Association between Feeding Difficulties and Language Delay in Preterm Infants Using *Bayley Scales of Infant Development-Third Edition*

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Objective To evaluate the relationship between abnormal feeding patterns and language performance on the *Bayley Scales of Infant Development-Third Edition* at 18-22 months adjusted age among a cohort of extremely premature infants.

Study design This is a descriptive analysis of 1477 preterm infants born ≤26 weeks gestation or enrolled in a clinical trial between January 1, 2006 and March 18, 2008 at a National Institute of Child Health and Human Development Neonatal Research Network center who completed the 18-month neurodevelopmental follow-up assessment. At 18-22 months adjusted age, a comprehensive neurodevelopmental evaluation was performed by certified examiners including the Receptive and Expressive Language Subscales of the *Bayley Scales of Infant Development-Third Edition* and a standardized adjusted age feeding behaviors and nutritional intake. Data were analyzed using bivariate and multilevel linear and logistic regression modeling.

Results Abnormal feeding behaviors were reported in 193 (13%) of these infants at 18-22 months adjusted age. Abnormal feeding patterns, days of mechanical ventilation, hearing impairment, and Gross Motor Functional Classification System level ≥2 each independently predicted lower composite language scores.

Conclusions At 18 months adjusted age, premature infants with a history of feeding difficulties are more likely to have language delay. Neuromotor impairment and days of mechanical ventilation are both important risk factors associated with these outcomes. *(J Pediatr 2013;163:680-5)*.

Advances in neonatal intensive care have increased survival rates for extremely premature infants; however, concern remains for the long-term neurodevelopmental (ND) and functional status of surviving infants.[1-6] Researchers have demonstrated a dynamic yet maturation dependent vulnerability in the development, maturation, and differentiation of cerebral structures, including areas responsible for feeding and language. These neuropathologic risks are consistent with clinical data showing that prematurely born infants are more likely than term peers to have language delay and require additional educational resources at school entry, including speech therapy services.[7-9] Similarly, premature infants are more likely to have feeding difficulties compared with term peers and more likely to be evaluated in a feeding disorders clinic.[10]

Given that feeding and sucking behaviors are one of the earliest manifestations of motor control in a newborn, which utilize overlapping neural pathways involved in both feeding and language.[11] We hypothesized that feeding difficulties in early infancy in prematurely born infants would be associated with an increased risk of language delay in early childhood. This study explores the relationship between feeding dysfunction and language development at 18 months of age in a cohort of extremely low birth weight (ELBW) infants <1000 g, using the *Bayley Scales of Infant Development-Third Edition* (BSID-III) with a specific focus on the receptive and expressive language subscales.

Methods

This study is a descriptive analysis of a prospectively followed cohort of extremely premature infants followed in the National Institute of Child Health and Human

BSID-III	*Bayley Scales of Infant Development-Third Edition*
ELBW	Extremely low birth weight
GMFCS	Gross Motor Functional Classification System
IVH	Intraventricular hemorrhage
MRI	Magnetic resonance imaging
ND	Neurodevelopmental
NEC	Necrotizing enterocolitis
NICHD	National Institute of Child Health and Human Development
NRN	Neonatal Research Network
PVL	Periventricular leukomalacia

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Supported by the National Institutes of Health and NICHD, which provided grant support for the NRN's Generic Database and Follow-up Studies. Data collected at participating sites of the NICHD NRN were transmitted to RTI International, the data coordinating center for the network, which stored, managed, and analyzed the data for this study. The authors declare no conflicts of interest.

Portions of the study were presented at the Pediatric Academic Societies' annual meeting in May 2009.

 http://dx.doi.org/10.1016/j.jpeds.2013.03.006

Development (NICHD) Neonatal Research Network (NRN) Follow-Up Study who were born at ≤26 weeks (N = 1100) or who were greater than 26 weeks gestation and enrolled in a NRN clinical trial (N = 377). All infants have a comprehensive ND assessment at 18 months adjusted age. Each site obtained approval from their site institutional review board for all clinical trials and for the neurodevelopmental outcome study.

Neonatal and maternal data were systematically collected from birth until hospital discharge, transfer, death, or 120 days postnatal age, including demographic and neonatal variables that could potentially affect ND outcome.

Bronchopulmonary dysplasia was defined as the need for supplemental oxygen at 36 weeks postmenstrual age. Necrotizing enterocolitis (NEC) was defined as modified Bells stage IIA or greater.[12,13] Early onset sepsis (within 72 hours of birth) and late onset sepsis (after 72 hours) were defined by a positive blood culture and antibiotic therapy for ≥5 days. Cultures positive for organisms generally considered contaminants were not counted as indicative of sepsis.

