting in pediatric surgery, sterilization procedures, and equipment maintenance are critically important. Ophthalmic assistants and low-vision specialists provide pre-operative screening and post-operative care including refractions (see Fig. 25.1). Childhood

Fig. 25.1 Low-vision specialist performing post-operative refraction

Table 25.1 CEHTF personnel

Pediatric ophthalmologist
Pediatric anesthetist
Low-vision specialist/optometrist
Ophthalmic nurse
Surgical assistant
Childhood blindness coordinator and counselor

blindness coordinators are helpful with pre-operative counseling, tracking patient demographic data, facilitating future travel for follow-up care, and assisting with obtaining special educational needs. Table 25.1 lists the team members at a typical CEHTF in the developing world.

Surgical Equipment and Supplies

Economic constraints limit the availability of surgical equipment and supplies in the developing world. The cost to maintain or update equipment and replenish consumables is often too high to sustain pediatric cataract services. A cost analysis at two CEHTFs in Malawi and Zambia found the equipment costs at $178,121 and $179,832 [15]. Taking into consideration labor, consumables, and medications, the total cost for pediatric cataract surgery was $689 per child in Malawi and $763 per child in Zambia. While these costs are low compared to higher-income countries such as the United States [16], funding is largely dependent on donors who are often limited and inconsistent. Furthermore, the cost related to surgical equipment and

Table 25.2 Surgical equipment and consumables

Equipment and instruments	Consumables
Vitron 2020 (Geuder) pneumatic vitrectomy unit including tubing, handpiece, and AC maintainer	Intraocular lens – single-piece foldable acrylic or PMMA (Aurolab)
Scan Optics SO-161-R operating microscope	9-0 nylon suture
15 blade	Hydroxypropyl methylcellulose
Keratome	Triamcinolone and intracameral cefuroxime
MVR blade	

supplies can be substantially higher for pediatric surgery compared to that of adult surgery. Specifically, the costs of a vitrector, anesthesia machine, and foldable intraocular lenses are higher than instrumentation used for adults but are essential for pediatric cataract surgery [17].

To perform surgery within the economic constraints, older models and second-hand equipment are often used. Adaptations in surgical technique can be made to work with limited supplies and consumables. Table 25.2 lists suggested equipment and supplies.

Post-operative Management

Surgery is only the first step in a long process of restoring sight to a child with cataracts. After the natural lens is removed, the image a child sees must be focused on the retina to stimulate visual development in the brain. In an ideal setting, this is achieved with spectacles or contact lenses. However, these are not practical options in much of the developing world. The costs of continuously updating glasses or contact lens strength as the eye grows and replacing broken or lost ones make them an unreliable option. Poor hygienic living conditions and lack of freshwater to properly care for contact lenses also make them a high-risk option. This is why placing an intraocular lens, whenever possible, is critically important in children undergoing cataract surgery in the developing world. Uncorrected aphakia in this setting is often no better than the cataract itself in regard to visual outcomes.

Continued post-operative care with follow-up examinations is critical for maintaining updated refractions and to monitor for associated complications, such as glaucoma, strabismus, and visual axis opacifications. Long travel distances and the cost of travel make follow-up care challenging in the developing world. A childhood blindness coordinator can promote good follow-up through the use of cell phone reminders, patient tracking, and reimbursement for transport [18].

All the above limitations in the developing world affect surgical technique and decision-making. Preferred surgical methods are influenced by cost and possibilities of follow-up. We provide an extreme example that is influenced by cost-effectiveness. Our method may vary depending on location and availability of resources.

Fig. 25.2 An 8-month-old with bilateral cataracts

Case 1

An 8-month-old child presents with bilateral congenital cataracts (see Fig. 25.2). The mother noted nystagmus around 3 months of age. A key informant in the community alerted the mother of a potentially serious vision problem with her child that required medical attention. The mother brought the child to a local health worker where immunizations were provided. This led to referral to a pediatric surgical outreach in Mwanza, Tanzania. The outreach team was composed of members from two different CEHTFs in Tanzania. The mother and child traveled for 10 hours by bus to reach the center.

On examination, both lenses were white and opaque with no view to the fundus. The child appeared to have light perception vision in each eye, but no fixation or tracking of objects. The child otherwise appeared healthy and well-nourished.

Comment After examination, the mother was sent for counseling with the childhood blindness coordinator. The mother was educated on risks and benefits of the surgery, including the urgency of the situation in order to best stimulate the child's visual development. She expressed understanding of the logistics of and rationale for the surgery, including the importance of follow-up examinations and optical rehabilitation. The child was then admitted to pediatric eye ward and put on the list for next available surgery, which was anticipated to be 3–4 days later. Prior to surgery, the child was evaluated by the anesthesia team and deemed healthy enough for general anesthesia.

Immediate sequential bilateral cataract surgery was planned. Limited availability of anesthesia and a list of over 100 children waiting for surgery make sequential bilateral surgery a good option in this situation. However, if there are concerns about the sterilization process of instruments at a facility or wound security due to lack of suture, performing unilateral cataract surgery might be preferred.

Anesthesia

General anesthesia is administered by a nurse anesthetist with pediatric experience. Halothane gas is used as the anesthetic agent. Halothane is less expensive than newer agents such as sevoflurane but can give more post-operative nausea and prolonged somnolence. Alternatively, if an anesthetist and/or anesthesia machine is not available, intravenous ketamine is an inexpensive alternative that can produce sleep-inducing and analgesic effects. It typically is combined with a periocular local anesthetic injection. Ketamine is a safe alternative without the respiratory or cardiovascular suppression effects of inhaled agents but does create a less controlled anesthetic experience with potentially vivid dreams and illusions for the patient.

