

Long-term Postoperative Results of a Consecutive Series of Stages 4 and 5 Retinopathy of Prematurity

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Objective: The purpose of the study was to assess the long-term, anatomic, and functional results of a consecutive series of stages 4 and 5 retinopathy of prematurity (ROP) eyes after surgical management.

Design: A retrospective analysis of 42 eyes of 21 children yielded 34 eyes of 19 children who were operated on for stages 4 and 5 ROP.

Participants: In 33 of 34 eyes, it was possible to have age-appropriate vision testing. The children were followed for a mean of 44 months.

Results: Seventy-six percent of eyes (25 of 33) in which vision testing was possible had partial or complete attachment of the posterior pole. Fifteen percent of all eyes achieved 20/300 or better visual acuity. Thirty percent of all eyes achieved 20/800 or better visual acuity. Forty-eight percent of eyes achieved ambulatory vision of 20/1900 visual acuity or better, and 72% of eyes achieved light perception or better vision. All eyes were managed similarly for their preoperative screening, surgical therapy, and postoperative refractive correction by one vitreoretinal surgeon and one pediatric ophthalmologist.

Conclusion: Timely surgical intervention and appropriate postoperative care can result in useful vision in stages 4 and 5 ROP. *Ophthalmology* 1998;105:992-997

Several authors have described their experience relative to the management of stage 4 and 5 retinopathy of prematurity (ROP).¹⁻⁶ This article describes a consecutive retrospectively analyzed series of patients with stages 4 and 5 ROP treated by one pediatric ophthalmologist and one vitreoretinal surgeon. The children were treated in a consistent manner, and referral of patients was done in a timely fashion, allowing early intervention. The goal was to see whether such an organized and deliberate attempt for aggressive screening, early intervention, and intensive postoperative management could yield functional visual results.

Patients and Methods

Forty-two eyes of 21 patients were examined. One patient was lost to follow-up, and one patient died at the age of 2 years before visual data could be collected on either patient. This left 38 eyes of 19 patients, which yielded 34 eyes with retinal detachment: 1 eye with a stage 4A retinal detachment, 1 eye

with a rhegmatogenous retinal detachment after cryotherapy that presented as a stage 5 eye, and 32 eyes with stage 4B/5 ROP. Twelve of the eyes had initial peripheral laser ablation and 30 of the eyes had cryotherapy. Six of the 30 "cryoed" eyes had a second session of cryotherapy. Two of the 12 lasered eyes had a second session of peripheral ablation with cryotherapy. All eyes had been screened and treated consistent with the recommendations of the Retinopathy of Prematurity Cryo Study during the course of this study. The patients in this study were followed from 1982 to 1995. Only one patient was operated on in 1982, and the remaining patients were operated on from 1988 to 1995. Thirteen children were male and eight were female. Three children were black and 18 were white. The children involved in this study had a mean gestational age of 25.5 weeks and a mean birth weight of 784 g. Four (19%) of 21 children had asymmetric ROP with retinal detachment in one eye. Children underwent their primary retinal detachment surgery at a mean of 4.5 months from birth. Patient descriptions and surgical intervention are summarized in Tables 1 and 2.

All eyes before surgery underwent a complete ocular examination and had an examination while the patient was under anesthesia immediately before surgery. All eyes were believed to have light perception before surgery. Eyes with predominately effusive detachments underwent scleral buckling, whereas predominately tractional eyes underwent vitreous surgery, as we have described previously (Figs 1, 2, and 3).^{7,8} Although it is not the purpose of this article to outline the surgical technique, eyes that were candidates for scleral buckling had a 240 band placed around the greatest circle of the globe without drainage of subretinal fluid but did have paracentesis. Predominately tractional stage 4/5 eyes had lens-sparing vitrectomy if possible to try and achieve posterior pole attachment with clear lens. Eyes with large amounts of lens-touch had lensectomy, vitrectomy, and membrane peeling.^{7,8} Primary

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Table 1. Birth Data

	Gestational Age (wks)	Birth Weight (g)
Range	23–28	530–1264
Mean	25.5	784

vitreoretinal surgery of 33 eyes with postoperative vision-testing data was composed of 18 initial scleral-buckling operations (including 1 stage 4A eye and 1 eye with rhegmatogenous retinal detachment after cryotherapy, and 16 predominately effusive stage 4B ROP eyes). Nine eyes initially underwent lens-

sparing vitrectomy (eight ROP stage 4B tractional eyes and one open-funnel ROP stage 5 eye). Six clinical stage 5 eyes initially underwent lensectomy, vitrectomy, and membrane peeling (Tables 1, 2).

