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Relationship of Neonatal Oral Motor Assessment Scale to Feeding Performance of Premature Infants

Peter M. Bingham, MD*, Taka Ashikaga, PhD**, and Soraya Abbasi, MD†

**Department of Bioinformatics, University of Vermont, Burlington, VT 05401, United States

†CHOP Newborn Care at Pennsylvania Hospital, Pennsylvania Hospital, 800 Spruce St, Philadelphia, PA 19107, United States

Abstract

Objective—Some premature infants require prolonged tube-feeding, beyond term equivalent gestational age. Tools that could prospectively identify such infants from among otherwise healthy patients are needed. We examined how well the Neonatal Oral Motor Assessment Scale (NOMAS) predicts premature infants' transition from tube to oral feeding.

Design—Data from a prospective study of sucking behavior as a predictor of feeding skills were used to examine the relationship of NOMAS and other nominal predictors to pre-defined feeding milestones.

Setting—Neonatal intensive Care Unit

Patients—51 tube-fed, premature infants

Methods—NOMAS was administered soon (<72 hours) after oral feeding was initiated, and weekly thereafter, until infants reached full oral feeding. A timed measure of feeding efficiency was also done as oral feeding was initiated. A standardized, permissive protocol for feeding advance was used. Nonparametric rank sum tests and ANOVA were used to relate NOMAS, feeding efficiency, and other baseline variables to feeding milestones.

Results—Gestational age at birth, birth weight, and initial feeding efficiency predicted shorter transition and earlier acquisition to full oral feeding; NOMAS scores did not predict feeding outcomes.

Conclusions—NOMAS was a poor predictor, while feeding efficiency and other baseline traits were better predictors of feeding skills in premature infants.

Corresponding Author: Peter M. Bingham MD, Associate Professor of Neurology & Pediatrics, University of Vermont/Fletcher Allen Health Care., 1 South Prospect, UHC-Arnold 2434, Burlington VT 05401, Phone: (802)847-3749, Fax: (802)847-4190, Peter.Bingham@vtmednet.org, United States.

Competing Interests none

- The NOMAS is a 2 minute assessment that has been purported to indicate developmental readiness of tube-fed premature infants for oral feeding advance.
- These findings indicate that a simple feeding efficiency measure has greater utility than the NOMAS in predicting oral motor skills of premature infants.

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Keywords

tube feeding; Feeding behavior; premature infant; behavior state; non-nutritive sucking

Introduction

Most premature infants achieve full oral feeding by 38 weeks gestational age (GA). However, some premature infants require prolonged tube-feeding, beyond term equivalent gestational age. Starting with the very first trials of oral feedings for premature infants, nurses in the neonatal intensive care unit (NICU) routinely make informal feeding assessments. These assessments contribute to immediate decisions regarding oral feeding, and also to anticipation of delayed transition from tube to oral feeding. These nursing assessments are thus aimed towards early identification of “problem feeders,” so as to facilitate transition from tube feeding. What exactly are the best feeding skill assessment tools, and how well do they work?

The Neonatal Oral Motor Assessment Scale (NOMAS) is a widely used tool to guide decisions about feeding advances in newborns, including tube-fed premature infants. (Palmer, Crawley et al. 1993; Palmer 2002) Advantages of the NOMAS include that it is quickly performed (2 minutes); it involves an actual trial of oral feeding and thus integrates necessary oral motor skills; and it includes measures that pertain to both maturational features (the “disorganization” sub-score) and pathologic signs or symptoms (the “dysfunction” sub-score). In her initial studies of the NOMAS, Meyer noted that the NOMAS is “an attempt to provide a feeding scale that could be used to monitor progress in oral –motor function” (Braun and Palmer 1986) and to “categorize the oral-motor patterns that underlie poor feeding behavior in the neonatal period.” (Palmer, Crawley et al. 1993) Since that time, the NOMAS has been studied in tube-fed premature infants in a retrospective study (Hafstrom and Kjellmer 2000). However, we could not identify prospective studies that address the predictive validity of the NOMAS in tube-fed, premature infants in terms of oral feeding milestones.

Signs of oral motor dysfunction in the NOMAS include abnormalities of orofacial tone, including jaw clenching (hypertonia), increased jaw excursion or glossoptosis (hypotonia), or retracted tongue. These relatively rare signs of suck dysfunction are considered to be indicators of pathology, and so might be expected to show more stability over the course of development.

