



Feeding Methods at Discharge Predict Long-Term Feeding and Neurodevelopmental Outcomes in Preterm Infants Referred for Gastrostomy Evaluation

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Objective To test the hypothesis that oral feeding at first neonatal intensive care unit discharge is associated with less neurodevelopmental impairment and better feeding milestones compared with discharge with a gastrostomy tube (G-tube).

Study design We studied outcomes for a retrospective cohort of 194 neonates <37 weeks' gestation referred for evaluation and management of feeding difficulties between July 2006 and July 2012. Discharge milestones, length of hospitalization, and Bayley Scales of Infant Development–Third Edition scores at 18–24 months were examined. χ^2 , Mann-Whitney *U*, or *t* tests and multivariable logistic regression models were used.

Results A total of 60% (*n* = 117) of infants were discharged on oral feedings; of these, 96% remained oral-fed at 1 year. The remaining 40% (*n* = 77) were discharged on G-tube feedings; of these, 31 (40%) remained G-tube dependent, 17 (22%) became oral-fed, and 29 (38%) were on oral and G-tube feedings at 1 year. Infants discharged on a G-tube had lower cognitive (*P* < .01), communication (*P* = .03), and motor (*P* < .01) composite scores. The presence of a G-tube, younger gestation, bronchopulmonary dysplasia, or intraventricular hemorrhage was associated significantly with neurodevelopmental delay.

Conclusions For infants referred for feeding concerns, G-tube evaluations, and feeding management, the majority did not require a G-tube. Full oral feeding at first neonatal intensive care unit discharge was associated with superior feeding milestones and less long-term neurodevelopmental impairment, relative to full or partial G-tube feeding. Evaluation and feeding management before and after G-tube placement may improve long-term feeding and neurodevelopmental outcomes. (*J Pediatr* 2017;181:125–30).

Technological advances for infants born premature have raised the rates of survival but contributed to increased aerodigestive and neurodevelopmental morbidity¹ and high societal costs.² Prematurity negatively impacts attainment of feeding milestones,^{3,4} because 40% of infants referred to feeding clinics are born preterm.⁵ Infections, growth failure, bronchopulmonary dysplasia, necrotizing enterocolitis, and neurologic sequelae in the neonatal intensive care unit (NICU) are associated with neurodevelopmental and feeding dysfunctions in later childhood.^{6–9}

The relationship between concurrent postdischarge childhood feeding behaviors and neurodevelopmental status has been assessed.^{10,11} Postdischarge feeding difficulties in infancy likely are related to sensory or motor neurologic vulnerabilities, static or progressive neurologic diseases, behavioral deficits, chronic lung disease, gastrointestinal causes, or most often a combination of all these etiologies.^{12–15} Furthermore, feeding difficulties, when fully apparent in later life, have deleterious consequences because the condition already has made an imprint on the developing sensory-motor neural architecture and aerodigestive reflex functionality.¹⁶ Dysfunctional feeding behaviors at 18 months of age are associated with neurodevelopmental delays (assessed by the Bayley Scales of Infant Development–Third Edition [BSID-III]).¹⁰ To our knowledge, however, no studies have addressed the impact of personalized feeding methods attained at the first NICU discharge on later neurodevelopmental outcomes.

Diagnosis and management of neonatal feeding difficulties is difficult because of individual heterogeneity, interplay between multiple target organs, regulatory and coordinating neurosensory/neuromotor processes, evolving pathophysiology, involvement of multiple disciplines, and empiric therapies.^{12,17–19} Therefore, we examined prospectively the following variables: (1) the proportion of infants in the NICU with complex feeding difficulties, discharged with a gastrostomy tube

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BSID-III	Bayley Scales of Infant Development–Third Edition
G-tube	Gastrostomy tube
GERD	Gastroesophageal reflux disease
NICU	Neonatal intensive care unit
PMA	Postmenstrual age

(G-tube) from a Neonatal and Infant Feeding Disorders Program that included an individualized plan based on clinical and physiologic characteristics; (2) the feeding milestones attained by 1 year of age in those infants who received a G-tube before NICU discharge; and (3) the hypothesis that oral feeding at first NICU discharge is associated with less neurodevelopmental impairment and better feeding milestones at 2 years age, compared with infants with a G-tube.

Methods

Participants were convalescing infants born premature referred to our neonatal feeding disorders program for the evaluation and management of severe feeding difficulties, including evaluation for a G-tube placement. Feeding difficulties were characterized by an inability to consume adequate oral feeding, gavage-tube dependence, feeding or postprandial related-cardiorespiratory spells, coughing, gagging, arching, refusal to feed, and/or poor sucking ability.

