Prognostic value of the neurologic optimality score at 9 and 18 months in preterm infants born before 31 weeks' gestation

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Objective: The Hammersmith Infant Neurological Examination was performed in a cohort of 74 preterm infants whose gestational age ranged between 24 and 30.5 weeks. The infants were examined between 9 and 18 months' chronologic age (6-15 months' corrected age) and scored with the optimality score system previously standardized in a cohort of low-risk term infants. The aim of the study was to establish the frequency distribution of the optimality scores in this cohort and to establish whether the scores can predict locomotor function at 2 years of age.

Results: The results showed that this standardized neurologic examination can be performed in preterm infants as early as 9 months' chronologic age to predict motor outcome at 2 years old. The scores showed no significant association with the degree of prematurity or the age of assessment.

Conclusion: This examination should be particularly useful in very premature infants who are at high risk of severe neurologic and developmental disabilities and for whom the early prediction of motor function can be difficult. (J Pediatr 2002;140:57-60)

Advances in perinatal care have improved survival of extremely preterm infants.[1-3] However, approximately 10% to 50% of infants born before 30 weeks' gestation or with extremely low birth weight have severe neurologic and developmental disabilities. These disabilities are highest among infants born before 25 weeks' gestation.[3] Thus, it has become important to identify early prognostic indicators of outcome in these children.

The Hammersmith Infant Neurological Examination is a simple and scorable method for assessing infants between 2 and 24 months of age. This examination and an optimality score have been standardized in a low-risk population of term infants assessed between 12 and 18 months of age.[4] The optimality score has been developed on the basis of the frequency distribution of the findings for each item. The examination has also been validated in a population of term infants who had perinatal asphyxia,[5] and this has shown that the global optimality score obtained in term infants between 9 and 15 months can predict the ages of sitting and walking.

The aim of this article was to apply the optimality score to a cohort of very preterm infants between 9 and 18 months chronologic age (6-15 months corrected age) and to establish (1) the range of scores at this age, (2) whether the optimality scores are affected by gestational age, the age when examinations were performed, or by the presence and type of abnormalities seen on neonatal cranial ultrasonograms, and (3) whether the optimality score obtained at this age could be predictive of motor impairment.

Patients and Methods

The patients were prospectively enrolled preterm infants, born before 31 weeks' gestation, at or referred to the Hammersmith Hospital, London, United Kingdom, after January 1997. Ethical permission was obtained from the Hammersmith Hospital Research Ethics Committee and parental permission was given in each case. Infants were included if they had (a) an infant neurologic examination between 9 and 18 months of chronologic age (6-15 months corrected age) and (b) a follow-up neurodevelopmental assessment between the ages of 2 and 3 years.

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Submitted for publication Mar 16, 2001; revision received July 10, 2001; accepted Aug 16, 2001.

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0022-3476/2002/$35.00 + 0 **9/21/119626**

doi:10.1067/mpd.2002.119626

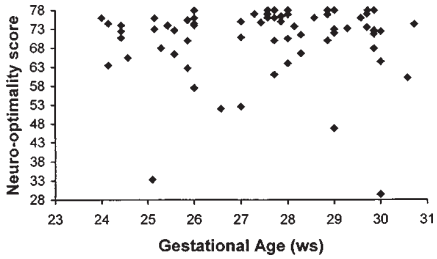

Fig 1. Correlation between neuro-optimality scores and gestational age.

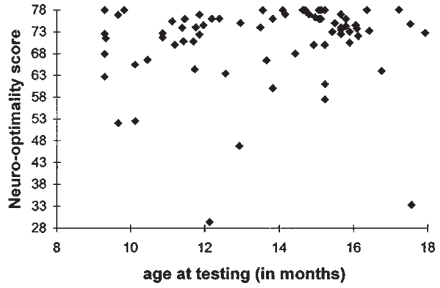

Fig 2. Correlation between neuro-optimality scores and age at testing.

Neurologic Examination

The Hammersmith Infant Neurological Examination[4] was used to assess neurologic status and was given an optimality score based on the frequency distribution of the scores in a low-risk normal term population at 12 and 18 months of age.[4] Each item is scored separately, and the scores can be added to achieve a global optimality score.

Cranial Ultrasonography

All 74 infants had early ultrasonograms, and 59 also had one at term. Early ultrasonograms were classified as "abnormal" if there was the presence of flares, ventricular dilatation, germinal layer hemorrhages, intraventricular hemorrhage (with or without parenchymal involvement), cystic periventricular leukomalacia, or other parenchymal abnormalities. Ventricular dilatation was graded as "mild" if the transverse diameter on the coronal view was between 14 and 18 mm, "moderate" if it was >18 mm but the size of the ventricles was <0.5 of the hemisphere, and "severe" if it was >0.5 of the hemispheres. Late (term) ultrasonograms were classified as "normal," or "abnormal" if flares, ventricular dilatation, porencephalic cysts, atrophy, and cystic periventricular leukomalacia were present.

