

Eight-year Outcome of Very-low-birth-weight Infants Born in KK Hospital

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Abstract

Aim: To determine the education, neurodevelopmental outcome and educational achievement of babies weighing <1500 g at 8 years of age. **Materials and Methods:** This prospective study involved 171 of 202 survivors from KK Women's and Children's Hospital (KKWCH). Cognitive function was assessed using the Weschler Intelligence Scale for Children – version III (WISC–III). **Results:** Of these, 90.1% were in mainstream education and 1.2% were in home or religious schools. Special education programmes were recommended for 11.1% of children [24.4% of 56 extremely-low-birth-weight (ELBW) babies <1000 g and 9.6% of 115 larger babies weighing 1000 to 1499 g]. Of these, only 7.8% eventually enrolled and 1.2% were not in any programme. In 136 children who had psychological assessments, the mean full-scale, verbal and performance intelligence scores were 87.0 ± 17.7 , 86.6 ± 17.0 and 90.1 ± 21.8 in ELBW and 96.1 ± 18.3 , 93.3 ± 15.7 and 100.0 ± 17.5 in larger children, with the former having significantly lower scores than the latter (full scale: $P = 0.02$, 95% CI –18.23, –4.18; verbal: $P = 0.04$, 95% CI –13.8, –1.95; performance: $P = 0.004$, 95% CI –17.67, –3.35). 33.8% of the cohort, 49.0% of ELBW and 25.3% of larger children had neurodevelopmental impairment (full scale score <85 or in need of special education). Logistic regression analysis showed that birth weight <1000 g, female sex, Chinese race, a non-intact family structure and bronchopulmonary dysplasia (BPD) were significant risk factors associated with neurodevelopmental impairment. 72.7% of children scored $\geq 50\%$ of total marks for English, Mathematics and second language. 14.1% had Band 4 (<50% of total marks) in all 3 subjects. Logistic regression analysis showed that the only significant risk factors associated with adverse school performance in any of these three subjects were hypoglycaemia in the newborn period and impaired cognitive function. **Conclusion:** The outcome of ELBW is a major cause of concern. BPD and hypoglycaemia were the only perinatal factors that still exerted an influence on outcome at 8 years. Better methods of prediction of academic difficulty are critical for this high-risk group of children

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Key words: Cognitive outcome, Education, Extremely low birth weight, Long-term outcome

Introduction

The outcome of very-low-birth-weight (VLBW) premature babies with birth weights of <1500 g has remained an area of great concern for both parents and medical personnel.¹⁻³

The primary aim of this study was to determine the outcome of VLBW babies by the educational programmes they were enrolled in, neurodevelopmental impairment and academic achievement at age 8 for those children in mainstream education. The secondary aim was to determine the effects of demographic, socio-economic and perinatal factors on the outcome.

Material and Methods

The study involved 202 VLBW survivors born in KK Hospital between 1990 and 1992 and managed by the Department of Neonatology I. They were enrolled into a follow-up programme which included medical, hearing

and visual assessments, an early intervention programme, referral to support services when indicated and cognitive assessments at 2, 5 and 8 years. The data were collected prospectively.

Outcome Measures

Educational programmes: These were categorised in the following manner:

- Mainstream education, i.e., schools administered by the Ministry of Education in Singapore;
- Non-mainstream education, e.g., home-schooling, Muslim religious schools;
- Special programmes conducted by the Association for Persons with Special Needs (APSN), Movement for the Intellectually Disabled of Singapore (MINDS), Program for Children with Multiple Handicaps (PCMH), Singapore School for the Visually Handicapped (SSVH) and Singapore School for the Deaf (SSD).

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Neurodevelopmental assessment: The Weschler Intelligence Scale for Children—Version III (WISC-III) (using 8 subtests) was administered by educational psychologists.⁴ The assessors were not blinded to the neonatal problems of these children. Neurodevelopmental outcome was considered to be normal if the full-scale score was ≤ 1 SD below the mean (≥ 85)⁵ and impaired if the score was < 85 , if they were already enrolled in special education programmes for the cognitively impaired and if neurodevelopmental impairment was obvious from the history and clinical assessment.