Reoperations were performed in 11 eyes. Eight of the scleral-buckled eyes required lensectomy, vitrectomy, and membrane peeling for increasing vitreoretinal traction. Two eyes that had undergone primary lens-sparing vitrectomy needed additional surgery (one of the eyes requiring lensectomy, vitrectomy, and membrane peeling and another second eye requiring lensectomy alone). Of the six eyes that initially underwent lensectomy, vitrectomy, and membrane peeling, one eye required repeat vitrectomy and membrane peeling because of re proliferation and continued vitreoretinal traction.

Table 2. Surgery Data of All Patients Studied

Patient No.	Laser	Cryo	SB	LSV	LVMP	Posterior Pole Attached	Presenting Stage ROP	Final Stage ROP†	Postoperative Visual Acuity
1	OD: X OS: X		P		R	A	4B E	5	20/1900
2	OD: X OS: X	XX	P		R	A	4B T	5	20/1900
3	OD: X OS: X	XX	P			A	4B E		20/470
4	OD: X OS: X	X	No	Ret	Det	(A)	4B T		20/470
5	OD: X OS: X	XX	P			A	4B E		6/200
6	OD: X OS: X	XX	P			A	4B E		—
7	OD: X OS: X	X	P		R	A	4B E	5	20/300
8	OD: X OS: X	X	No	Ret	Det	(A)	4B E		20/160
9	OD: X OS: X	X	P			A	4B E		LPP
10	OD: X OS: X	X	P/Rheg		P, R	A	5		NLP
11	OD: X OS: X	X	P			A	4B T		—
12	OD: X OS: X	X	P			A	4B E		20/800
13	OD: X OS: X	X	P			A	4B T		NLP
14	OD: X OS: X	X	P			A	4B T		NLP
15	OD: X OS: X	X	P			A	4B T		20/1400
16*	OD: X OS: X	X	P			A	5 Rheg		20/1900
17	OD: X OS: X	X	P			A	4B E		20/94
18	OD: X OS: X	XX	P		R	D	4B E	5	NLP
19*	OD: X OS: X	XX	P		R	D	4B E	5	NLP
20*	OD: X OS: X	X	P		R	D	4B E	5	NLP
21	OD: X OS: X	X	P			A	4B E		20/470
22	OD: X OS: X	X	P			A	4B E		20/470
23	OD: X OS: X	X	P			A	4B E		20/470
24	OD: X OS: X	X	P			A	4A	5	20/1900
25	OD: X OS: X	X	P			A	4B E	5	NLP
26	OD: X OS: X	X	P			A	4B E	5	NLP
27	OD: X OS: X	X	P			A	4B E	5	LP
28	OD: X OS: X	X	P			A	4B E	5	NLP
29	OD: X OS: X	X	P			A	4B E	5	NLP
30	OD: X OS: X	X	P			A	4B E	5	NLP
31	OD: X OS: X	X	P			A	4B E	5	NLP
32	OD: X OS: X	X	P			A	4B E	5	NLP
33	OD: X OS: X	X	P			A	4B E	5	20/100
34	OD: X OS: X	X	No	Ret	Det	(A)	—		—
35	OD: X OS: X	X		P		A	5		No data; lost to F/U
36	OD: X OS: X	X		P		A	5		
37	OD: X OS: X	X		P		A	4B T		LP
38	OD: X OS: X	X		P		A	4B T		LP
39	OD: X OS: X	[X]	P			A	4B T		20/63
40	OD: X OS: X	[X]	P			A	4B E		20/1400
41*	OD: X OS: X	X			P	Bleed	5		Died at 24 mos
42*	OD: X OS: X	X		P		A	4B T		
43*	OD: X OS: X	X	P			A	4B E		LP at least systemically unable to test
44	OD: X OS: X	X	No	Ret	Det	(A)			
45	OD: X OS: X	X	P		R	A	4B E	5	LP
46	OD: X OS: X	X	P		P	A	5		LP

A = attached; (A) = never detached; 4B E = predominately effusive 4B; 4B T = predominately tractional 4B; D = detached; P = primary procedure; R = reoperation; SB = scleral buckle; LSV = lens-sparing vitrectomy; LVMP = lensectomy, vitrectomy, membrane peeling; ROP = retinopathy of prematurity; Rheg = rhegmatogenous; F/U = follow-up.