Table I. List of items that had suboptimal scores more frequently in infants with a suboptimal global score and normal motor outcome

Items	Suboptimal scores (%)
Lateral tilting	75
Passive shoulder elevation	60
Trunk posture	40
Legs posture	35
Forward parachute	33
Arm protection	25
Popliteal angle	25
Ankle dorsiflexion	23

Outcome

All infants were assessed with a structured neurologic examination performed by a pediatric neurologist or one of the research fellows (F. C., S. L., M. F., C. F.). Cerebral palsy, if present, was classified according to the criteria proposed by Hagberg et al.[6] Maximal locomotor function at 2 years old was graded according to the simplified version of the classification suggested by Palisano et al,[7] already used in our previous study[5]:

1. Walks independently without restrictions: can take more than 10 steps without any help
2. Sits independently: infants maintain floor sitting and may pull to stand and take steps holding onto furniture
3. Cannot sit: infants are unable to maintain antigravity head and trunk control in prone and sitting positions

Data Analysis

The optimality scores were correlated to the age of testing and gestational age at birth with the Fisher exact text. The level of significance was set at .05. The scores were also correlated to ultrasonogram findings, but because of the number of ultrasonogram categories, no meaningful statistical analysis could be performed.

RESULTS

Preterm infants born before 31 weeks' gestation (n = 142) were born at or referred to the Hammersmith Hospital between January 1997 and October 1998; 32 infants died and 20 did not fulfill our inclusion criteria because they had no neurologic examination between 9 and 18 months (6-15 months corrected age), 14 were lost at follow-up, 1 had antenatal brain lesions (congenital infection), and 1 had a cardiocirculatory collapse at the age of 6 months. The final cohort consisted of 74 infants whose gestational age ranged between 24 and 30.5 weeks.

Infant Neurologic Examination

All infants had an examination between 9 and 18 months chronologic age (mean, 12.6 months). The global score, based on our term normative data, was optimal (above 73) in 43 infants and suboptimal in 31 infants.

Cranial Ultrasonography

All infants had an early scan; 7 infants had normal results, and 67 had abnormalities. Twenty-two of the 67 infants had mild flares or mild ventricular dilatation, 12 had mild-to-moderate flares with or without ventricular dilatation, and 33 infants had an intraventricular hemorrhage with flares with or without ventricular dilatation. Thirteen of the 33 infants with intraventricular hemorrhage had parenchymal involvement.

Outcome

Sixty-five of the 74 children were able to walk independently by the age of 2 years, and 4 had a mild hemiplegia. Of the 9 children who were unable to walk independently, 5 were able to sit but were unable to walk at 2 years of age; the remaining 4 were unable to sit unsupported. Of these 9 children, 2 had

tetraplegia, 2 had hemiplegia, 3 had diplegia, and 2 were hypotonic.

Neurologic Optimality Score and Gestational Age

There was no significant correlation between the neurologic optimality score and gestational age at birth (Fig 1).

Neurologic Optimality Score and Age at Assessment

There was no significant correlation between neurologic optimality score and age at assessment (Fig 2).

Neurologic Optimality Score and Cranial Ultrasonography

EARLY SONOGRAMS. All 9 infants with either normal scans or mild ventricular dilatation had either optimal scores or suboptimal scores that were not below 64. Infants with other ultrasonographic abnormalities had scores ranging from 29 to 78 (Fig 3).

TERM SONOGRAMS. All 28 infants with either normal scans or mild ventricular dilatation had either optimal scores or suboptimal scores that were not below 64. The 2 children with cystic periventricular leukomalacia had scores of 29 and 54, respectively. Infants who had other ultrasonogram abnormalities had scores ranging from 33 to 78 (Fig 3).

Neurologic Optimality Score and Outcome at 2 Years

Four of the 74 infants were unable to walk or sit unsupported at 2 years of age. All had scores below 52. Five children were able to sit unsupported but were unable to walk. Four had scores below 64 but above 52, and 1 had a score above 64. Sixty-five infants were able to walk at the age of 2 years. Forty-three of the 65 had optimal scores and 22 had suboptimal scores. Twenty of the 22 children with suboptimal scores had a score above 64 and 2 had scores between 52 and 64. The sensitivity of an optimality score above 64 to predict walking at 2 years was 98% and the specificity was 85%. Table I shows the items that more frequently had suboptimal scores in the infants with a normal outcome but a suboptimal global score. The correlation between outcome, optimality score, and ultrasonography is shown in Fig 3.

