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The Survival and Developmental Outcome of Extremely Low Birthweight Infants

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ABSTRACT: The purpose of this retrospective study is to compare the factors affecting the survival and developmental outcome of extremely low birthweight infants (ELBW; < 1,001 gms.). One hundred and forty of two hundred and twenty-three ELBW neonates (63%) from two Level III NICUs born between 1986 and 1988 survived until discharge. Lower birthweight, 5-minute Apgar ≤ 3, and no administration of surfactant were the best predictors of infant mortality as assessed via logistic regression (correct classification = 78%). The functioning of 34 of these infants was assessed at approximately 18 months of age with the Bayley Scales of Infant Development. Mean performance on the Mental Development Index (MDI) was 88.65 ± 21.75, with 35.3% and 20.6% of infants scoring, respectively, 1 (< 85) and 2 (< 70) standard deviations below the mean. Given survival, intraventricular hemorrhage (IVH, Grade III or IV) was the best predictor of MDI performance as assessed via stepwise multiple regression (adjusted $R^2 = .23$). Cerebral palsy affected one fifth of the sample and was also best predicted by IVH. Discussion focuses on the conceptual and practical implications of the finding that infant survival and infant developmental status were associated with different factors.

RESUMEN: El propósito de este estudio retrospectivo es comparar los factores que afectan la supervivencia y los resultados de desarrollo de infantes nacidos con un peso extremadamente bajo (ELBW; < 1,001 gms.). 140 de 223 ELBW recién nacidos (63%) de dos niveles III NICUs nacidos entre 1986 y 1988 sobrevivieron hasta que fueron dados de alta. Un peso más bajo al momento del nacimiento, cinco minutos de aplicación del sistema Apgar con un resultado de ≤ 3, y la falta de administración de surfactantes fueron los mejores indicadores de

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mortalidad infantil tal como fueron evaluados por medio de la regresión logística (clasificación correcta = 78%). El funcionamiento de 34 de estos infantes fue evaluado aproximadamente a los 18 meses de nacidos con la Escala Bayley para el Desarrollo Infantil. El promedio de actuación en cuanto al Indice de Desarrollo Mental (MDI) fue 88.65 ± 21.75 con 35.3 y 20.6 por ciento del puntaje de los infantes, respectivamente; uno (< 85) y dos (< 70) con una variante de error por debajo del promedio. Una determinada hemorragia intraventricular sobrevivida (IVH, grado III o IV) fue el mejor indicador de la actuación en el Indice de Desarrollo Mental tal como fue evaluado por medio de la regresión múltiple paso por paso (ajustado $R^2 = .23$). La parálisis cerebral afectó un quinto de la muestra y también la predijo mejor la IVH. La discusión se enfoca en las implicaciones conceptuales y prácticas de los hallazgos de que la supervivencia del infante y la condición de desarrollo del mismo se asociaron con diferentes factores.

RÉSUMÉ: Le but de cette étude rétrospective est de comparer les facteurs affectant la survie et le développement de nourrissons nés avec un poids de naissance extrêmement bas (abrégé ELBW; < 1001 mgs.). 140 sur 223 nouveau-nés ELBW (63%) de deux Unités de Soin Intensif Néonatal de niveau III nés entre 1986 et 1988 ont survécu jusqu'à leur sortie de l'hôpital. Un poids de naissance plus faible, un Apgar de 5 minutes ≥ 3, et aucune administration de surfactant étaient les meilleurs facteurs de prévision de mortalité infantile, évalué par régression logistique (classification correcte = 78%). Le fonctionnement de 34 de ces nourrissons a été évalué à approximativement 18 mois avec les Echelles Bayley de Développement Infantile. La performance moyenne sur l'Index de Développement Mental (abrégé MDI) était de 88,65 ± 21,75 avec 35,3 et 20,6 pourcent des nourrissons marquant, respectivement, une (< 85) et deux (< 70) erreurs types sous la moyenne. Supposé que l'enfant survive, l'hémorragie intraventiculaire (IVH, groupe III ou IV) était le meilleur facteur de prédiction de la performance MDI, évalué à travers une régression multiple des étapes (ajustée R^2 =,23). La paralysie cérébrale a affecté un cinquième de l'échantillon et était aussi la mieux prédite par IVH. La discussion met l'accent sur les implications conceptuelles et pratiques de la découverte que la survie infantile et le statut de développement du nourrisson étaient associés á des facteurs différents.