Academic achievement of children in mainstream schools: The results of mid-year or end-of-year examinations closest to age 8 in English, Mathematics and a second language were obtained from the parents. The results were graded as band 1 ($\geq 85\%$ of total marks), band 2 (70% to 84%), band 3 (50% to 69%) and band 4 ($< 50\%$, which is equivalent to a “fail” grade). This is the ranking system used in Singapore schools. The children were divided into 2 groups: Group 1 – band 1 to 3 in all 3 subjects and Group 2 – band 4 in at least 1 of the 3 subjects.

Perinatal Data

Ten variables were studied including birth weight (< 1000 g classified as ELBW, 1000 to 1499 g classified as “larger babies”), rupture of membranes (ROM) > 18 hours,⁶ maternal pyrexia $\geq 38^\circ\text{C}$,⁷ definite or advanced necrotising enterocolitis (NEC),⁸ bronchopulmonary dysplasia (BPD, defined as the presence of an oxygen requirement, respiratory symptoms and chest X-ray changes at 28 days of life⁸), hypoglycaemia (defined as having at least 1 episode of plasma glucose of < 2.2 mmol/L¹⁰), retinopathy of prematurity (ROP) of any grade, severe ROP ($\geq$ grade 3),¹¹ severe intracranial abnormality on the cranial ultrasound (intra-ventricular haemorrhage of $\geq$ grade 3, post-haemorrhagic hydrocephalus, periventricular leukomalacia and porencephalic cysts) and any cranial ultrasound abnormality (including grade 1 and 2 intraventricular haemorrhages).¹²

Demographic and Socio-economic Data

Nine variables were studied, including gender, race (categorised as Chinese or non-Chinese), relationship of the main caregiver to the patient (categorised as mother or other caregiver), the use of English at home, number of children in the family (categorised as ≤ 2 children or > 2 children), total family income (categorised as $< \$2000$ or $\geq \$2000$ per month), family structure and maternal/paternal education. Family structure was considered intact if the biological parents were still married and involved in the care of the child. The educational level of the parents was considered to be low if they had no or partial primary school education, or if the highest examination passed was Primary

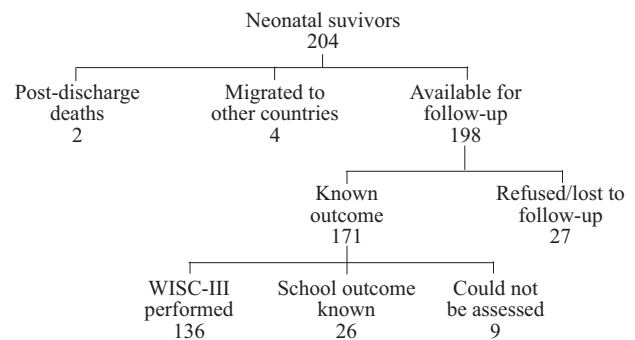


Fig. 1. Follow-up of neonatal survivors.

Six, i.e. ≤ 6 years of formal education.

The demographic, socio-economic and outcome data were obtained from parental interviews.

Statistical Analysis

Comparisons of numeric variables between groups were performed using the Student's *t*-test. Comparisons of categorical variables were based on the chi-square and Fisher's exact tests. Simple logistic regression models were used to analyse the effects of perinatal and socio-demographic variables on binary outcomes. A backward elimination method was used and results presented as odds ratios. Two perinatal variables (ROM and maternal pyrexia) involved a relatively large amount of missing data. Therefore, before performing multiple logistic regression analyses, we used the Student's *t*-test to compare the birth weight and the chi-square test to compare the race and gender distribution of subjects with and without missing values in these variables. The similarity in these background characteristics would suggest the absence of serious selection bias in the multiple logistic regression analyses that simultaneously consider all perinatal and socio-demographic variables. All *P* values were two-sided and a *P* value < 0.05 was considered significant. All analyses were performed using SPSS Windows Version 9.0.

Results

Figure 1 shows the outcome of the neonatal survivors. The 8-year outcome was known in 171 (84.7%) of the 202 available survivors. There were no children with major malformations or chromosomal abnormalities in this cohort of survivors.