Inclusion criteria were preterm birth (<37 weeks' gestation), inpatient referral to the neonatal feeding program, hospital discharge, and neurodevelopmental evaluation at 18-24 months' corrected age. Between July 2006 and July 2012, 320 infants were seen by our program, of whom 194 met all 4 study criteria. Of 126 infants who did not meet the study criteria, 91 were lost to follow-up, 6 died, and 29 did not have a BSID-III assessment (Figure 1; available at www.jpeds.com). Respiratory modalities, discharge diagnoses, and neurodevelopmental assessments at age 2 years were collected on all infants. Informed parental consent and institutional review board approval were obtained.

Because of heterogeneity among infants with feeding difficulties, our neonatal feeding and aerodigestive disorders management program provides both a targeted and individualized diagnostic approach and mechanisms-based feeding strategies for neonates convalescing in the NICU.

The feasibility of such an approach, validation of diagnostic methods, and description of specific strategies have been reported previously.^{17,18,20} In brief, neonatal nurses and nurse practitioners, neonatologists, pediatric surgeons, pediatric gastroenterologists, and parents requested referrals for the evaluation of oropharyngeal dysphagia, gastroesophageal reflux disease (GERD), and for G-tube placement, and/or fundoplication. Every infant received a complete history and physical examination, with attention to observation of swallowing-breathing coordination during feeds, sucking and swallowing reflexes, potentially undiagnosed congenital aerodigestive anomalies, and cardiorespiratory effort during feeding. If clinically indicated, initial structural and functional evaluations of the aerodigestive tract were performed by video fluoroscopic swallow and/or upper gastrointestinal fluoroscopy studies. Consultation with otorhinolaryngology occurred for evidence of upper airway obstruction. The neuromotor mechanisms of feeding-related symptoms were evaluated via assessment of swallow-integrated esophageal motility, concurrent with cardiorespiratory observations at baseline and

during provocation. Infants with suspected GERD were evaluated with a 24-hour pH impedance study.

Findings were discussed with the primary care team, and an individualized feeding management strategy was formulated to include feeding approach (type of milk, volume, feeding duration, feeding method, caloric density, and breastfeeding), feeding progression, nutrition, growth, related pathophysiology, and relevant pharmacologic treatment. Common evidence-based strategies to manage functional oropharyngeal dysphagia were explained to the team, including pacing techniques, nipple selection, feeding position, gradual progression from continuous to bolus feeds, and advancement toward minimizing feeding duration per feed. Breastfeeding was encouraged, and approaches were recommended to resolve feeding difficulties during breastfeeding. Behavioral therapy was attempted with encouragement of pacifier-dips, alleviating infants' stress with hand containment, facilitated tucking, and kangaroo care with parents. Self-regulatory behaviors and tolerance to positional changes were encouraged before reacting to events. GERD was treated with pharmacologic therapy and decreasing feeding flow rates.²¹ Rarely, poor gut motility was treated with short-term prokinetic agents (amoxicillin/clavulanate or erythromycin) to improve oral feeding and feeding intolerance.

Compliance with the individualized feeding plan was monitored by our feeding program and during multidisciplinary feeding rounds. Strategies included (1) education regarding factors that are helping or impeding feeding progress; (2) monitoring nutrition and growth; and (3) personalized guidance for feeding delays.²⁰ Feeding-related education was provided to nurses, feeding therapists, and parents to ensure compliance to the directions. Each infant's self-regulatory behaviors and tolerance to positional changes were noted, and bedside providers were taught to respond to these behaviors.

Infants were followed in the outpatient follow-up program as well as primary care providers, and infants with lung disease were followed in our chronic lung disease program. During clinic visits, infants were assessed for feeding, growth, and airway-related issues. BSID-III examinations were conducted at 18-24 months' corrected gestational age by independent occupational and physical therapists, and results were stratified based on feeding method at discharge.

The primary metric was discharge feeding outcomes (full oral or G-tube feeding). The secondary outcomes were postdischarge aerodigestive milestones and developmental follow-up studies at 18-24 months. Aerodigestive metrics were ventilation duration, first oral feed attainment, prevalence of G-tube or tracheostomy, and supplemental oxygen at 36 weeks' postmenstrual age (PMA) and discharge. Feeding methods were categorized as follows: full-oral fed was considered as exclusive oral feeding, and those infants who were transitioning and partially tube-fed were categorized under G-tube feeding. We classified the severity of bronchopulmonary dysplasia according to the National Institutes of Health consensus definition at 36 weeks' PMA.²² Neurodevelopmental outcomes included composite scores of BSID-III comprising cognitive, communication, and motor scores, corrected for

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