抄録：このレトロスペクティブな研究の目的は、出産時体重が極度に低い(ELBW;<1,001 grams) 乳児の生存および発達達成度に影響を与える要因の比較にある。1986年から1988年の間に生まれた、 2つのレベルIII NICUs からの 223名のELBW新生児のうち、 140名 (63%)が退院まで生存した。出産時低体重、 5分目アプガー・スコア≦ 3, そして界面活性剤無投与が、ロジスティック回帰分析を用いての評価では、乳児の死亡率を最も適格に予測した（適性分類率78%)。その乳児のうち34名に関し、Barley Scale of Infant Developmentを使い、月齢約18か月の時点で、機能を評価した。Mental Development Index (MDI)の平均値は、 88.65±21.75 で、平均よりの標準偏差が1 (<85), 標準偏差が2 (<70)の%はそれぞれ35.3, 20.6であった。生存者に限って言えば、 MDI値を最も適格に予測したのは、段階的多項目回帰分析を使って評価した場合、心室内出血(IVH, grade III or IV)であった。サンプルの 1/5で脳性マヒがみられたが、それを最も適格に予測したのも IVHであった。考察においては、乳児の生存と発達状態が各種要因と関係してくるという所見の意味合いに焦点を合わせた。

Over the past 15 years, improvements in perinatal care have resulted in a lower mortality rate for ELBW infants, particularly those born in regional medical centers (Alberman & Botting 1991; Blackman, 1991; Hack & Fanaroff, 1988; Kitchen et al., 1991; Parker, Lindstrom, & Cotton, 1992; Robertson, Hrynchyshyn, Etches, & Pain, 1992; Victorian Infant Collaborative Study Group [VICSG], 1991). Factors associated with the survival of ELBW infants include higher Apgar scores, higher birthweights and greater gestational age (Allen, Donohue, Dusman, 1993; Horbar et al., 1993; Lipper, Ross, Auld, & Glassman, 1990), the absence of intrauterine growth retardation (Phelps et al., 1991), and the administration of artificial surfactant (Bose et al., 1990; Repka, Hudak, Parsa, & Tielsch, 1992; Zola et al., 1993).

It is not clear to what degree declines in neonatal mortality have been paralleled by difficulties in the development of these low birthweight infants (Kitchen et al., 1991; Robertson et al., 1992; VICSG, 1991). The majority of ELBW infant survivors appear to have little or no developmental handicap. However, cognitive, motor, and/or sensory

impairment is frequent during infancy and childhood and may be particularly prevalent at moderate levels (Barrera, Rosenbaum, & Cunningham, 1987; Gorga, Stern, & Ross, 1985; Hack et al., 1994; McCormick, Brooks-Gunn, Workman-Daniels, Turner, & Peckham, 1992; Watt, 1986). This study identifies the factors associated with the survival of ELBW infants and, in separate analyses, the developmental integrity of older ELBW infants who survived the neonatal period. The focus is on whether neonatal survival and the adequacy of later functioning are associated with the same factors.

METHODS

The subjects for this retrospective study were 223 neonates born weighing less than 1,001 grams who were admitted to two Level III Newborn Intensive Care Units (NICU) staffed by a common team of neonatologists at the University of Utah Medical Center or Primary Children's Medical Center between January 1, 1986, and December 31, 1988. Data, including diagnoses made by the attending neonatologist, were abstracted from the infants' hospital records. Intraventricular hemorrhage (IVH) was diagnosed at 1 week by routine ultrasound and earlier if IVH was suspected. Variables with significant univariate associations were entered into a logistic regression to find the factors that best predicted infant survival.