Neonatal and Perinatal Data

Of the 171 children analysed, 56 (32.7%) were ELBW and 115 (67.3%) were larger babies. The mean birth weights of the whole cohort, the ELBW and the larger babies were 1118.6 ± 241.3 g, 828.1 ± 127.9 g and 1260.1 ± 132.5 g, respectively. Table I shows the breakdown of the

TABLE I: NUMBER(%) OF VERY-LOW-BIRTH-WEIGHT CHILDREN BY BIRTH-WEIGHT GROUP

Birth weight (g)	No. of patients	% of total
500 to 699	10	5.8
700 to 799	8	4.7
800 to 899	16	9.4
900 to 999	22	12.9
1000 to 1099	16	9.4
1100 to 1199	21	12.3
1200 to 1299	28	16.4
1300 to 1399	31	18.1
1400 to 1499	19	11.1
All babies	171	100.0

study cohort by birth-weight groups.

Table II shows that, in approximately a third of cases, the data on ROM and maternal pyrexia were absent. There were no significant differences in the mean birth weight of the babies with known ROM status and those where the data were absent (1110.47 ± 234.76 g versus 1135.80 ± 255.95 g, $P = 0.5$, 95% CI -103.45 to 5280), in their race composition (50.9% versus 57.9% Chinese, $P = 0.8$, 95% CI 0.67 to 2.43) and in the gender (40.0% versus 46.6% female, $P = 0.4$, 95% CI 0.68 to 2.51). There were also no significant differences in the mean birth weight of the babies with known maternal pyrexia status and those where the data was absent (birth weight means: 1111.05 ± 237.71 versus 1133.36 ± 249.61 , $P = 0.5$, 95% CI -99.41 to 5479 ; race: 51.7% versus 57.2% Chinese, $P = 0.8$, 95% CI 0.65 to 2.31 and gender: 37.9% versus 47.8% female, $P = 0.2$, 95% CI 0.79 to 2.86). Thus, the data were used for analysis as perinatal infection has been suspected as a risk factor for adverse long-term neurological outcome.^{13,14} Table III shows the demographic and socio-economic factors in the cohort.

Educational Programmes at 8 Years of Age (Table IV)

TABLE III: DEMOGRAPHIC AND SOCIO-ECONOMIC FACTORS IN VERY-LOW-BIRTH-WEIGHT BABIES

Factor studied	Yes (%)	Data not known (%)
Chinese	55.0	0
Male gender	44.4	0
Intact family	83.9	6.4
Low maternal education	36.9	4.7
Low paternal education	42.9	12.7
Monthly family income <\$2000	45.0	6.0
Caregiver – mother	69.6	6.4
English spoken at home	51.0	8.7
≤2 children in family	54.6	6.0

TABLE II: PERINATAL AND NEONATAL PROBLEMS IN VERY-LOW-BIRTH-WEIGHT BABIES

Perinatal/neonatal problem	Present (%)	Data unavailable (%)
ROM ≥18 hours	17.0	32.2
Maternal pyrexia ≥38°C	7.0	33.9
NEC	2.9	8.8
Hypoglycaemia	25.7	8.8
BPD at 28 weeks	19.9	8.8
Abnormal cranial ultrasound	22.8	10.5
Abnormal cranial ultrasound (severe)	8.8	10.5
ROP of any grade	27.4	10.5
ROP of ≥stage 3	9.9	10.5

BPD: bronchopulmonary dysplasia; NEC: necrotising enterocolitis; ROM: rupture of membranes; ROP: retinopathy of prematurity

Of the 154 in mainstream schooling, 4 children (2.6%) were in classes below their peers. Special education had been recommended in a total of 22 of the 171 children (14 ELBW and 8 larger children) representing 12.9%, 25.0% and 7.0% of their respective cohorts. Of these, initial recommendations for special schooling were not accepted by the parents in 9 cases.

