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EFFECT OF BRIGHT LIGHT IN THE HOSPITAL NURSERY ON THE INCIDENCE OF RETINOPATHY OF PREMATURITY

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Abstract The preterm infant is subjected to prolonged exposure to ambient nursery illumination at levels that have been found to produce retinal damage in animals. We prospectively investigated the effect of exposure to light in two intensive care nurseries by comparing the incidence of retinopathy of prematurity among 74 infants from the standard bright nursery environment (median light level, 60 foot-candles [ftc]) with the incidence among 154 infants of similar birth weight for whom the light levels were reduced (median, 25 ftc). There was a higher incidence of retinopathy of prematurity in the group of infants who had been exposed to the brighter nursery lights, particularly in those with birth weights below 1000 g (86 per cent vs. 54 per cent, $P<0.01$ by chi-square test). We conclude that the high level of ambient illumination commonly found in the hospital nursery may be one factor contributing to retinopathy of prematurity and that safety standards with regard to current lighting practices should be reassessed. (N Engl J Med 1985; 313:401-4.)

WITH the increased survival rate of premature infants, especially those of very low birth weight, there has been a concomitant increase in retrolental fibroplasia, now known as retinopathy of prematurity. Severe retinopathy of prematurity has nearly reached the epidemic frequency of the 1950s, with an estimated 500 to 600 infants blinded each year.[1] Although the duration of exposure to an elevated oxygen tension and immaturity of the retina are regarded as the principal factors associated with the disease, other factors contribute. One factor may be early exposure to light.

The intensity of light in the hospital intensive care nursery has increased 5-fold to 10-fold over the past two decades. In marked contrast to the ambient level of approximately 10 foot-candles (ftc) in the 1960s, the median level in our nurseries in 1982 was 90 ftc (range, 35 to 190) — similar to current levels reported elsewhere[2-4] and typically present for 24 hours a day.*

In addition to being exposed to these levels of ambient light, most preterm infants are now exposed to supplementary sources of light, such as the heat lamp (200 to 300 ftc) and the phototherapy lamp (300 to 400 ftc). The baby's eyes are routinely protected during phototherapy, but not while he or she is under a heat lamp or near a window. Adequate illumination is necessary for monitoring infants or performing even routine medical treatments. However, there is growing concern about the possible consequences of this exposure to light in young infants who may spend weeks or even months in the hospital nursery.[2-6] Indeed, research with animals has established the hazards of exposure to light at intensities similar to those found in the nursery.[5,7-11]

The existing studies of human infants exposed to bright nursery light have shown no evidence of gross retinal damage as determined by the electroretinogram, light threshold, and acuity screening.[3,6] However, these studies of otherwise healthy preterm and normal full-term infants provide little evidence regarding the safety of current light levels for the infant of very low birth weight or the infant receiving oxygen. Therefore, we studied the possible influence of bright nursery light on the development of retinopathy of prematurity in infants.

METHODS

Experimental Treatment

The treatment consisted of placing a square piece of neutral-density filter (60 cm) over the top and down the back of each infant's incubator as soon after admission as possible and for the duration of the hospital stay. The filter was a thin sheet of transparent acetate similar to the filter in sunglasses (Rosco Sun neutral density filter

*Multiplying foot-candles by 0.092 yields the equivalent in candles per square meter.[3]

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[N-3 and N-6], City Lights, Inc., Washington, D.C.), which reduced the intensity of light at the infant's face by approximately 50 per cent. The location of each infant and the level of exposure to light were checked twice a week for the duration of the hospital stay. Median light levels measured at the faces of infants during the control and treatment periods were 60 and 25 ftc, respectively.

Subjects

Three hundred thirty-three infants who met the criteria for the study were admitted to an intensive care nursery at Georgetown University Hospital or Children's Hospital National Medical Center between July 1982 and December 1983. All the infants weighed less than 2001 g and had a gestational age of less than 35 weeks at birth. Those weighing between 1500 and 2000 g were included only if they received oxygen in the nursery. All the infants were admitted to the nursery by the second day after birth and remained in the hospital for at least seven days. Infants with a major congenital anomaly, such as Down's syndrome or spina bifida, were excluded. Otherwise, the degree of illness was not a factor determining selection. To allow for possible compliance problems in the treatment condition, the design of the study called for enrollment of one third of the infants in the control (unprotected) group and two thirds in the treated (protected) group. The birth-weight distribution and the proportion of infants who died, were lost to follow-up, or had no eye examination were comparable in the unprotected and protected groups (Table 1). Because compliance was not a problem, the final sample consisted of 228 infants, 74 in the unprotected group and 154 in the protected group.