Early cranial ultrasound scans	Optimal score (73 or above)	Suboptimal score (64-72.9)	Suboptimal score (52-63.9)	Suboptimal score (<52)
Normal (n=7)	○○○○○	○○		
Mild VD (n=2)	○○			
Mild flares (n=20)	○○○○○○○○○○○○○○	○○○○○	◗	●
Moderate flares (n=7)	○○○○○○○		◗	
Mild-mod. flares with VD (n=5)	○○○	○		●
GLH/IVH+flares (n=20)	○*○○○○○○○○○	○○○○○ ○○	○◗	
IVH+HPI +flares (n=13)	○*○*○○	○○○○◗	○◗	●●

Term cranial ultrasound scans	Optimal score (73 or above)	Suboptimal score (64-72.9)	Suboptimal score (52-63.9)	Suboptimal score (<52)
Normal (n=10)	○○○○○○○	○○○		
Mild flares (n=12)	○○○○○○○	○○○○○		
Mild VD + mild atrophy (n=6)	○○○○○	○		
Mod.-marked VD (n=4)	○○	○	◗	
Flares+/-VD+/-atrophy (n=17)	○○○○○○○○○○○○○○	○	○◗◗	●
Porencephalic/atrophy/VD (n=9)	○○○	○○○◗	○	●●
CPVL (n=2)			◗	●

Fig 3. Correlation between cranial ultrasonography, neuro-optimality scores, and outcome. *VD*, Ventricular dilatation; *GLH*, germinal layer hemorrhage; *IVH*, intraventricular hemorrhage; *HPI*, hemorrhagic periventricular infarction; *CPVL*, cystic periventricular leukomalacia; *open circle*, walks independently at 24 months; *filled half-circle*, sits at 24 months but does not walk; *filled circle*, cannot sit at 24 months; *asterisk*, cases with mild VD.

DISCUSSION

We have recently demonstrated that the Hammersmith Infant Neurological examination can be used reliably to assess neurologic status and predict motor outcome around 1 year of age in term infants who had hypoxic-ischemic encephalopathy at birth.[5] In the current study, we applied the same scoring system to a cohort of premature infants examined between 9 and 18 months' chronologic age (6-15 months' corrected age). We found that, with the criteria for optimality established in low-risk term infants, 52% of the premature cohort had optimal scores and 48% had suboptimal scores.

The magnitude of the scores was not significantly associated with the degree of prematurity. It is of interest, however, that the peak of abnormal scores was found in infants born between 27 and 30 weeks and not in infants born at younger gestational ages. This might reflect the reduced survival rate in the lower age group with more severe lesions.[8]

There was also no significant association between the global neurologic optimality scores and the age when the neurologic examination was performed because the suboptimal scores were spread widely across our cohort, irrespective of whether the infant had been assessed at 9 or 18 months. The scores were also not invariably associated with the pattern of ultrasonogram findings.

Although normal scans or minor lesions tended to be associated with optimal scores and cystic periventricular leukomalacia with low scores, other ultrasonogram abnormalities were associated with both optimal and suboptimal scores. This is not surprising because hemorrhages and periventricular densities can be associated with both normal and abnormal neurodevelopment.[9-13]

As with our previous study in infants with hypoxic-ischemic encephalopathy, the optimality scores recorded between 6 and 15 months' corrected age in our premature infants were able to predict independent walking at 2 years. However, there was a difference in the range of scores that was associated with independent walking at 2 years. In the term cohort, <10% of infants with independent walking at 2 years had a suboptimal score (below 73); in the premature cohort, one third of the infants with similar outcome had scores between 64 and 73. To ascertain the cause of this difference, we investigated which items were most frequently suboptimal in the infants who had a global suboptimal score despite a normal gross locomotor function at 2 years of age. The items that were more frequently suboptimal in this subgroup were maturational items, such as lateral tilting and parachute reaction, but some of the items assessing tone, such as passive shoulder elevation or trunk posture, also frequently had suboptimal scores.

In conclusion, our study has demonstrated that a standardized neurologic examination performed as early as 9 months can be used reliably in very preterm infants to predict motor outcome. This information is of particular value because severe neurodevelopmental abnormalities are frequent in infants born before 30 weeks' gestation or with extremely low birth weight. Our results are in agreement with a previous study[14] that also reported that a neurologic examination performed at 6 months can predict the neurodevelopmental outcome. In that study, however, the outcome was assessed at 12 months, and at this age, it is often difficult to predict the level of motor function in infants with mild or moderate neurologic abnormalities.

However, our results have to be interpreted with caution because the relatively normal motor milestones and the ability to walk at 2 years does not exclude that some children might have a very mild hemiplegia or diplegia. Other children, although not having cerebral palsy, might also still be clumsy at school age.[15-18] These infants need to be followed up until school age to exclude minor motor or perceptual-motor problems, and it will be interesting to see whether the infants with relatively low scores (above 64) who have normal motor outcome at 2 years are the same children recognized as clumsy at school age.

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