

Infant Neurological Examination from 3 to 12 Months: Predictive Value of the Single Items

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Key words

- infant
- cerebral palsy
- neurological risk
- predictive value
- ROC curve

Abstract

▼ The prognostic value of the single items of a standardised neurological examination, the Hammersmith Infant Neurologic Examination (HINE), was explored longitudinally in 658 infants at 3, 6, 9 and 12 months post-term age. ROC curves were built based on the presence/absence of cerebral palsy at 2 years of age. Global HINE scores showed very high prediction (ROC curve areas above 0.9) at all ages. The items with the highest

predictive value were always movement quality and quantity. In the first semester, among the most predictive items were those assessing tone, while beyond that time they were reflexes and reactions. Our results show that the high predictive value of the HINE across the first year of life is granted by the successful combination of different groups of items for each age-period. This should be recognised in clinical practice when assessing the significance of individual neurological profiles.

Introduction

▼ The *Hammersmith Infant Neurologic Examination* (HINE) is a scorable assessment recently developed for use after the neonatal period in infants between 2 and 24 months of age [3]. It proved highly predictive at 9 months or later in infants at risk for neurological development (i.e., very pre-term infants [1] or term infants with hypoxia-ischaemia [2]) or as early as 12 weeks post-term age in infants at general neurological risk [6]. It might be expected that the high predictive value across this long age-span is granted by a successful combination of the items, differentially tapping the various phases of early neurological development. To explore this hypothesis, in the present study we assessed the predictive value of the single items of the HINE as applicable to cerebral palsy (CP) in a large cohort of infants at neurological risk, included in the neurodevelopmental follow-up programme of our neonatal unit. We longitudinally performed the HINE at 3, 6, 9 and 12 months corrected age and established at each time period the items that were most and least predictive as applicable to cerebral palsy at two years of age.

Patients and Methods

▼ This work is part of a prospective study of the Neonatal Intensive and Sub-intensive Care Units of the University of Catania. All preterm newborns with gestational age below 37 weeks and all term newborns with neonatal encephalopathy (Sarnat grade II and III), born between 1/2000 and 6/2005 were recruited for the study. Exclusion criteria were the non-attendance to one or more appointments and the presence of major congenital malformations or genetic disorders. The ethical committee of our institution approved the study, and informed written parental consent was obtained in all cases.

HINE evaluations were performed at 3, 6, 9 and 12 corrected months. The examination consists of 26 items assessing cranial nerves, posture, movements, tone and reflexes. Each item is scored separately, and the scores for the 26 items can be added to achieve a global score (range: 0–78). Neurological outcome was assessed at two years corrected age using a structured examination [9], and the diagnosis of CP was made accordingly [4].

The predictive value of the global scores and of the single items was measured at each time-period using the receiver operating characteristic curve (ROC) analysis, a powerful means of assess-

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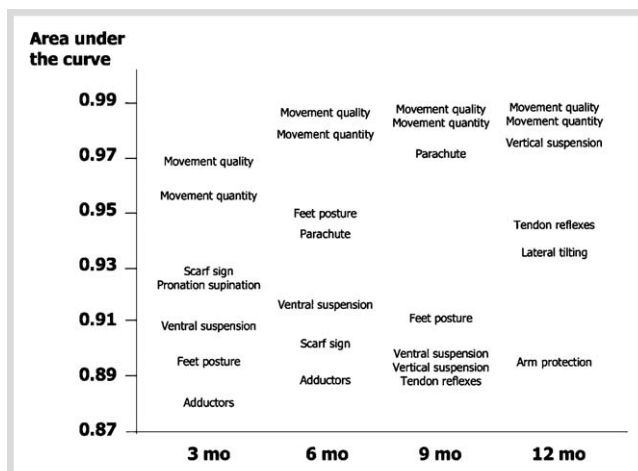


Fig. 1 Items of the HINE with the highest predictive value in each age range, based on ROC analysis.

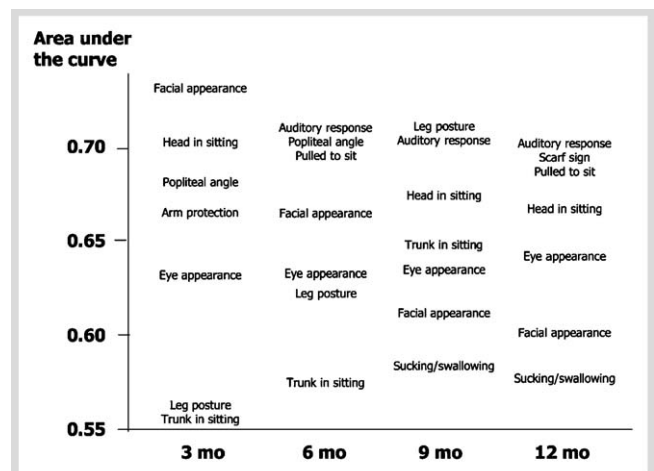


Fig. 2 Items of the HINE with the lowest predictive value in each age range, based on ROC analysis.

ing a test's predictive power [7]. Each point on the plot represents a sensitivity/specificity pair corresponding to a particular cut-off value and the area under the curve expresses the predictive power (maximum value = 1).