Neurodevelopmental Assessment

WISC-III assessments were performed in 136 (79.5%) of the 171 children studied at a mean age of 8.0 ± 3 months. The mean overall intelligence score was 93.0 ± 18.6 . The verbal and performance intelligence scores were 91.7 ± 16.5 and 96.2 ± 19.6 , respectively, with a significant difference between the 2 scores ($P = 0.002$, 95% CI -8.45 , -2.61). Table V shows the mean full scale, verbal and performance scores in children who were ELBW compared to those with birth weight of 1000 to 1499 g. All 3 scores were significantly lower in the ELBW group. There was also a significant difference between the verbal and performance scores among the larger babies ($P = 0.004$, 95% CI -10.16 , -3.16) but not in the ELBW ($P > 0.05$, 95% CI -8.29 , 2.15).

TABLE IV: EDUCATION OF VERY-LOW-BIRTH-WEIGHT CHILDREN AT AGE 8

Educational programme	No. of children (%)
Mainstream education	154 (90.1)
Non-mainstream education	2 (1.2)
Special schools/programmes	13 (7.6)
Program for Children with Multiple Handicaps	3 (1.8)
Movement for the Intellectually Disabled of Singapore	2 (1.2)
Association for Persons with Special Needs	6 (3.5)
Singapore School for the Visually Handicapped	1 (0.6)
Singapore School for the Deaf	1 (0.6)
Not in any programme	2 (1.2)

TABLE V: MEAN OVERALL, VERBAL AND PERFORMANCE INTELLIGENCE SCORES OF VERY-LOW-BIRTH-WEIGHT CHILDREN

WISC-III	Mean score		P value
	ELBW	1000 to 1499 g	
Overall	87.0 ± 17.7	96.1 ± 18.3	0.001
Verbal	86.6 ± 17.0	93.3 ± 15.7	0.009
Performance	90.1 ± 21.8	100.0 ± 17.5	0.000

WISC-III: Weschler Intelligence Scale for Children—Version III

Of the 136 children, 3 had only performance scores because of language/speech problems. Of these, 2 were in special education programmes. Six could not be assessed because of severe visual impairment (3) or multiple handicaps (3). One was already enrolled in a special education programme. These 9 children were considered to have cognitive impairment. They were never able to enter mainstream education. The combined outcome is summarised in Table VI.

All the 19 variables were individually analysed. Univariate analysis showed that 7 factors were associated with neurodevelopmental impairment (Table VII). These were: birth weight, BPD, severe cranial ultrasound abnormalities, ROP of any grade, severe ROP, race and gender.

Table VII indicates the 7 significant factors for the development of neurodevelopmental impairment. The other factors were not found to be statistically significant.

TABLE VI: NEURODEVELOPMENTAL OUTCOME IN VERY-LOW-BIRTH-WEIGHT CHILDREN

Cognitive outcome	ELBW	1000 to 1499 g	VLBW
WISC-III ≥85 (normal) (%)	26 (51.0)	68 (74.7)	94 (66.2)
WISC-III <85 (impaired)	20	19	39
Cognitive impairment from history	5	4	9
Total (%)	25(49.0)	23 (25.3)	48 (33.8)
Total	51	91	142

ELBW: extremely low birth weight; VLBW: very low birth weight; WISC-III: Weschler Intelligence Scale for Children—Version III

Academic Achievements

Results of all 3 subjects were available in 143 (92.9%) of the 154 children in mainstream schooling. This did not include any of the children with severe visual or hearing impairment who were either in special education programmes or had not enrolled in any programme. Primary 1 results were used in 105 children (73.4%) and Primary 2 results in the other 38 children (26.6%). All the 19 variables were again analysed individually. The twentieth variable analysed was the presence of neurodevelopmental impairment. Univariate analysis showed that 6 factors were statistically significantly associated with a band 4 result in at least 1 subject in Primary 1 or 2 (Table VIII).