* Patients 16, 19, and 20 data not complete and therefore not used in final calculations.

† Final stage present if different from presenting stage.

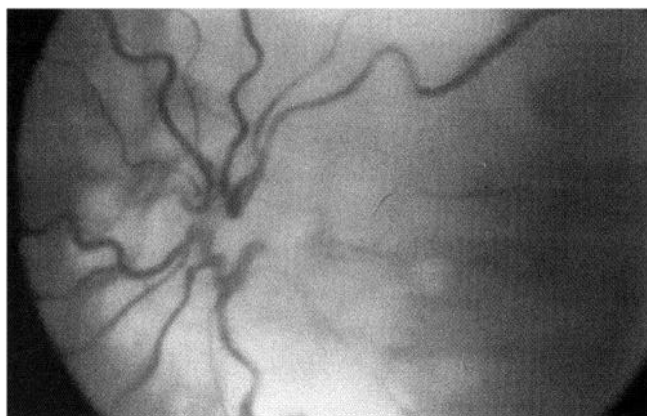


Figure 1. Predominately effusive stage 4B retinopathy of prematurity detachment.

Scleral buckling was performed according to the protocol that we described previously.⁷ This involved encirclage with a 240 band and paracentesis. The band then was divided at 3 months after encirclage if the retina reattached or at the time of vitreous surgery if further vitreous surgery was performed.

All eyes were approached for vitreous surgery so that lens-sparing vitrectomy could be performed. Both lens-sparing vitrectomy and lensectomy–vitrectomy–membrane peeling were performed using the technique of two-port vitreous surgery in children that we have described previously.⁸

After vitreoretinal surgery, children were referred promptly back to the pediatric ophthalmologist, who performed frequent follow-up examinations including occlusion therapy, refraction, and, when appropriate, early involvement in education programs for visually impaired children stressing multisensory education. Vision was assessed with a visual function battery,⁹ Teller acuity cards,¹⁰ and Allen and Snellen figures. In the preverbal group, grating acuities were converted to Snellen equivalents at a 55-cm testing distance. The authors are aware that no true equivalents exist between grating acuity (resolution acuity) and Snellen acuity (recognition acuity).^{9,10} However, studies have shown that both methods stratify visual acuity in a similar fashion and can be used for comparison purposes. For this reason, when possible, children were tested with more than one type



Figure 2. Predominately tractional stage 4B retinopathy of prematurity detachment.

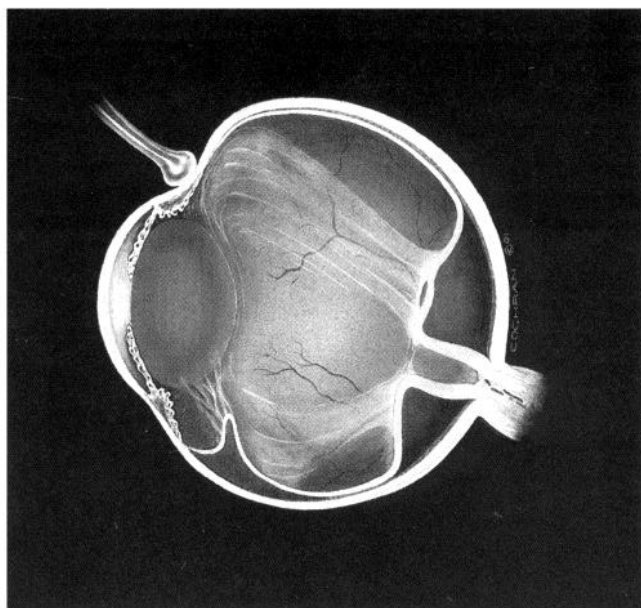


Figure 3. An artist's drawing of a predominantly tractional stage 4B retinal detachment.

of visual acuity technique. Of the 34 eyes with retinal detachments, only 1 eye could not be tested because of the systemic condition of the child.

