Modified 23-Gauge Vitrectomy System for Stage 4 Retinopathy of Prematurity

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Objective: To evaluate the outcome of a novel, modified 23-gauge vitrectomy system in the treatment of stage 4 retinal detachment in retinopathy of prematurity.

Methods: Consecutive patients with stage 4 retinopathy of prematurity treated with modified 23-gauge vitrectomy were included in this medical record review. Major novel modifications included the use of a small infusion cannula, a 20-gauge blade for the creation of sclerostomies in the pars plicata, and a 23-gauge endoilluminator and vitreous cutter. Conjunctival dissection and suturing of sclerostomies were performed using this modified 3-port, 23-gauge vitrectomy technique. Anatomic success and surgical complications were analyzed.

Results: Twenty-six eyes of 17 patients were included and analyzed. The mean (SD) gestational age was 28.0 (2.5) weeks, and the mean birth weight was 1199 (449) g. Mean postmenstrual age at the time of vitrectomy was 40.5 (3.0) weeks. Overall, 20 eyes (77%) achieved retinal attachment in a single operation, and 23 eyes (88%) achieved retinal attachment after multiple procedures. Postoperative complications included disc dragging (5 eyes [19%]), cataracts (4 [15%]), glaucoma (2 [8%]), persistent vitreous hemorrhage (1 [4%]), and posterior synechiae (1 [4%]).

Conclusions: This 23-gauge vitrectomy system seems to be a safe and effective approach for treatment of stage 4 retinopathy of prematurity. This modified system combines the benefits of 20- and 23-gauge vitrectomy and offers safer insertion of infusion cannulas in smaller eyes, more working space in pediatric eyes, a cutting port that is closer to the retina, and a faster cutting speed with less vitreous traction during the operation.

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Retinopathy of prematurity (ROP) remains one of the leading causes of childhood blindness worldwide. Surgical intervention is indicated once stage 4 or stage 5 ROP with retinal detachment occurs. Surgical procedures should be performed as early as possible when retinal detachment develops because the prognosis of stage 4 ROP is much better than that of stage 5 ROP. For stage 4 ROP, both scleral buckling and vitrectomy have been used to treat retinal detachment. Scleral buckling achieves moderate anatomic success but is limited by a high incidence of induced refractive errors and the need for additional procedures to dissect or remove the buckling material. Recently, vitrectomy has become popular for the treatment of stage 4 ROP because of improved instrumentation and the ability to directly release transvitreal traction resulting from fibrous proliferation. Vitrectomy has a more favorable anatomic success rate (70%-95%) compared with scleral buckling. Functional outcome is even more impressive for stage 4A ROP treated with vitrectomy, allowing patients to achieve an average visual acuity of 20/58 to 20/62.

Newer, smaller-gauge vitrectomy is becoming more popular than traditional 20-gauge vitrectomy for treatment of vitreo-retinal disorders because of several potential benefits. The reported advantages in adults are reduced surgical time achieved with the sutureless nature of this system, increased patient comfort, faster visual recovery, and low complication rate. Smaller instruments might have additional advantages in infants with ROP.

There are few reports of surgical management of ROP using 25-gauge instruments with various modifications. However, the efficiency of such a system seems to be limited because 47% of eyes require multiple operations when 25-gauge vitrectomy systems are used.
Surgical Technique

When the plus disease or pre-plus disease was evident or there was extensive proliferation of fibrovascular membranes in the ROP eyes, bevacizumab (Avastin) was administered intravitreally less than a week before vitrectomy. Injection of bevacizumab was used primarily to reduce the chances of bleeding during the subsequent vitrectomy. Three-port pars plicata vitrectomy using 23-gauge instrumentation was performed by one of us (W.-C.W.). The pupil was dilated with phenylephrine, 1.25% (Wu Fu Laboratories Co Ltd, Yilan, Taiwan), and tropicamide, 1% (Mydriacyl; Alcon-Couvreur, Puurs, Belgium), before vitrectomy. Conjunctival dissection was performed to expose the pars plicata. The sclerotomy was made approximately 0.5 to 1.0 mm posterior to the limbus through the pars plicata with a 20-gauge microvitreoretinal (MVR) blade. Trocar cannulas were not used. The MVR was directed perpendicularly to the globe initially and then directed toward the center of the eyeball after the MVR blade passed the lens equator. The infusion was placed at the sclerotomy in the inferotemporal or inferonasal quadrant by an anterior chamber maintainer with a length of 3 mm (self-retaining anterior chamber maintainer 20 gauge; PMS, Tuttlingen, Germany) (Figure 1) depending on the configuration and extent of retinal detachment. The position of the infusion tip was confirmed with an endoilluminator before initiating the infusion. The remaining 2 sclerotomies were made at approximately the 3-o’clock and 9-o’clock positions so that both the superior and inferior vitreous could be addressed with a vitreous cutter without damaging the lens (Figure 2). The 23-gauge vitreous cutting tool and endoilluminator were then inserted through the remaining 2 sclerotomies in the horizontal region. The vitrectomy machine (Accurus; Alcon, Fort Worth, Texas) was used with vacuum levels of 150 to 250 mm Hg and cutting rates of 1200 to 1500 cuts per minute. The traditional proportional vacuum mode was used. A wide-angle viewing system (Volk Optical Inc, Mentor, Ohio) was used to view the peripheral retina. A corneal contact lens was used for central retina viewing. The surgical goal was to relieve vitreous traction on the retina to the greatest extent possible. Traction forces from the ridge to peripheral retinal walls, ridge to lens, ridge to ridge, and ridge to the optic disc were addressed (Figure 3). Care was taken to avoid a retinal break or hemorrhage during the procedure. The lens was not removed unless the proximity of the retina to the lens greatly limited the space available at the surgical entry site. Partial gas-fluid exchange was performed at the end of the operation to prevent ocular hypotony during suturing of the sclerotomy. The conjunctival wound was then closed with an 8-0 polygastro 910 suture (Vicryl; Ethicon, Inc, Somerville, New Jersey). At the end of the operation, a transparent plastic eye shield was used to reduce the chance of eye rubbing or direct trauma by hands.