Table VIII shows the results of the 6 variables that were found to be statistically significant. 72.7% and 33.8% of the children had band 1 to 3 scores and 1 to 2 scores,

TABLE VII: UNI- AND MULTI-VARIATE ANALYSIS OF SIGNIFICANT FACTORS AFFECTING NEURODEVELOPMENTAL OUTCOME

Factor		Normal	Impaired	Neurodevelopmental outcome			
				Univariate analysis OR	95% CI	Multivariate analysis OR	95% CI
Birth weight	<1000 g	26	25	2.8*	1.36 to 5.87*	8.9*	1.18 to 40.48*
	1000 to 1499 g	68	23				
BPD	Absent	79	28	0.25*	0.106 to 0.585*	0.01	0.0007 to 0.27*
	Present	12	17				
Abnormal cranial ultrasound (severe)	Absent	85	34	0.12*	0.031 to 0.463*	0.37	0.09 to 1.55
	Present	3	10				
ROP	Absent	1	24	0.34*	0.156 to 0.77*	0.66	0.21 to 2.07
	Present	20	20				
Severe ROP	Absent	92	34	0.24*	0.08 to 0.71*	0.50	0.11 to 2.19
	Present	6	10				
Race	Chinese	64	21	0.305*	0.17 to 0.74*	0.40*	0.17 to 0.96*
	Non-Chinese	30	27				
Gender	Female	36	27	2.7*	1.02 to 4.20*	3.07*	1.23 to 7.64*
	Male	58	21				
Family structure	Intact	80	37	0.60	0.21 to 1.72	0.05*	0.005 to 0.56*
	Not intact	9	9				

* Significant results

BPD: bronchopulmonary dysplasia; OR: odds ratio; ROP: retinopathy of prematurity

TABLE VIII: UNI AND MULTIVARIATE ANALYSIS OF SIGNIFICANT FACTORS AFFECTING EXAMINATION RESULTS

Factor studied		Group 1	Group 2	Univariate analysis		Multivariate analysis	
				OR	95% CI	OR	95% CI
Birth weight	<1000 g	28	18	0.43*	0.20 to 0.923*	0.13*	0.12 to 0.90*
	1000-1499 g	76	21				
Hypoglycaemia	Absent	75	19	2.4*	1.04 to 5.53*	19.27*	1.48 to 251.42*
	Present	23	19				
Abnormal cranial scan (severe)	Absent	93	27	6.88*	1.02 to 29.39*	1.53	0.28 to 8.44
	Present	3	6				
ROP	Absent	77	19	2.83*	1.22 to 6.62*	3.09	0.77 to 12.38
	Present	20	14				
ROP (severe)	Absent	91	26	4.08*	1.26 to 13.21*	0.21	0.03 to 1.31
	Present	6	7				
Neurodevelopmental outcome	Impaired	8	22	0.06*	0.02 to 0.15*	0.07*	0.007 to 0.51*
	Normal	78	12				

* Significant results

OR: odds ratio; ROP: retinopathy of prematurity

respectively, in all 3 subjects. 14.1% had band 4 in all 3 subjects. In individual subjects, 77.8%, 81.6% and 80.8% had band 1 to 3 scores in second language, English and Mathematics, respectively, while 50.3%, 49.0% and 63.7% had either band 1 or 2 scores. 64.6% had band 3 or 4 scores in at least 1 subject.

In 5 cases, parents enrolled the children into mainstream education despite recommendations for special schooling. Table IX summarises their academic outcome.

Multivariate Analysis

Tables VII shows that birth weight of less than 1000 g, the presence of BPD, being a non-Chinese and male were significant risk factors associated with neurodevelopmental impairment. Table VIII shows that birth weight of <1000 g, the presence of hypoglycaemia and neuro-

developmental impairment were significant risk factors associated with a band 4 result in at least 1 subject in Primary 1 or 2.

Discussion

Educational Programmes

Special education had been recommended to 12.9% of the entire cohort, 25.0% of the ELBW and 7.0% of larger children. Other studies have reported that 11% to 33% of ELBWs, 25% of children of birth weight 1000 to 1249 g and 17% of those with birth weights 1250 to 1499 g required special education.^{1,15,16} Studies from other countries also report that up to 38% of children in mainstream education required special assistance.¹⁶ Local schools have a learning support programme for children who are underachievers. However, the provision of private learning support (i.e. private tuition) is a widespread practice and is very dependent on the financial resources of the family and the desire to maximise the potential of the child. Thus, it was not possible to determine the percentage of children who genuinely required learning support.