Patients 16, 19, and 20 were not included in anatomic or visual data because data either were not available or the patient was not testable. The last known results of these patients are included in Table 3 for completeness.

Results

Seventy-six percent (25 of 33) of eyes with vision testing showed reattachment of the posterior pole at the last follow-up visit. Eleven of the eyes required reoperation. Nine eyes after presentation progressed to stage 5 (one 4A eye, seven 4B effusive eyes, and one 4B traction eye.) Eight eyes presented with stage 5 ROP. This resulted in a total of 17 eyes that progressed to or presented with stage 5 ROP. One of eight eyes that presented as stage 5 was found to be rhegmatogenous (Table 4).

Visual Results

Vision was tested in 33 of 34 eyes after retinal detachment surgery. Visual acuity at the last follow-up visit ranged from 20/63 to no light perception (NLP). Fifteen percent of eyes had visual acuity of 20/300 or better. Thirty percent of eyes had visual acuity of 20/800 or better. Forty-eight percent of eyes had visual acuity of 20/1900 or better, and 72% of eyes had light perception vision or better. Twenty-eight percent of eyes were NLP. We have used 20/800 or better vision to signify eyes that frequently can have reading vision in which near vision is disproportionately better than their distance vision. One of the authors (PD) has shown in a previous study that functional battery testing, which includes visually dependent life tasks, is a better visual testing tool than Teller acuities for low visual function children.⁹ Based on experience with functional battery

Table 3. Vision Testing Data for All Patients

Patient No.	Visual Acuity*	TAC CY/CM	VFB Quotient
1	OD: 20/1900 OS: 20/1400	0.32 0.64	11/24 11/24
2	OD: 20/470 OS: 20/470	2.4 3.2	NR NR
3	OD: 6/200† OS: NO	NR Retinal	NR Detachment
4	OD: NLP OS: NO	0 Retinal	0/21 Detachment
5	OD: 20/300† OS: 20/160†	NR NR	NR NR
6	OD: LPP OS: NLP	NR NR	NR NR
7	OD: LPP OS: 20/800†	0.32 NR	9/21 NR
8	OD: NLP OS: NLP	0 0	0/18 0/18
9	OD: 20/1400 OS: 20/1900	0.43 1.3	6/15 15/15
10	OD: 20/94 OS: NLP	6.5 0	24/24 0/24
11	OD: LP OS: NLP	0 0	3/24 0/24
12	OD: 20/470 OS: 20/1900	1.3 0.32	16/24 11/24
13	OD: NLP OS: LP	0 0	0 3/24
14	OD: NLP OS: NLP	0 0	0/15 0/15
15	OD: 20/100† OS: NO	NR Retinal	NR Detachment
16	OD: No data/ OS:	Lost to F/U	
17	OD: LP OS: LP	0 0	0 0
18	OD: 20/63 OS: 20/1400	9.8 0.43	24/24 6/15
19	OD: No data/ OS:	Patient died	
20	OD: No data/ OS:	Systemically	Unable to test
21	OD: LP OS: LP	0 0	1/24 1/24

TAC = Teller acuity cards; VFB = visual function battery; F/U = follow-up.

* In young children, fractional acuities were estimated from TAC and VFB testing.

† Resolution acuities possible.

Table 5. Anatomic Results of Eyes with Vision Testing Data

ROP Stage	Presenting Stage (no. of eyes)	Eyes that Progressed to or Presented as Stage 5	Attached Last Follow-up Examination
4A	1	1	1/1
4B E	16	7	13/16
4B T	8	1	7/8
5	8*	8*	4/8*
Total eyes	33	17	25/33 (76%)

* One eye was rhegmatogenous that presented as stage 5.

testing of low-vision children, the authors have used 20/1900 visual acuity or better to define ambulatory vision in a child.