Results

Twenty-one patients underwent modified 23-gauge vitrectomy between June 1, 2007, and May 31, 2010. The records of 4 patients were excluded because of follow-up of less than 6 months. Therefore, data on 26 eyes from 17 patients (10 boys and 7 girls) were included and...
analyzed in this study. The mean gestational age was 28.0 (2.5) weeks (range, 24-31 weeks), and the mean birth weight was 1199 (449) g (range, 556-2400 g). The mean follow-up time of the patients was 13.9 (9.5) months (range, 6-34 months). The patient characteristics and surgical results are shown in the Table.

Fifteen eyes of 9 patients were stage 4A ROP, and 11 eyes of 8 patients were stage 4B ROP. Twenty-three of 26 eyes (88%) were subjected to laser treatment before vitrectomy. The mean number of laser treatments was 1.5 (0.5) (range, 1-2). Eight eyes (31%) received a bevacizumab injection before vitrectomy. Scleral buckling had been performed in 4 eyes (15%) at other hospitals before they received vitrectomy at our hospital. In these eyes, scleral buckle was dissected at the time of vitrectomy. Combined vitreous or preretinal hemorrhage was found in 5 eyes (19%) with stage 4 ROP. One stage 4B eye was found to have combined tractional and rhegmatogenous retinal detachment. For the other eyes, the retinal detachment was only tractional. Mean postmenstrual age at the time of vitrectomy was 40.5 (3.0) weeks (range, 36-50 weeks). Final retinal reattachment was achieved in 23 eyes (88%). Two eyes (8%) with stage 4A ROP progressed to stage 4B ROP after initial 23-gauge vitrectomy and received additional vitrectomies to reattach the retina. One eye (4%) with stage 4A ROP progressed to stage 5 ROP, and successful retinal reattachment was achieved after surgical intervention. Overall, in 20 eyes (77%), retinal attachment was achieved after surgical intervention. In 23 eyes (88%), retinal attachment occurred after multiple procedures. The retina failed to reattach in 3 eyes (12%) after 23-gauge vitrectomy and additional operations. These 3 eyes had retinal breaks either before or after vitrectomy. Postoperative complications occurred in some infants. Disc dragging was noted in 5 eyes (19%) during follow-up. Four eyes (15%) developed cataracts and underwent subsequent cataract operations. Two eyes (8%) developed glaucoma during postoperative follow-up and underwent filtering surgical procedures after medical therapy failed. Persistent vitreous hemorrhage was noted in 1 eye (4%); an additional vitrectomy was performed to clear the hemorrhage. Posterior iris synechia occurred in 1 eye (4%) during follow-up. None of the patients developed endophthalmitis during follow-up.

**Vitreous operations in infant eyes remain challenging.** Because newborn eyes are much smaller than adult eyes, the anatomy and the surgical approach are different. Instruments are also adjusted for use in smaller eyes. Most important, the chance to amend undesirable complications, ie, retinal break, is much slimmer. Therefore, a better approach that offers both safety and efficacy is sorely needed.

**Modifications of smaller-gauge vitrectomy are necessary in ROP because of these differences.** We have made several modifications. First, sclerotomies are made in the pars plicata because of underdevelopment of the pars plana in newborns. Second, trocars are not used in newborn eyes because of the chance that the retina could be damaged by distortion of the globe during insertion of trocars into such small eyes. Third, the 23-gauge infusion cannula is replaced with a smaller anterior chamber maintainer so that a contact prism lens or a wide-angle viewing lens can be placed on the cornea without bumping the infusion or other instruments. Fourth, sclerotomies and conjunctiva are sutured to ensure wound integrity. Self-sealing of sclerotomy wounds may be difficult; adequate coverage of the conjunctiva is not always possible because of proximity of the wound to the limbus. In addition, we are concerned about the integrity of the wound if left unsutured because of the potential harm when infants cry and strain during eye examinations. In our cases, we did not encounter postoperative hypotony or endophthalmitis during the follow-up period.