Group Assignment

Assignment to the control or treatment group was accomplished sequentially. That is, during the control period all the infants received the illumination that was customary in each hospital nursery. Thereafter, the treatment condition was instituted for all infants within each hospital. Thus, control and treatment were not simultaneous. The purpose of this design was to prevent control-group contamination that might occur once the staff and parents became familiar with the treatment. The treatment condition was likely to be preferred, and it would have been impossible to apply the treatment blindly. The treatment period began in Georgetown Hospital in November 1982 and in Children's Hospital in April 1983. The study ended in both hospitals on December 31, 1983.

Procedure

Examination for retinopathy of prematurity was routinely conducted in each hospital at discharge or shortly thereafter by pediatric ophthalmologists using an indirect ophthalmoscope. The eye examinations were scheduled for the most part when infants were between 35 and 40 weeks' conceptional age (gestational age plus age from birth). The ophthalmologists were unaware of the group to which the infants belonged. Classification of retinopathy was similar to McCormick's method.[12] Grade I was defined by a sharp demarcation line between the vascular and avascular retina, or shunt formation; Grades II to III were defined by a raised shunt and intravitreal neovascularization, and Grades IV to V by partial or complete retinal detachment.

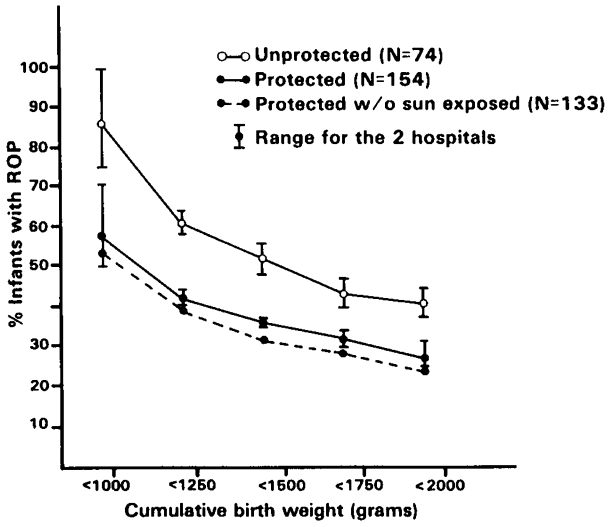

Figure 1. Effect of Illumination Level on the Incidence of Retinopathy of Prematurity (ROP) in Two Intensive Care (Level III) Nurseries (Cumulative Birth-Weight Function).
Broken lines indicate protected and without exposure to sunlight.

Results

Incidence of Retinopathy of Prematurity

The results indicated a significant relation between the intensity of light exposure and the incidence of retinopathy of prematurity. As shown in Figure 1, significantly more retinopathy was found in the group of infants exposed to brighter ambient light (unprotected), with parallel results at each hospital.

In a subgroup of infants, an association between light level and retinopathy was also found. During the treatment period, nursery renovations in one hospital resulted in a southern exposure in the intermediate nursery. On occasion, protected infants whose beds were next to the window were observed to have the sun in their faces. Since the neutral-density filter had been placed over the top and the back of the incubator, and not the front, this meant periodic exposure to intensities in excess of 400 ftc. Of the 14 infants in the protected group who had retinopathy, 11 (79 per cent) had been in a bed next to the window. Ten of these infants could be matched for birth weight with infants in the same protected group who did not have retinopathy. Only 1 of these 10 birth-weight–matched infants without retinopathy (10 per cent) had been in a bed next to the window. On the basis of this empirical relation between probable sun exposure and retinopathy (Fisher's

Table 1. Comparison of the Unprotected and Protected Groups.