Cranial sonograms were reviewed by the radiologist at each center based on Papile criteria,[14] with grades 3 and 4 considered severe for this analysis. Periventricular leukomalacia (PVL) was defined as cystic echolucencies in the periventricular white matter.

Hearing impairment was defined as a permanent hearing loss that interferes with the ability of the child to follow directions and communicate despite amplification.

Adjusted age- and sex-specific percentiles for height, weight, and head circumference were computed using the Centers for Disease Control and Prevention growth charts.[15]

As defined in the NICHD follow-up manual of operations, parents are routinely questioned about feeding behaviors of the child at the time of the 18-month follow-up visit. Dysfunctional feeding behaviors were defined as any of the following: (1) physician order not to ingest feedings by mouth; (2) any need for gastrostomy or tube feedings; (3) gags/chokes or coughs with oral feeds; (4) documented history of aspiration; (5) excessive drooling during feeds; or (6) difficulty swallowing. The type and consistency of the feedings the child receives were recorded, including table foods, soft foods, and/or thickened liquids.

A comprehensive ND evaluation was performed at 18-22 months adjusted age. Certified examiners performed a standardized neurosensory examination and the Cognitive and Receptive and Expressive Language Subscales of the BSID-III. Cognitive and language domains are reported as composite scores with a mean of 100 and SD ± 15. Based on their BSID-III language composite scores, children were classified into 3 groups: no delay (85+), mild delay (70-84), and moderate-severe delay (<70). Children judged to be so severely developmentally delayed that they were untestable (N = 39) were assigned a cognitive score of 54 and a composite language score of 46, per guidelines from the Harcourt manual. Receptive and expressive language subscale scores were generated based on scale of 1-19.[16] ND impairment, a composite outcome, was defined as 1 or more of the following: moderate to severe cerebral palsy with a Gross Motor Functional Classification System[17] (GMFCS) level ≥2, a BSID-III cognitive score <70, bilateral blindness with vision <20-200, or permanent hearing loss despite amplification that interferes with ability to understand or communicate.

Statistical Analyses

We conducted descriptive bivariate analyses comparing demographic and neonatal characteristics and ND outcomes for children with dysfunctional versus normal feeding behaviors, using χ^2 tests for categorical variables and ANOVA for continuous variables. Next, we conducted a multilevel logistic regression model to determine which factors predicted dysfunctional feeding behaviors at 18 months when including demographic and neonatal characteristics (sex, birth weight, primary language, race, education, insurance status, multiple gestation, postnatal steroids, ventilator days, severe grade 3-4 intraventricular hemorrhage [IVH] and/or PVL, NEC), as well as postneonatal hearing impairment and GMFCS level at 18 months, and accounting for clustering of children within research center. Similarly, multilevel linear regression models were conducted to examine the relationship between feeding behaviors and BSID-III scores, controlling for the variables listed above and clustering within research centers. The multilevel models for categorical outcomes (ie, dysfunctional feeding) were conducted using the SAS (SAS Institute, Cary, North Carolina) GLIMMIX procedure and the multilevel models for the continuous outcomes were conducted using the SAS MIXED procedure. We then conducted receiver operating characteristic curve analyses to further explore the relationship between days on ventilation and dysfunctional feeding behaviors and to determine a cut point for days of ventilation that maximizes sensitivity and specificity for identifying children with dysfunctional feeding behaviors.

Results

Of the 2678 infants born between January 1, 2006 and March 18, 2008 at one of the 20 participating NICHD NRN sites who did not have congenital infection or congenital anomalies, 1054 died prior to the 18-month follow-up assessment, and 147 were lost to follow-up. We evaluated outcomes of the remaining 1477 (91%) infants whose characteristics are shown in Table I. Comparisons between these 1477 infants and 147 infants who were lost to follow-up indicated that those lost to follow-up were less likely to be white ($P = .033$), multiple gestation ($P < .001$), have early onset sepsis ($P = .043$), and have parents with less than a high school education ($P < .001$); however, they had similar birth weight, gestational age, and other neonatal morbidities.

Of the 1477 children in the study, 193 (13%) were reported to have dysfunctional feeding behaviors at 18 months adjusted age. Compared with children who reported normal feeding behaviors, those with dysfunctional feeding patterns had significantly lower gestational age and birth weight (Table I). They were also more likely to be black, have IVH/PVL, late onset sepsis, NEC, bronchopulmonary dysplasia, have received postnatal steroids, and spent more time on the ventilator. The