Signs of disorganization within the NOMAS system include (1) degree to which sequences of suck bursts are sustained (absence of habituation); (2) duration of suck bursts; and (3) consistency of suck bursts (variability in number of sucks per burst). The presence of nasal flaring, head turning, and increased limb movement constitute other behavioral signs of disorganized nutritive sucking. Although they may be more difficult to recognize in the breast-fed infant, these signs, together with increased respiratory rate, oxygen de-saturation (by pulse oximeter), or color changes, characteristically appear in an infant with immature nutritive suck, whether bottle or breast-fed (Palmer 2002). Because of their neurologic immaturity, premature infants under 35 weeks gestational age (GA) typically show disorganization when they begin feeding. Abnormalities of organization are thus “normal” for premature infants.

In principle, either disorganization, as a measure of oral-motor development, or dysfunction, as an indicator of oral-motor pathology, could be useful predictors of feeding difficulty, i.e., identify infants who will require prolonged tube feeding. We therefore carried out

prospective observations to address whether disorganization or other NOMAS scores predict weak feeding performance in premature infants. We also performed the NOMAS serially, from the start of oral feeding through to the full oral feeding milestone, so that we could confirm whether NOMAS results— especially the disorganization score – change in parallel to infant maturation and transition to oral feeding. Since relatively little research has been done regarding feeding predictors in this group, we collected other baseline measures that might identify infants who will experience feeding difficulty and require protracted (i.e., beyond term age equivalent) tube-feeding. A better understanding of how and whether NOMAS vs. other nominal predictors relate to subsequent feeding performance would facilitate implementation of developmental interventions for feeding difficulty.

In a prospective study, we examined the relationship of the NOMAS sub-scores and other potential clinical indicators (timed feeding score, gestational age and weight at birth) to measures of oral feeding performance (Bingham, Ashikaga et al. 2009). We hypothesized that variation in degree of disorganization shown by premature infants of equivalent gestational age who are just beginning to feed orally will correspond with the age at which they eventually attain full oral feeding. To better understand the notion of disorganization as a developmental aspect of oral motor skills, and dysfunction as a sign of pathology in premature infants, we also examined internal consistency of sub-scores, and changes in NOMAS over the course of a semi-structured, 2-3 week oral feeding advance.

Methods

Study subjects

The study population consisted of 51 premature infants born between 25 and 34 weeks' GA (Table 1) who were participants of an NIH-funded study of the predictive value of nonnutritive sucking (NNS) behavior for feeding skills development. Patients were recruited from NICUs at a smaller, rural academic hospital (Fletcher Allen Health Care, Burlington, VT) and also a larger, urban hospital (Pennsylvania Hospital, Philadelphia, PA). Subjects with orofacial anomalies, neurologic problems, or those undergoing major procedures were excluded. Informed consent was obtained from parents after the nature of the study was explained. All procedures were approved by Institutional Review Boards at both institutions.

Neonatal Oral Motor Assessment Scale (NOMAS)

NICU feeding therapists, and research nurses at both study sites received training in administering the NOMAS with the author, Marjorie Palmer (NOMAS® Certification Course). Sub-scores of the NOMAS comprise 12 dichotomous assessments of nutritive suck organization (suck rhythm) and 8 assessments of nutritive suck function (lip seal, tongue and jaw movement) (Palmer, Crawley et al. 1993). Consistency in NOMAS scoring was confirmed by the NOMAS™ certification process, which requires 100% agreement in diagnosis of normal vs. disorganized vs. dysfunctional sucking pattern, and 85% agreement in scoring 5 different 2 minute observations of infant feeding. NOMAS scoring for this study was initiated within 72 hours after the infant successfully initiated oral feeding and continued weekly within 48 hours of reaching full oral feeding.

Feeding Milestones

Feeding outcome measures included (1) GA at Initiation of Oral Feeding (IOF), (oral consumption of at least 5 ml milk); (2) GA at Full Oral Feeding (FOF) (infant orally consuming at least 100ml/kg/day and absence of tube feeding for 48 hours); (3) transition time (days from initiation of oral feeding to full oral feeding).