Group	Birth Weight (g)			Total
	500–1000	1001–1500	1501–2000*	
Control period				
No. admitted to ICN†	41	40	29	110
No. who died within first month	20	4	2	26
No. lost to follow-up or given no eye exam	0	6	4	10
Final no. of unprotected infants	21	30	23	74
Treatment period				
No. admitted to ICN†	83	85	55	223
No. who died within first month	35	6	1	42
No. lost to follow-up or given no eye exam	3	15	9	27
Final no. of protected infants	45	64	45	154

*Includes only the infants in this birth-weight category who required oxygen in the nursery.
†ICN denotes intensive care nursery.

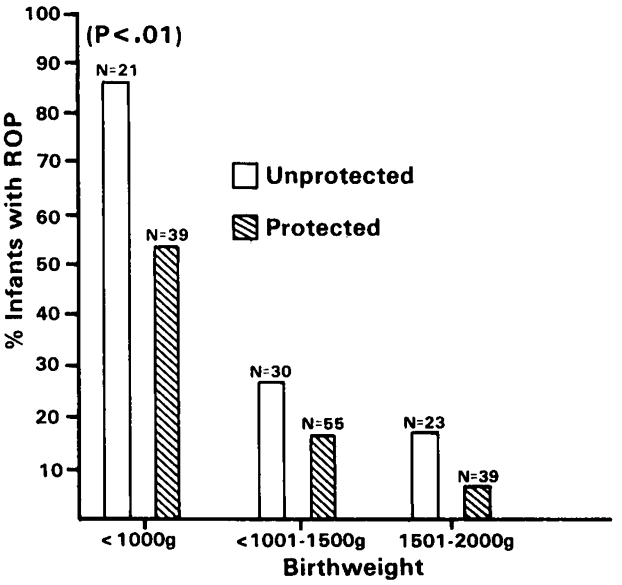

Figure 2. Effect of Bright Light in the Hospital Nurseries on the Incidence of Retinopathy of Prematurity (ROP). Infants are grouped according to birth weight.

exact $P<0.005$), subsequent analyses excluded from the protected group the 21 babies whose beds had been next to the window in that intermediate nursery, whether or not they acquired retinopathy of prematurity. As shown in Figure 1, removal of this subgroup from the protected group further enhanced the treatment effect.

The data were then classified into separate birth-weight categories: below 1000 g, 1001 to 1500 g, and 1501 to 2000 g. As shown in Figure 2, the unprotected infants in each birth-weight category were more likely to have retinopathy of prematurity, although the difference was statistically significant only for the infants with birth weights below 1000 g ($P<0.01$ by chi-square test).

To determine whether the 86 per cent incidence of retinopathy of prematurity in unprotected infants weighing less than 1000 g at birth and the 54 per cent incidence in protected infants might be accounted for by some other variable, protected and unprotected infants in this birth-weight category were compared for a number of factors. As outlined in Table 2, sex, mean birth weight, mean gestational age, and one-minute and five-minute Apgar scores did not differ significantly between the protected and unprotected groups by chi-square or t-test (two-tailed). There were no significant differences between the protected and unprotected groups in severity of respiratory disease as measured by days of ventilator therapy or duration of oxygen therapy, nor were there differences in degree of central nervous system compromise as defined by the severity of intraventricular hemorrhage or the presence of meningitis, periventricular leukomalacia, or seizures (chi-square tests). Length of hospitalization, reflected by the median number of days before discharge, was also similar in the two groups. By design, the level of ambient light was different in the two groups. All the infants received vitamin E as part of their standard hospital care.

Severity of Retinopathy of Prematurity

Two infants had bilateral retinal detachments (Grades IV to V) and blindness. Both were in the unprotected group. There was no statistically significant difference in the incidence of blindness between the protected group (<0.7 per cent) and the unprotected group (3 per cent).

Discussion

Our study was a prospective comparison of preterm infants under the standard, bright lights in the hospital nursery and preterm infants of similar birth weight who were under reduced levels of light. The higher incidence of retinopathy of prematurity among the in-

Table 2. Characteristics of Infants Weighing Less than 1000 g at Birth.