Eyes were tested by visual function battery, Teller acuity cards, and Allen or Snellen acuity. All eyes were tested by at least one technique. Twenty-five eyes were tested by two or more techniques. The mean follow-up time for these results was 44 months, with a range of 153 to 6 months. The visual results and vision-testing techniques used are summarized in Table 5. Table 3 summarizes vision-testing results stratified by final ROP stage. Table 4 shows that if stage 4B effusive was the final ROP stage, then 77% of eyes achieved 20/800 visual acuity or better, whereas only 28% of stage 4B tractional and only 6% of stage 5 eyes achieved 20/800 or better visual acuity.

Discussion

The management of ROP presents some unique considerations of retinal detachment treatment. It must be realized that the retinal detachment of ROP is a detachment that progresses during the period of initial visual development. This increases the need for timely intervention to try and repair the retinal detachment during this period of visual maturation. In this study, we have shown that this management scheme can produce eyes with useful vision. Table 3 shows that eyes with final stage 4B effusive have a much higher chance of 20/300 visual acuity (44% of stage 4B effusive eyes) compared with that of other stages.

As always, this type of therapeutic intervention must be compared against the natural history. The natural history of stage 4 and 5 ROP perhaps has been best defined by the natural history data of the Retinopathy of Prematurity.

Table 4. Vision by Final Retinopathy of Prematurity (ROP) Stage*

ROP Stage	No. of Eyes	20/20–20/300	20/400–20/800	20/1000–20/1900	LP	NLP
4B E	9	4/9/44%	3/9/33%	1/9/11%	0/0%	1/9/11%
4B T	7	1/7/14%	1/7/14%	1/7/14%	2/7/28%	2/7/28%
5	16†	0/0%	1/16/6%	3/16/19%	6/16/37%	6/16/37%
Total	32	5/32	5/32	5/32	8/32	9/32

LP = light perception; NLP = no light perception.

* Percentages are rounded to nearest full percent.

† One eye that was rhegmatogenous was not included since not actually stage 5.

rity Cryo Study, which has shown that visual outcomes in eyes with stages 4 and 5 ROP end up with poor visual outcomes.¹¹ Stage 5 eyes, in particular, all led to NLP outcomes without surgical intervention.¹¹

Our study shows that with appropriate timing and intervention, useful vision can be achieved. Other studies have shown that useful vision is possible after surgical therapy for stage 4 and 5 ROP.^{3,5} However, these studies were not able to give us the benefit of a consecutive series of patients with uniform preoperative and postoperative care with long-term follow-up.

In one operative study of stage 4/5 ROP children, a very high percentage of children had central nervous system abnormalities, much higher than would have been expected in the general very premature population as a whole.⁶ In a general population of very low birthweight children (birthweight < 750 g), only 20% would be expected to fall into the category of unable to test.¹² In this postoperative ROP study, central nervous system or physical impairment did not allow good vision testing in 80% of patients. Our study had only 1 patient (5%) of 19 who systemically was unable to participate in vision testing.

Another article describing the experience of several surgeons using a variety of surgical techniques for advanced ROP was not organized into a uniform approach. This study showed very poor anatomic and visual results after surgical therapy.¹¹ That study does not outline an optimal surgical management for advanced ROP but does give us insight into the natural history of stage 5 ROP as the cohort of patients untreated all resulted in NLP.¹¹

Other studies have shown that during longer periods of follow-up, initial anatomic retinal detachment successes can redetach and fail.^{6,13} In our study, 11 reoperations were performed, 10 of which were for redetachment or continued vitreoretinal traction and 1 for lensectomy. Of the 11 eyes that were reoperated on, 7 eyes resulted in posterior pole retinal attachment, 3 eyes achieved 20/1900 or better visual acuity, 8 eyes achieved light perception vision or better, and 3 eyes were NLP.

As reported previously, we found that eyes with attached posterior poles had better visual results than those eyes that were detached.¹⁴ Only one eye with a detached posterior pole had light perception vision coming from an area of attached peripheral retina. Two eyes with attached posterior pole had NLP vision, presumably because of retinal damage by subretinal fluid before reattachment.

In this series, surgery of each eye was considered as an independent event. This resulted in only two children with bilateral no-light-perception vision. We believe it reduces the chance of total blindness (NLP) if both eyes are managed in an independent, timely fashion.