Feeding Advance Protocol

Initial oral feeding attempts began 72 hours after subjects reached 32 weeks' GA. To ensure that feeding outcomes reflected infant feeding skills as much as possible, a standardized feeding advance protocol was designed that permitted infants to advance according to their own cues and skills. Feeding trials were initiated when subjects were awake. Once they had consumed 5 ml orally, they had opportunities to feed orally 3 times (Level 1). Level 2 (feeding trial every 6 hours; 4× per day) began once subjects consumed at least 10ml/kg/feeding at Level 1 without signs of distress (tachypnea, regurgitation, cyanosis, head turning, fending/protest gestures). Next, infants advanced to oral feeding trials every 3 hours (Level 3). Breastfed subjects were weighed immediately pre-/post feeding attempts to document intake using an Olympus infant scale accurate to ± 1 gram. Within the structure of this feeding advance, feedings were carried out in standardized fashion. If the infant did not finish the prescribed volume in 20 minutes, the remaining milk was given by naso- or orogastric tube. To assess the volume consumed, the bottle was weighed before and again after the feeding. Any milk leakage during the feeding sessions was measured by weighing the bib pre- and post-feeding (Milk density ~ 1.01 , 1 g ~ 1 ml).

Other Predictors of Feeding Outcomes

Potential baseline predictors of feeding outcomes included (1) feeding efficiency (volume consumed in the first 5 minutes of bottle-feeding – see below); (2) weight and GA at birth; (3) duration of respiratory support. *Assessment of Oral Feeding Efficiency (Timed Feeding)*, defined as consumption rate (ml/min), was done because this measure has been suggested as a predictor of feeding skills (Lau, Sheena et al. 1997). Two 5 minute timed feeding measures were obtained following the method of Schanler et al. (Schanler, Shulman et al. 1999). These measures, performed by the same individuals as those performing the NOMAS, were done during the period of transition from tube to oral feeding, and within 72 hours of the first day that the subject consumed 10ml/kg by mouth twice within a 24 hour period. The duration of a feeding included pauses between sucking bouts. If the infant paused feeding, the nipple was kept in contact with the lips or tongue, but the subject fed at his/her own pace.

Analysis—Data were described with means, standard deviations, medians and ranges. Reliability of the items for NOMAS sub-score scoring was assessed using Cronbach's alpha, a measure of internal consistency reliability based on the average correlation among the items making up the sub-scores. Exploratory Factor Analyses were conducted to examine the factor structure to supplement examination of the reliability of the two NOMAS sub-scores. Test-Retest reliability was assessed using Pearson correlation coefficients as was the relationship of baseline clinical observations and NOMAS sub-score values. Repeated measures ANOVA was used to assess changes in NOMAS sub-scores over time. Cox proportional hazard models were used to examine the relationship of the Transition Time (FOF – IOF) and Gestational Age at Full Oral Feeding to NOMAS sub-scores, and to other baseline characteristics and the feeding efficiency measures. The predictive validity assessment was limited to the initial NOMAS, since feeding milestones occurred anywhere after the baseline observation while the first three serial NOMAS observations were used for reliability and temporal validity assessments. Statistical significance was defined as $p < 0.05$ for analyses relating nominal predictors and feeding performance.

Results

Table 1 summarizes patient characteristics. A greater number of girls were recruited, and, likely because of inclusion criteria, subjects had a relatively mild course in terms of respiratory complications. There was a relatively wide range of ages at which subjects initiated oral feeding (32-36.3 weeks), reflecting GA at birth as well as feeding readiness. As

expected, relatively few infants showed feeding dysfunction on the NOMAS. The number of infants with 1, 2, or 3 serial NOMAS observations was 50, 49, and 45 respectively; those with 4, 5, or 6 observations numbered 11, 2 and 1 respectively. This decrease essentially reflected that, whereas NOMAS observations were performed weekly, most subjects “graduated” to full oral feeding by 4 weeks after oral feeding had commenced.

Cronbach's alpha values for the two baseline NOMAS sub-score dimensions were 0.026 for the Disorganized and 0.506 for the Dysfunctional sub-scores, respectively. The second and third NOMAS observations had somewhat larger alpha values for the Disorganized ($\alpha = 0.223$ and 0.605) and Dysfunctional ($\alpha = 0.525$ and 0.615) sub-scores. These results aligned with the Exploratory Factor Analysis results which indicated that both the Disorganized and the Dysfunctional sub-score items for each of the three NOMAS observations did not reflect the existence of a single underlying factor score structure that would justify the validity of the two NOMAS subscales (data not shown).