Of the 140 infants who survived until discharge, 41 (one of whom subsequently died and was excluded from analyses of follow-up status) were seen at least once at the Neonatal Follow-up Program of the Utah State Department of Health. A logistic regression was used to determine if there were differences between survivors who returned for follow-up care and assessment and those who did not. The developmental course of the 40 surviving infants was assessed through the clinical assessments of a multidisciplinary team. The Bayley Scales of Infant Development (Bayley, 1969) were administered by psychologists when infants were as close as possible to 18 months of age. In all, 19 Bayleys were conducted at eighteen months, 4 at six months, 2 at nine months, 5 at twelve months, 1 at twenty-four months, and 3 at thirty months.[1] The infant's age at administration was corrected for prematurity (cf. Barrera et al., 1987) and the infant's raw mental score was converted to a Mental Development Index (MDI).

Infants' cerebral palsy (CP) and visual and auditory deficits were diagnosed, respectively, by a pediatric neurologist, a pediatric ophthalmologist, and a pediatric audiologist. From a functional perspective, the presence of CP indicated from slight to substantial interference with day-to-day activities. CP was diagnosed at 2 years and this diagnosis was confirmed at 5 years for six of the eight affected infants. Because severe sensory deficit was rare in this sample—with one case of bilateral blindness and no cases of deafness—these variables were not included in analyses. The socioeconomic status (SES) of the infant's family (Hollingshead, 1975), yearly income, insurance coverage, and marital status were also assessed at follow-up. Both neonatal and SES variables were used as predictors of CP and Bayley MDI.

[1]If an infant did not have an 18-month score, the score administered at the age closest to 18 months was used. If there were two scores from administration at which the child's age was equidistant from 18 months (e.g., 12 and 24 months), the score administered at the older age was used. In six cases, there were no Bayley data because of the unsuitability of the assessment.

Table 1
Univariate Descriptors of Infants Who Did and Did Not Survive Until Hospital Discharge

	Neonatal deaths ($n = 83$)	Neonatal survivors ($n = 240$)	p
5-min Apgar ≤ 3 (%)	54.3	10.9	.00
Surfactant (%)	40.2	63.9	.00
Parity + S.D.	2.76 (1.66)	2.19 (1.46)	.01
Birthweight in grams	663.49 (150.20)	801.78 (121.68)	.00
Outborn (%)	14.5	17.8	.51
Vaginal delivery (%)	48.2	57.1	.20
IVH (III or IV) (%)	21.7	22.1	.93
Male (%)	49.4	44.2	.46
White (%)	89.1	89.1	1.00
AGA (%)	92.8	89.3	.39

Analysis Summary

All dichotomous variables—infant survival until hospital discharge, infant presence at the follow-up clinic, and infant CP at follow-up—were predicted with logistic regressions. Bayley MDI at follow-up, a continuous variable, was predicted with a multiple regression. In preparation for each of these analyses, predictor and predicted variables were examined to assure their approximate normality or, in the case of dichotomous variables, their skew. For each prediction analysis, only predictor variables with significant associations ($p < .05$) with the predicted variable were entered in the analyses. To assess univariate significance, chi square or Fischer's exact test was conducted when both predictor and predicted variables were categorical; t tests were conducted when one variable was categorical and the other continuous; and correlation coefficients were used when both variables were continuous. For each prediction analysis, correlation and chi square tables of the predictor variables were inspected and tests of tolerance were conducted to avoid multicollinearity. Both the logistic regression and multiple regression analyses were run in SPSSX using forward entry (criterion for inclusion, $p < .01$; criterion for exclusion, $p > .05$). Residuals from these analyses were examined to insure the normality, linearity, and equivariance of their distributions.