The decision to enrol a child in a special education programme depends on the educational philosophy and wishes of the parents, their financial ability and their acceptance of the child's disability. In 9 out of 22 cases where special education had been recommended, parents refused to accept the advice given. The first child had been enrolled in MINDS but was transferred to kindergarten at age 8 prior to placement in primary 1, despite his obvious cognitive impairment. The education of the second child was discontinued due to financial constraints. The third child had spastic dysplasia, severe visual impairment and speech delay and was enrolled in a Muslim religious school. One child had a severe visual impairment. The

TABLE IX: OUTCOME OF CHILDREN IN MAINSTREAM EDUCATION WHO REFUSED SPECIAL EDUCATION

Name of child	Mathematics	English	2 nd language	Outcome
MG	Band 4	Band 3	Band 3	Remained in mainstream education
TBC	Band 4	Band 4	Band 4	Transferred to APSN
JBA	Band 4	Band 4	Band 4	Remained in mainstream education
VRE	Band 4	Band 3	Band 4	Remained in mainstream education
NYL	Band 4	Band 4	Band 4	Transferred to APSN

APSN: Association for Persons with Special Needs

family could not accept his handicap and to the best of our knowledge, he is at home without intervention.

Occasionally, parents who refused special education for their children could be persuaded to change their minds after becoming personally convinced of their children's difficulties in coping with primary school. Two children scored band 4 in all their examinations in school and were eventually transferred to the APSN programme by the end of primary 1 or 2. Other parents preferred that their children stayed in mainstream education even if they failed to cope academically in every subject every year, rather than transfer them to special schools, as was the case in 3 of these children.

Children with handicaps and cognitive impairment do benefit from structured programmes. The children who had enrolled in the SSD and SSVH were in programmes equivalent to kindergarten 2 at age 8, i.e., 2 years behind their peers. Parental acceptance of their child's problems is a crucial factor in maximising the potential of the child.

Neurodevelopmental Assessment

The mean full-scale, verbal and performance in the whole cohort were well within 1 SD below the mean. 28.8% had full-scale scores <85 (i.e. >1 SD below the mean) compared to 20.8% in a study of 298 babies born in New Zealand in 1986.⁵ The outcome of ELBW babies is a particular area of concern. They had 7 to 10 points less than the bigger babies in the full-scale, performance and verbal scores. Other studies have reported full-scale scores of 91 to 96 (± 16 to 17).^{1,15} 42.2% of the ELBW children in this study had full-scale scores <85 compared to 24% to 28% in other studies.^{2,15} The percentage of ELBW children with neurodevelopmental impairment increased to 51% if those with clinical impairment were included. There are several possible reasons for the poorer outcome of the ELBW children in this cohort compared to published studies. Surfactant only became available in mid-1991 and helped to reduce the incidence of early BPD, which was shown to be a significant factor associated with cognitive impairment in this study. White matter injury now found to be associated with cognitive delay in the premature baby was not easily recognisable with the skill and equipment at that time.¹⁷ Withdrawal of care was not a therapeutic option, even in critically ill babies and advanced methods of ventilation were not yet available.

22.2% of the larger babies had overall scores of <85, which was similar to the New Zealand cohort.²

Performance scores in the cohort were much higher than verbal scores, which was the opposite of what was found in an Italian study of 53 VLBWs.¹⁸ One possible reason could have been the heterogeneity of the local population and the multiple languages spoken. There was no statistical

difference between the 2 scores in the ELBW group, which was also seen in other studies.^{1,15}

In the multivariate analysis, birth weight <1000 g, female gender, the non-Chinese race, the absence of an intact family structure and the presence of BPD were significant risk factors associated with an impaired cognitive outcome. The influence of race was seen in a study conducted by the University of South Carolina, where African-American children were more affected by low birth weight than white children.¹⁹ The difference between the 2 sexes was apparent in other studies.^{1,20} The presence of a father figure has been found to be a consistent association with positive cognitive and academic outcome.²¹ Children with BPD in our cohort had 14 points less in the overall score than those without. The association between BPD and cognitive outcome has been noticed before.^{17,22} Of all the significant factors identified, this was the only factor that could be modified in the perinatal period.