In this study, we found that visual results were better if the eye's final stage was 4B ROP instead of 5 even with successful reattachment. Although this series did not include a large number of 4A ROP eyes, it is reasonable to think that these stage 4A eyes likely would have a better visual prognosis than would stages 4B and 5 ROP. This is borne out by the experience of the CRYO-ROP

data in which only 22% of stage 4A eyes found at 3 months after peripheral ablation progress to a more severe form compared to 64% of the stage 4B eyes found at the same time.¹⁵

In our study, 13 of 16 stage 4B effusive and 7 of 8 stage 4B tractional eyes or 20/24 (83%) had attached posterior poles at the final follow-up visit. Thirty-one percent of those stage 4B eyes obtained 20/300 or better visual acuity. This suggests that treatment may be of benefit in stage 4B eyes. These results are based on final grading of the predominately effusive or tractional component with appropriate surgical management and aggressive follow-up.

Children in our study received their first vitreoretinal surgical procedure other than peripheral ablation at a mean age of 4.5 months from birth. Although the occurrence of retinal detachment is variable, this timing reflects the attempt to operate on these eyes soon after detachment occurs.

Certainly, the management of ROP should be greatly weighted toward avoiding the outcome of stages 4 and 5 ROP. Hopefully, newer and earlier therapies,¹⁶ such as the Supplemental Therapeutic Oxygen for Prethreshold Retinopathy of Prematurity Study, may be able to eliminate the problems of ROP. Until that time, however, it seems that appropriate screening, peripheral ablation, and timely vitreoretinal surgery techniques offer the best possible alternative available for a child affected with ROP.

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Discussion
by
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Dr. Trese and associates analyzed the results of closed vitrectomy in 33 eyes with stages 4 and 5 retinopathy of prematurity (ROP), with a mean follow-up period of 44 months. These authors achieved reattachment of the retina in the posterior pole in 75% of all eyes. Among those reattached retinas, 30% of patients had 20/800 or better visual acuity; one of these patients had stage 5 ROP. The results of vitrectomy in stage 5 ROP reported previously by some authors are disappointing¹⁻⁴ with the exception of a few authors who reported positive results.⁵⁻⁷ Currently, however, the surgical results in stage 5 ROP still are far from satisfactory, but I believe that they will improve if we determine how to stop neovascular activities and their effects, thus allowing us to perform vitrectomy for retinal detachment during the early active stage of ROP.

Regarding the management of stage 4 or partial retinal detachment in ROP, the use of scleral buckling is effective in many cases. The retina also can reattach spontaneously without treatment in some cases. Currently, when treating stage 4 ROP, the treatment of choice appears to be left to the judgment of the surgeons. In a multicenter trial of cryotherapy for ROP, Gilbert et al⁸ reported that of 22 eyes of patients with stage 4B ROP or partial detachment with macular involvement who were diagnosed at 3 months of age, 14 eyes (64%) had a total retinal detachment, retinoschisis, or a retrolental membrane with visual loss when the patients reached 4 1/2 years. Visual acuity measured at the age of 4 1/2 years was generally poor.⁸

Although the conclusion cannot be drawn that the natural history of stage 4 ROP is poor in every case from that study, which was conducted in two separate examination periods with a small patient group,⁸ retinal reattachment surgery appears to be indicated in some cases of stage 4 ROP. Dr. Trese and associates chose lens-sparing closed vitrectomy as the primary surgery to treat seven eyes for stage 4B ROP. It would be helpful to know the extent of detachment, the location of the retinal ridge, the presence or absence of PLUS disease, and the patient ages at which vitrectomy was performed to determine whether vitrectomy should be the primary surgery or whether scleral buckling is the better choice. Vitrectomy may be consid-

ered to treat advancing traction retinal detachment in an eye that does not have PLUS disease, and if the retinal ridge or highest retinal elevation is significantly posterior to the equator where the buckle cannot be applied effectively. The authors showed that vitrectomy was helpful in achieving relatively good visual acuity in some patients with stage 4 ROP, but the number of patients was still small. I hope the authors will continue to approach the problem cautiously and share their experience with us to help establish guidelines to manage stage 4 ROP in the future.

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