RESULTS

Predicting Infant Survival and Follow-up

Of the 223 neonates, 83 (37.2%) died in the hospital and 140 (62.8%) survived until discharge from the hospital. Demographic and neonatal characteristics of both groups are compared in Table 1. Univariate analyses indicated that neonates who survived until hospital discharge had higher birthweights, were more likely to have received surfactant, were less likely to have had a 5-minute Apgar of 3 or below, and had mothers with a smaller mean number of deliveries than neonates who did not survive until discharge.[2]

[2]To avoid spurious associations, the frequency of diagnoses of respiratory ailments made up to several weeks after birth (i.e., respiratory distress) and their course of treatment (i.e., number of days on supplemental oxygen) were not compared between groups. These variables tend to have spurious positive associations with infant survival because the presence of such diagnoses and a greater number of days of treatment indicate an infant's continued survival which, in turn, is associated with survival until hospital discharge.

Table 2
Logistic Regression Coefficients and Odds Ratios for Factors Predicting Neonatal Mortality

	Coefficient	Odds ratio	95% CI of odds ratio	*p* if excluded
5 min. Apgar ≤ 3	1.843	6.316	2.681–14.925	.00
Surfactant	−1.254	.285	.139–.587	.00
Birthweight	−.729*	.482	.419–.556	.00
Constant	5.153			

*Per 100-gram increase in birthweight.

A logistic regression using stepwise entry indicated that lower birthweight, a 5-minute Apgar score of 3 or below, and absence of treatment with surfactant were each uniquely associated with neonatal mortality. The relative risk of each of these factors when controlling for the other factors in the model is displayed in Table 2. Together these factors correctly classified the outcome of 78% of the infants in the sample.

Predicting Attendance at Follow-up

The next task was to determine differences between the 41 survivors who were seen at least once at the Neonatal Follow-up Program and the 100 who did not return for follow-up. Table 3 shows univariate differences in measures of perinatal status, later diagnoses, and courses of treatment between these two groups. Infants who attended follow-up were more likely to have an in-state (Utah) address and more likely to have been outborn than infants who did not attend follow-up. In addition, they received supplemental oxygen for a greater number of days and were less likely to have been treated with surfactant than infants who did not attend follow-up. Forward entry logistic regression (see Table 4) indicated that having not received surfactant and having an in-state address made significant, unique contributions to predicting attendance at follow-up. Together these factors correctly classified the follow-up status of 79% of neonatal survivors.

Table 3
Univariate Comparison of Perinatal Factors Among Infants Who Did and Did Not Attend Follow-Up

	Attended follow-up ($n = 41$)	Did not attend follow-up ($n = 99$)	*p*
5-min Apgar ≤ 3 (%)	12.8	10.2	.66
Surfactant (%)	29.7	77.1	.00
Parity (S.D.)	2.25 (1.48)	2.17 (1.46)	.77
Birthweight	782.05 (123.87)	809.67 (120.47)	.23
Outborn (%)	40.0	9.0	.00
Vaginal delivery (%)	62.5	55.0	.42
IVH (III or IV) (%)	17.5	24.0	.40
Male (%)	37.5	47.0	.31
White (%)	84.6	90.9	.28
AGA (%)	95.0	87.0	.17
In-state address (%)	87.2	64.0	.00
Days on O_2 (S.D.)	81.36 (56.73)	55.64 (36.74)	.01

Table 4
Logistic Regression Coefficients and Odds Ratios for Factors Predicting Attendance at Neonatal Follow-Up

	Coefficient	Odds ratio (95% Confidence Interval)	*p* if excluded
Surfactant	−2.016	.133 (.055–.326)	.00
In-state address	1.378	3.969 (1.291–12.198)	.02
Constant	−0.848		