Because it is important to plan for ROP repair before the intervention, anesthetists are consulted beforehand...
to evaluate the risk of general anesthesia. This is necessary because the operation may need to be postponed if the infant’s condition is unstable. If plus or pre-plus disease is noted on the fundus, bevacizumab is injected less than 1 week before vitrectomy. Hemorrhage in the vitreous or in the proliferative fibrovascular membranes during vitreous shaving in the course of the subsequent vitrectomy could be reduced. Although angiogenesis is inhibited after bevacizumab use, the fibrotic component of ROP may accelerate and retinal detachment might worsen.24 Thus, we suggest that vitrectomy be performed within 1 week of bevacizumab injection. If patients have received scleral buckling beforehand, the division of buckling material is performed before vitrectomy. Before the operation, the fundus is checked again to determine the configuration of retinal detachment. The area with the least retinal dragging is selected as the infusion site. The vectors that involve tractional force on the retina are dissected until the surgeon determines that the force was relieved by the vitreous cutter. Aggressive membrane peeling is avoided, and efforts are made to reduce the possibility of iatrogenic break, which usually carries a poor prognosis. Retinal flattening takes several months because of the exudative component in the subretinal space. Documentation of the surgical procedure is important and is done using a video recording system.

The benefits of 23-gauge vitrectomy compared with traditional 20-gauge vitrectomy for ROP include easier insertion of the instrument because of its smaller size, more working space in the vitreous as a result of the use

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Abbreviations: BW, birth weight; GAB, gestational age at birth; PMS, postmenstrual age at surgery; ROP, retinopathy of prematurity; RRD, rhegmatogenous retinal detachment; VH, vitreous hemorrhage.
of a smaller vitrectomy probe, a cutting port that is closer to the retina, and a higher cutting speed with less vitreous traction during the procedure. Surgeons could adapt to this technique easily because the setup of this system is similar to that of traditional 20-gauge vitrectomy. Safety has also been enhanced with a smaller infusion line in the pediatric eye. The drawback of this system is the higher expense associated with 23-gauge vitrectomy systems.

The potential benefits of 23-gauge vitrectomy compared with 25-gauge vitrectomy include a sturdier probe, which facilitates eye rotation; higher cutting efficiency because of a larger port in the cutter; better instrument manipulation, thus avoiding damage to the lens and retina; and a better lighting source that allows for clearer visualization of the fundus. The need for an additional operation is also reduced. Gonzales et al.\(^\text{22}\) reported that 47% of eyes undergoing 25-gauge vitrectomy for stages 4 and 5 ROP require more than 1 retinal operation for persistent retinal detachment and/or vitreous hemorrhage. Of our patients, only 6 eyes (23%) needed more than 1 retinal operation for persistent retinal detachment and/or vitreous hemorrhage. The drawback of this system compared with 25-gauge vitrectomy is the need to dissect the conjunctiva and the suturing of sclerotomies and conjunctiva. In addition, mild leakage from the sclerotomy site occurs because of the 20-gauge MVR blade.

Our anatomic success is comparable to that of previous reports.\(^\text{2,4,6,9,10,12,13,20-22}\) on procedures using a 20- or 25-gauge vitrectomy probe. The retina failed to reattach in 3 eyes (12%) after 23-gauge vitrectomy and additional surgical procedures. All 3 eyes had retinal breaks either before or after vitrectomy. One patient with stage 4B ROP was found to have rhegmatogenous retinal detachment before vitrectomy. That infant had undergone laser treatment twice before vitrectomy. The retinal break could have been caused by excessive laser energy. The other 2 patients developed retinal breaks after vitrectomy, possibly related to vitrectomy, gas-fluid exchange, or existing breaks that were not identified during vitrectomy. Unfortunately, repeated procedures failed to reattach the retina. It is difficult to compare the results of other studies because of the heterogeneity of study populations and previous treatments. Some cases might not be suitable for the system described here if they are associated with significant anterior proliferation. With increasingly more 23-gauge instruments available, intervention in more difficult cases, ie, ROP with denser membranes, could be attempted with the current system. Furthermore, because the sclerotomy was made using a 20-gauge MVR, 20-gauge instruments, such as the membrane peeler cutter scissors, could be used as a backup if there is a need to dissect heavy membranes.

Our study is limited by its retrospective design, small number of patients, and limited follow-up. We have made several modifications to the 23-gauge vitrectomy system in infant eyes. Information on the functional outcome of this technique is not yet available. The current system offers an acceptable surgical outcome and a good safety profile. The modifications we implemented worked well in our initial experience. However, no definitive conclusion could be drawn, as no long-term results are available.

In conclusion, this modified 23-gauge vitrectomy in neonates offers better manipulation and better illumination than the 25-gauge vitrectomy. Moreover, this system provides a larger working space and reduced peripheral retinal traction with a high-speed vitrectomy probe and a smaller instrument size than that involved in traditional 20-gauge vitrectomy. Use of 23-gauge vitrectomy for retinal detachment in ROP seems to achieve an excellent balance between the results of 20- and 25-gauge vitrectomy. The anatomic success and complication rates are comparable to those in studies that used the traditional 20-gauge vitrectomy system.

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