Educational Achievement

64.4% had a band 3 or 4 in at least 1 of the 3 subjects. Other studies have shown that 45% of VLBWs <1250 g were having difficulty with 1 or more school subjects, requiring more educational interventions or support than normal weight controls.²³⁻²⁵ VLBW children were less competent than full-term children in all subscales, word reading and basic number skills.²⁴ Low-birth-weight boys had more problems with reading than girls.²⁶ 51% of children with birth weight <800 g had a developmental co-ordination disorder (DCD) compared to 5% or controls (OR 17.5)²⁷ and were more likely to have a learning difficulty in arithmetic.

Hypoglycaemia was the only perinatal factor that was significantly associated with adverse neurodevelopmental outcome at age 8 in the present study. It has been previously shown to be strongly associated with persistent neurodevelopmental deficit at 5 years of age.²⁸ While normal neurodevelopmental outcome is important for academic success as seen in this study, other factors also play their parts. Behavioural difficulties in adolescents with DCD included poor concentration in class, which may go unnoticed.²⁷ Teachers scored the VLBW group higher on items relating to emotional problems (worries, fears, unhappiness, tics, fussiness) and overactivity (fidgeting, restlessness and inattention).²⁹ VLBW children had more school-coping problems than term controls, even after controlling for socio-economic status, and VLBW boys had more conduct and emotional problems than controls.³⁰

Prediction of School Failure and Learning Problems

Many children with school failure at age 9 did not have a report of school failure at age 5.¹⁶ Motor performance at 6 years was reported to be the best predictor of later school

performance.¹⁶ Children with poor head growth over the first 8 months may be particularly at risk for school failure.³¹ This is an interesting observation as it is one of the earliest possible predictive signs in children with no major obvious early neurodevelopmental delay.

Intervention

Unfortunately, there are very few studies in this area. In the Infant Health and Development Program in New York, intervention in the first 3 years in low-birth-weight children showed favourable outcomes at age 3 but did not persist at age 8. Parameters studied were cognitive functioning (WISC-III), academic achievement and parental reports on school performance and behaviour.³² There was no evidence of catch up between 6 and 12 years of age. This is an area where there is much scope for research. While the educational problems are clearly obvious, intervention strategies have yet to be adequately studied.

The strength of this study was that it was a longitudinal one carried out for a reasonable length of time, that allowed clinically relevant outcomes to be determined. The main flaws were that no information was available in 15.3% of survivors, there was no control group and the academic results were from different schools, which may have varying standards. It was also a cohort managed 10 to 12 years ago, reflecting practices that have seen significant improvement or changes over time. However, it is the first published analysis of the 8-year outcome of VLBWs in Singapore.

Conclusion

This study has highlighted the significant concerns regarding the cognitive outcome of VLBW children and the educational outcome of those who enter mainstream schooling. The logistic regression analyses showed that birth weight was a significant risk factor associated with both neurodevelopmental impairment and academic difficulty. The hospital's perinatal high-risk team has an active policy of preventing delivery for as long as possible by careful monitoring and aggressive management of complications of pregnancy. Hypoglycaemia was a significant risk factor for academic difficulty. Improvements have been made in the monitoring of plasma glucose levels, treatment of documented hypoglycaemia and auditing of cases where resolution was delayed. BPD was a significant factor for neurodevelopmental impairment. With the routine use of surfactant, more skilled use of conventional and high-frequency ventilation, better nutrition and the reduction of ventilator-associated pneumonia, fewer babies now have BPD. Hypoglycaemia and BPD were the only perinatal factors that were still significant at age 8 which could be modified by improvements in neonatal care. The next long-term review would show if these improvements in neonatal care have made any significant impact. In addition, the

formal assessment must include a wider range of tests to allow the detection of behavioural problems and subtle or specific learning disabilities that prevent successful mainstream education. A more focussed attempt to assist children with these subtle problems can then be planned. This is an area where much work remains to be done. Otherwise, once a VLBW leaves the hospital, numerous socio-economic, demographic and psychological factors begin to play their complex roles.

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