Describing and Predicting Status at Follow-up

Families seen at follow-up were of predominantly intermediate socioeconomic status, as indicated by their Hollingshead Scale scores and yearly family income, with a substantial degree of variability noted in yearly family income. Bayley MDIs of the follow-up sample indicate that although the majority of infants were functioning in the normal range, a third were either at risk or functioning at a suboptimal level (see Table 5). Table 5 also indicates that infants whose Bayleys were administered before 12 months of age were overrepresented among infants functioning in the normal range. Infants with CP were overrepresented among the infants with at-risk or suboptimal MDIs. Univariate analyses [see Table 6(A)] indicated that two conditions that were relatively rare in this sample, IVH (Grades III or IV) and not being ethnically White, were associated with lower MDIs. Longer periods of treatment with oxygen were also associated with lower MDIs [see Table 6(B)]. In addition, the younger an infant was when the Bayley was administered, the higher the MDI tended to be [see Table 6(B)].

In a stepwise multiple regression, IVH was a unique predictor of MDI, explaining 23% of the adjusted variance (see Table 7). Infants with IVH obtained significantly lower MDI scores from other infants. No other variable(s) accounted for a significant portion of the remaining variance in MDI score. Nevertheless, concerns about the association between IVH effects and the age at which the Bayley had been administered were addressed in two ways. First, when the age of Bayley administration was forced to enter the regression equation first (adj. $R^2 = .13$, $p = .11$), the effect of IVH remained significant (adj. $R^2 = .27$, $p = .01$), rendering the effect of age nonsignificant. Second, when the analysis was limited only to infants whose Bayleys had been administered at 18 months of age, IVH remained the sole significant predictor (adj. $R^2 = .33$, $p = .01$).

Table 5
Bayley MDI and Cerebral Palsy (CP) Status at Follow-up

	Number (%)	Number (%) with Bayley before 12 months	Number (%) with any CP
MDI < 70	7 (20.6)	0 (0)	2 (40)
MDI 70–84	5 (14.7)	1 (16.7)	3 (60)
Total MDI < 85	12 (35.3)	1 (16.7)	5 (100)
MDI ≥ 85	22 (64.7)	5 (83.3)	0
Missing	6	0	3
Total	40	6	8
Mean (SD)	88.65 (21.75)	96.50	65.20 (8.67)
Median	94	99	70

Table 6(A)
Distribution of Dichotomous Infant Status Variables and Their Univariate Associations with the Bayley MDI (n = 34)

	Identifier present		Identifier absent		
	#	MDI Mean (SD)	#	MDI Mean (SD)	*p* value
5-min Apgar ≤3	4	76.25 (29.34)	30	90.93 (20.69)	.22
Surfactant	8	86.25 (8.87)	26	88.30 (22.00)	.83
IVH (III or IV)	5	60.00 (14.14)	29	90.24 (20.22)	.00
Male	22	88.27 (20.35)	12	89.33 (25.07)	.89
Ethnic White	30	92.64 (20.30)	4[a]	70.80 (21.99)	.04
Resp. distress	4	100.00 (10.42)	30	87.13 (22.52)	.27
In-state address	31	88.61 (22.39)	3	89.00 (17.06)	.98
Married	30	90.00 (21.03)	4	86.50 (26.41)	.77

[a]Two of these infants were Native American and two were Hispanic.

IVH was the only infant status variable with a significant univariate association with CP and emerged as a significant predictor of the presence of CP in a stepwise logistic regression, correctly classifying 85% of the infants. To insure that the association between IVH and lowered MDIs was not confined to infants with CP, a multiple regression predicting MDI was run that excluded infants with CP (see Table 8). IVH remained the most powerful predictor (adj. $R^2 = .28$) in this analysis, with number of days on oxygen accounting for the remaining variance (adj. $R^2 = .52$).