Results

A total number of 658 infants were included in the study, 550 born preterm (mean gestational age 34.8 ± 2.14 weeks; mean birth weight 2219 ± 535 g) and 108 born at term or near term (mean gestational age 37.3 ± 0.8 weeks; mean birth weight 2641 ± 675 g). Seventy infants developed a cerebral palsy: 57 were born preterm (10% of all preterm) and 13 were born at term (12% of all term).

The HINE global scores were highly predictive at all four time-periods, with areas under the ROC curves of 0.982 at 3 months, 0.983 at 6 months, 0.988 at 9 months and 0.995 at 12 months.

The most predictive items are shown in **Fig. 1**. Items assessing movement quality and quantity showed the highest prediction in all four examinations. Tone items were very predictive in the first semester, particularly those assessing upper limb (scarf sign, pronation/supination) and axis (ventral suspension). In these items more than 75% of the infants with normal outcome scored in the first column, while only around 5% did so among those who developed cerebral palsy. Conversely, reflexes and reactions were highly predictive only beyond the 6th month corrected age. Forward parachute was already present in 40 percent of normal infants at 6 months (82% at 9 and 96% at 12 months), while it was only present in 8 percent of the infants with abnormal outcome at 12 months (and never earlier). Similar figures applied to arm protection at 9 and 12 months (60 and 70% in the normal group and 2 and 4% in the CP group), to vertical suspension (kicking was symmetrical in 60 and 80% in the normal group and in none in the CP group), and to lateral tilting at 12 months (90% in the normal group and 15% in the CP group). Posture items were not among the most predictive with the exception of feet posture between 3 and 9 months.

The least predictive items are shown in **Fig. 2**. Items assessing cranial nerve function are among them across all age-periods. Postural items assessing legs, trunk and head in sitting are also among the least predictive ones, leg and trunk posture from 3 to

9 months and head posture from 9 to 12 months. Tone items with low prediction are popliteal angle, at 3–6 months, and pulled to sit at 6 and 12 months, while among reflexes and reactions there is only arm protection at 3 months.

Discussion

Our results confirm the high predictive value of the HINE in the first year of life, in infants at neurological risk, in accordance with previous findings in smaller samples [1,2]. As we were interested in exploring the general value of the assessment when applied in a standard neonatal follow-up programme, we included in our cohort infants of all gestational ages. However, when interpreting the results and their relevance to a clinical setting, it should be considered that more than 80% of the subjects were born preterm.

Consistent with our hypothesis, in each time-period we found different groups of items among the most and least predictive. It is of interest that at all time-periods movement quality and quantity were the most predictive. This is in line with abundant literature on the predictive value of general movements at 3 months but is more surprising for later assessments. It may be the result of the intrinsic nature of these items, as they require a global judgement of motor function (normal/abnormal quantity of movements or presence/absence of smoothness and variability). Otherwise, the pattern of most predictive items changed across the assessments. In the first semester tone items were most predictive, particularly those assessing upper limb and axial tone, while beyond the 6th month corrected age, reactions such as forward parachute, arm protection, lateral tilting and vertical suspension, were among the most predictive. These findings are consistent with the literature. The forward parachute is an important marker of normal neuromotor development as its delayed appearance is associated to late acquisition of independent walking [5]. Also, arm protection, forward parachute and vertical suspension, at 6 to 9 months predict neurological outcome in preterm infants with periventricular brain damage [8].

It is not surprising that items assessing cranial nerve function were among the least predictive across all time-periods. Although abnormalities of visual and auditory functions and

poor sucking have a high incidence in children with CP, this is still not a universal finding making these items poorly predictive (high number of false negatives). Similarly, it is understandable that at 3 months items assessing maturational aspects such as “arm protection” or “trunk in sitting” show very poor predictive values. It is indeed more surprising having found leg and trunk posture (up to 9 months) and head posture (after 9 months) among the least predictive items. This was mainly due to the fact that even at 9 months less than half of the infants with normal outcome showed a straight trunk (trunk in sitting), and at the same time more than half of the infants who developed a CP showed a head straight in midline (head in sitting). In summary, our study confirms that the high predictive value of HINE across the first year of life is granted by the combination of different groups of items for each age-period. The differential, age-dependent, predictive value of each item should be considered in clinical practice when assessing the significance of individual neurological profiles. Based on our findings and on future studies, short forms of the infant neurological assessment could be designed, to be applied as a screening assessment at different age-periods.

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