	Group	
	Unprotected (n = 21)	Protected (n = 39)*
No. with retinopathy of prematurity (%)	18/21 (86)	21/39 (54)
No. male (%)	8/21 (38)	13/39 (33)
Mean birth weight — g	910	830
No. <750	0/21	7/39
Mean gestational age — wk	27.7	26.9
No. <26	0/21	5/39
Mean 1-min Apgar score†	3.2	3.4
No. with 1-min Apgar <4 (%)	10/18 (56)	21/36 (58)
Mean 5-min Apgar score†	5.7	6.1
No. with 5-min Apgar <7 (%)	11/18 (61)	18/36 (50)
Duration of ventilator therapy — wk		
No. with <1 (%)	4 (19)	8 (21)
No. with 1–2 (%)	1 (5)	4 (10)
No. with 2–4 (%)	3 (14)	3 (8)
No. with >4 (%)	13 (62)	24 (62)
Duration of oxygen therapy — wk		
No. with <1 (%)	3 (14)	6 (15)
No. with 1–2 (%)	1 (5)	1 (3)
No. with 2–4 (%)	1 (5)	3 (8)
No. with >4 (%)	16 (76)	29 (74)
No. with CNS manifestations (%)‡		
None	4 (19)	9 (23)
Minor (IVH Grades I–II)	8 (38)	18 (46)
Major (IVH Grades III–IV, periventricular leukomalacia, seizures, or confirmed meningitis)	9 (43)	12 (31)
No. requiring exchange transfusions (%)	5 (24)	5 (13)
Median days until discharge	117	102
Median light levels — ftc (range)§	70 (55–100)	25 (20–40)

*Excludes sun-exposed infants; see text for explanation.

†Apgar scores for some infants were not recorded.

‡CNS denotes central nervous system, and IVH intraventricular hemorrhage.

§The group data were calculated from the medians obtained for each baby.

fants under the brighter lights suggests that the light levels commonly found in the hospital nurseries may be one factor contributing to this disease.

According to a recent collaborative study by Kinsey and associates,[13] the most important factors related to retinopathy are birth weight, gestational age, and duration of supplementary oxygen treatment. These variables are all highly intercorrelated, and all reflect functional immaturity. The effect of light in our study was strongest in the infants weighing less than 1000 g at birth.

Possible explanations for the effect of light in increasing the risk of retinopathy in infants may be provided by the extensive literature on the effects of exposure to light in animals. For example, light may make the eyes more sensitive to the damaging effects of oxygen on immature vessels, by altering the retinal vasculature[14,15] or the cell metabolism.[16] Altered metabolism could lead to abrupt shifts in oxygen demand by the inner retinal layers. Exposure to light leads to bleaching, and the byproducts of excessive bleaching could serve as a catalyst for anomalous neovascularization.[17]

Furthermore, the development of retinopathy of prematurity may be related to underlying structural damage. For example, excessive exposure to light in animals has resulted in damage to the photoreceptors, the pigmented epithelium, and the choroid — all structures involved in retinal oxygen transport. Damage to the pigmented epithelium could interfere with its important role in phagocytosis, which in turn would result in an accumulation of extralamellar matter,[18] also a possible catalyst for abnormal neovascularization. Finally, not only may light make the eye more sensitive to possible oxygen damage, but oxygen may increase the eye's sensitivity to light damage.[15,19,20]

Although reducing the intensity of light in the present study was associated with a reduction in retinopathy, an environment of continuous dim light may not be optimal for the preterm infant. Furthermore, in view of the extensive literature on the effects of visual deprivation, keeping a preterm infant in continuous darkness is likely to be inappropriate. There is no known study of retinopathy of prematurity that has looked at the effects of cycled lighting (dark/dim or dark/light). Some evidence indicates that cycled lighting may protect against light damage.[17] Theoretically, cycled lighting could be especially protective against the development of cicatricial stages of retinopathy. It might be useful to pursue this line of evidence in future research.

In summary, this study suggests that the levels of light common in the hospital nursery may contribute to the incidence of oxygen-induced retinopathy of prematurity, especially in infants weighing less than 1000 g at birth. The findings were substantiated by parallel results in each hospital and by an effect of exposure to light within the treatment group. Although preliminary, this research raises serious questions regarding the levels of light appropriate for preterm infants.

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