DISCUSSION

This retrospective study describes and predicts the incidence of survival and the later functioning of extremely low birthweight infants. The neonatal survival rate of 63% documented here is comparable to the rate in other Level III hospitals during overlapping periods (Hack & Fanaroff, 1988; see also Collin, Halsey, & Anderson, 1991). Findings that lower birthweight, an Apgar score of 3 or below at 5 minutes, and not receiving surfactant were each independently associated with increased neonatal mortality replicate the results of others (Horbar et al., 1993; Lipper et al., 1990; Phelps et al., 1991). The finding that artificial surfactant was associated with increased rates of infant survival in a noncontrolled clinical setting corroborates identical experimental findings (Bose et al., 1990; Repka et al., 1992; Zola et al., 1993). These results suggest the importance of prenatal measures

Table 6(B)
Descriptors of Continuous Infant Status Variables (n = 40) and Their Univariate Associations with the Bayley MDI (n = 34)

Parameters	Mean	Median	SD	SE	Correlation coefficient	*p*
Yearly income	$24,291	$22,000	$1,860	$2,735	.04	.84
Hollingshead	2.88	3	1.27	0	−.10	.61
Birthweight	782.05	795.00	123.87	19.59	.10	.58
Days on O_2	81.36	79.00	56.73	9.08	−.35	.04
Age at Bayley	16.41	18.00	6.28	1.08	−.45	.01

Table 7
Regression Equation Predicting the Bayley MDI

Variable	*B*	*SE B*	Beta	95% confidence interval	Adjusted *R* square	*p* if excluded
IVH (III or IV)	−30.01	9.25	−0.50	−48.90 to −11.12	.23	.00
Constant	93.89	3.60				

designed to avoid ELBW births and, in the case of ELBW births, the importance of surfactant administration and aggressive resuscitation, to survival.

As in other retrospective studies, subject attrition was a difficulty. Approximately two thirds of the infants discharged alive from the hospital were not seen at follow-up. Infants seen at follow-up were less likely to have received surfactant and more likely to have lived within the same state as the follow-up clinic. Living in-state suggests the influence of familial convenience and does not indicate a systematic medical bias distinguishing infants seen at follow-up from other survivors. However, infants seen at follow-up were less likely to have been treated with surfactant and univariate analyses indicated that these infants were treated with oxygen for longer time periods. This suggests that infants seen at follow-up were more likely to have received extensive (but not prophylactic) treatment for respiratory difficulties.

Approximately one third (12/34) of the sample showed at-risk or delayed cognitive performance. The rates of low performance on tests for mental ability parallel reports from other studies of ELBW infants assessed at school age (Hack et al., 1994; McCormick et al., 1992). However, the 20% CP rate (8/40) in this study appears to be elevated in comparison with studies of other ELBW infants (9%; Hack et al., 1994) and a meta-analysis of infants with birthweights under 1,500 grams (median rate 7.7%; Escobar, Littenberg, & Pettiti, 1990). The high rate of CP observed may be due to an overrepresentation of disabled infants in this follow-up sample.

These observations suggest the results of the developmental analyses may be most generalizable to high-risk samples with relatively lengthy periods of oxygen dependence and relatively high rates of CP. In future studies, greater follow-up compliance might be achieved by assessing parents' perceptions of their infants' health status, tracking family moves and changes in infant health care providers, as well as by specifically targeting infants with shorter periods of intensive neonatal care who did not show CP for aggressive recruitment campaigns.

Table 8
Logistic Regression Coefficients and Odds Ratios Involved in Predicting Cerebral Palsy

	Coefficient	Odds ratio (95% confidence interval)	*p* if excluded
IVH (III or IV)	2.59	13.330 (1.974 − 90.017)	.01
Constant	−2.306		

A factor impacting the predictive validity of the study was that the seven infants who received their Bayley exams early, at 6 or 9 months, had higher MDI scores than other infants (see Tables 5 and 6B). Before 1 year, MDI performance is typically dependent on sensorimotor competence and motor control. After 1 year, MDI performance is typically dependent on more sophisticated cognitive tasks such as using means to ends, matching shapes, and demonstrating object constancy. It may be that the ELBW infants in this sample showed greater deficits on these more advanced items. Alternately or in addition, the competence of ELBW infants may have declined over the age span that Bayleys were administered. In either case, it is possible that we underestimated the deficits of the seven infants whose Bayley exams were administered before 12 months. More generally, the future prognosis of these ELBW infants is unclear, with some researchers reporting a reduction in handicap (Kitchen et al., 1987) and other researchers reporting an increase in at least minor deficits (Collin et al., 1991) between infancy and early childhood.