Equipment

The Vitron 2020 (Geuder, Germany) pneumatic vitrectomy unit was used for the case. It comes with a 20-gauge cutting probe and an anterior chamber (AC) maintainer. It has the advantages of being significantly less expensive and easier to maintain compared to other vitrectors. It is also compact and relatively lightweight making it a good portable option for the outreach setting. It utilizes a manual syringe for its suction mechanism. This mechanism can be more cumbersome and provide less controlled suction if the surgeon is not experienced with the device. It also has a limited cut speed of only up to 800 cuts per minute, which can cause unwanted vitreoretinal traction during anterior vitrectomy.

Scan Optics SO-161-R operating microscope was used for the case. It has the advantages of being cost-effective, easy to maintain, and portable. The optical clarity is not as good when compared to more expensive and modern operating microscopes. It is also less user-friendly as it has only a manual focus knob and no zoom capability.

Wound Construction

A superior scleral tunnel is constructed with a 15 blade. This wound is later extended through the cornea into the anterior chamber to facilitate IOL insertion. The scleral flap can later be closed with non-absorbable suture that is covered by the conjunctiva. Two 20-gauge stab incisions are made at the limbus, one for the vitrector probe and the other for the AC maintainer. The location of each incision may vary based on surgeon's preference. These incisions and the entry incision into the anterior chamber can be approximated to size with the tip of the 15 blade if a 20-gauge MVR blade and keratome are not available.

Cataract Removal

Using the vitrector probe at a cut rate of 200–300 cuts/minute, an anterior capsulectomy, or vitrectorhexis, is made. The lens is aspirated in its entirety using the manual suction action of the syringe attached to the vitrector probe.

IOL Decision-Making and Implantation

For this patient, there is no keratometer or A-scan ultrasound available for IOL calculations. IOL power selection is made based on the patient age (see Table 25.3). These are suggested guidelines for bilateral cases when biometry is not available. If A-scan ultrasound were available, estimations could be made based on axial length (see Table 25.4). A target post-operative refraction of emmetropia is preferred as post-operative spectacle correction is not a reliable option. With this refractive target, the child is likely to become fairly myopic as they age, but treating amblyopia is of much greater concern in this setting. Young children have a limited window to stimulate their visual pathway, whereas progressive myopia can be corrected at any age. We implant IOLs whenever possible in the developing world. Reasons for not implanting IOLs include microphthalmia and corneal diameter less than 9 mm. Caution is used when implanting IOLs with corneal diameters less than 10 mm.

Hydroxypropyl methylcellulose is used as an inexpensive viscoelastic for filling the capsular bag. A foldable, single-piece acrylic IOL is selected for capsular bag placement. Aurolab in India provides these IOLs at a low cost. PMMA can be used as a less expensive option, but these lenses require larger wounds. They can also cause significant post-operative fibrinous uveitis, especially in very young children with strong immune systems. For this reason, we try to avoid PMMA lenses in children less than 5. The Aurolab foldable lens comes with a disposable injector that uses a syringe-like plunger to implant the IOL into the bag. Alternatively, the Monarch® injector system (Alcon, USA) has a reusable handpiece and cartridge that can provide a more controlled insertion with plunger that is guided by a screw mechanism. While this device is designed for Alcon IOLs, we have found it to be interchangeable with IOLs from other manufacturers.

Table 25.3 IOL power selection based on age

Age	Power
<6 months	27–30
6–12 months	26
1 year	25
2 years	24
3 years	23
4 years	22
5 years and older	20–22

Table 25.4 IOL power selection based on axial length

Axial length	Power
17 mm	28–30
18 mm	27
19 mm	26
20 mm	25
21 mm	23
22 mm	22

Posterior Capsulotomy and Anterior Vitrectomy

A pars plana posterior capsulotomy and anterior vitrectomy are performed after the IOL is inserted into the bag. Alternatively, this could be performed anteriorly through the limbal incision by lifting up and going under the IOL with the vitrector probe. Pars plana has the advantages of less IOL disruption in smaller eyes and less vitreoretinal traction. As follow-up care and availability of a YAG laser are uncertain, primary posterior capsulotomy is performed in all children less than 10 years old.

Wound Closure and Intraoperative Medication

The scleral incision and pars plana sclerotomy are closed with a single cross-stitch 9-0 nylon. The limbal incisions are hydrated. An anterior chamber air bubble can provide additional temporary tamponade to the limbal incisions. Given concerns for sanitation in the developing world, intracameral antibiotic (cefuroxime) is used. The superior conjunctiva incision site is hydrated with triamcinolone, which allows it to cover the scleral sutures. The triamcinolone stays deposited on the ocular surface longer compared to dexamethasone. This can be beneficial if compliance with post-operative eye drops is a concern.

Post-operative Care

The child stays overnight in the hospital ward. After patch removal the following day, atropine 1% drops and a combination of chloramphenicol 0.5% + dexamethasone 0.1% drops are started. On post-operative day 2, the child is refracted. By post-operative day 3, the child has received spectacles and is discharged home after the eye is cleared of any evidence of endophthalmitis. The child is counseled by the childhood blindness counselor with emphasis on the need to return for future post-operative examinations.

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