Forced entry multiple regression indicated that IVH was a robust and consistent predictor of MDI whose presence rendered the tendency of Bayley MDIs to decline with age nonsignificant. In fact, when we limited the analysis to infants whose Bayleys had been administered at 18 months of age, the link between IVH and MDI scores became stronger. IVH predicted close to a quarter of the variability in infant MDI functioning in the sample as a whole. This parallels other findings indicating that increased severity of IVH is associated with lower scores on tests of mental performance (Hack et al., 1994; Landry, Chapieski, Fletcher, & Denson, 1988; Msall et al., 1994). As in other studies Hack et al., 1994; Msall et al., 1994), IVH was also a significant predictor of CP. These results underscore the degree to which insult to the developing brain affects later mental functioning and sensorimotor competence.

Though there was a univariate association between dependence on oxygen and MDI performance in the sample as a whole, IVH more adequately accounted for this variance when "competing" with oxygen dependence. Among infants who did not have CP, however, number of days of oxygen dependence was also associated with cognitive performance. These results are similar to the findings of other researchers who have found that both cerebral insult (IVH) and indices of chronic respiratory disease explain variance in cognitive performance (Hack et al., 1994; Landry et al., 1988).

This study's most important finding was that infant survival and later developmental functioning were associated with different factors. As in studies by others, infant birthweight, 5-minute Apgar score, and the administration of artificial surfactant were strong predictors of infant survival (e.g., Bose et al., 1990; Horbar et al., 1993; Lipper et al., 1990; Phelps et al., 1991). However, once survival had been established, these factors were not associated with the degree of developmental deficit seen in the second and first years of life. A similar pattern has been reported by Hack et al. (1994), who found that when IVH and long-term oxygen dependence were used to account for cognitive performance and incidence of CP, birthweight ceased to be a significant predictor. Conversely, grade of intraventricular hemorrhage had the strongest influence on later developmental status and no significant association with survival before discharge from the hospital. In fact, we know of only one study (Msall et al., 1994) in which IVH was associated with infant mortality.

Mortality and later morbidity are often seen as points along a scale. In this view, normal functioning is an extreme point on the scale, developmental deficit is a middle

ground, and neonatal death is at the opposite extreme. This study suggests the analogy is not apt. Although survival is an obvious precursor to healthy development, neonatal mortality and developmental deficits appear to be associated with different factors. Higher birthweight and adequacy of cardiovascular and respiratory functioning best predict survival. Once survival is established, deficits in later functioning are best predicted by cerebral insult. This suggests that the incidence of neonatal survival and developmental deficits in ELBW infants may be different dimensions of functioning.

One proviso is that factors necessitating continued dependence on oxygen may be related to neonatal mortality and often emerge as predictors of later disability. Nevertheless, medical staff should be aware of the possibility that the factors that endanger the lives of neonates may differ from the factors that, if the neonates survive, have the most direct bearing on their later functioning. Resources devoted to preventing mortality among ELBW infants may or may not reduce levels of developmental deficit among survivors.

In conclusion, two thirds of extremely low birthweight infants were discharged alive from Level III hospitals and survivorship could be predicted by birthweight, 5-minute Apgar score, and the administration of surfactant. Three eighths of the infants seen at follow-up (15 out of 40) showed CP or a below normal Bayley MDI. These outcomes were most adequately predicted by the grade of neonatal IVH, a measure of cerebral insult. The results suggest that neonatal survival and functioning in and around the second year of life may be linked to different factors. Prospective studies with aggressive follow-up are needed to explore this possibility.

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