Test-retest reliability of the two NOMAS sub-scores for the first three observation time points revealed correlations between Disorganized scores of $r_{12} = +0.541$ ($p=0.0001$), $r_{13} = +0.233$ ($p = 0.123$), and $r_{23} = +0.573$ ($p < 0.0001$) where the subscripts indicate the observation time points (Table 2a). The Dysfunctional scores had correlations of $r_{12} = +0.2500$ ($p = 0.0832$), $r_{13} = +0.3747$ ($p = 0.011$), and $r_{23} = +0.612$ ($p < 0.0001$). The NOMAS showed at best moderate test-retest reliability correlations between the three consecutive observations.

Forty-five subjects with complete NOMAS data at baseline and the two follow-up time points were examined using repeated measures ANOVA. Disorganized scores showed a significant difference ($p<0.0001$) between the three serial observations within subjects. The change over time showed was characterized by a significant linear effect ($p=0.0002$; mean values 4.2, 3.7 and 3.4). In contrast, the Dysfunctional scores did not show a significant change ($p=0.667$) within subjects (mean values 0.1, 0.2 and 0.1). These temporal changes for the Disorganized scores accord with the correlation between consecutive time points observed for the test-retest results, while the lack of temporal changes in the Dysfunctional scores may be related to the less systematic correlation between these observations.

The baseline and subsequent two NOMAS sub-scores did not correlate well with the baseline and other trial measures, indicating that NOMAS scores were not confounded with these other measures (Table 2b). However, significant negative correlations were found between baseline Timed Feeding scores and Dysfunction sub-scores (data not shown).

The Cox model results (Table 3) show that the baseline NOMAS did not predict either Transition Time (TT) or GA at FOF. In contrast to the NOMAS results, Cox models for TT indicated that several baseline measures (GA at Birth, Birth Weight, Timed Feeding #2) were significant predictors of TT. In addition to these baseline measures, the number of days of respiratory support also predicted GA at FOF. Transition time was predicted by the second, but not the first, Timed Feeding measure. Thus, infants with stronger feeding efficiency at the beginning of their course from IOF and FOF ultimately showed a shorter transition time to FOF.

Discussion

Our study focuses on a clinical need to have some kind of formal, objective measure that could help identify premature infants who are likely to have delayed feeding milestones. Considering that prior studies have not addressed the relationship of the NOMAS to actual feeding milestones, we assessed the relationship of NOMAS scores, along with an array of other potentially useful infant characteristics, to the timing of attainment of full oral feeding.

In a prospective, observational study, we also explored the psychometric properties of the NOMAS instrument. Baseline NOMAS sub-score results did not predict subsequent feeding performance, or show concurrent validity with other predictors of feeding performance. This finding is surprising, considering that these standardized observations effectively comprise subjects' suck-swallow-breath coordination skills. It remains uncertain why even the later NOMAS Dysfunction Score does not correspond to feeding outcome measures.

As expected considering the putative developmental aspects of disorganization features, average NOMAS Disorganized scores decreased significantly over the three time points, while the Dysfunctional scores remained relatively constant. This change over time suggests that the NOMAS Disorganized score does measure some facet of maturation. While it may have validity as an indicator of maturation of feeding skills, NOMAS does not appear to reflect key, performance-related features of premature infants' feeding behavior.

In contrast to the NOMAS scores, several baseline and other trial measures did predict GA at FOF and TT reasonably well (Table 3). This finding accords with results from related studies of premature infants' feeding performance (Dodrill, Donovan et al. 2008). Additional analyses (data not shown) are consistent with the lack of predictive value of NOMAS scores, in that NOMAS scores did not correlate with other, established, predictors.

Oral feeding is a reflexive behavior of premature neonates that follows a developmental trajectory beginning with non-nutritive sucking and culminating with organized rhythms of sucking, swallowing, and breathing. Increasing frequency of sucking, length of sucking bursts, and consistency in the intervals between sucks within a burst occur during the transition from tube to full oral feeding (~28-35 weeks), in parallel with objective stages of feeding (Hafstrom and Kjellmer 2000; Lau, Alagurusamy et al. 2000). At a neuroanatomic and neurophysiologic level, this maturation parallels increasing coordination of inter-connected "central pattern generators" that mediate breathing, sucking, and swallowing (Bieger and Neuhuber 2006). In a related study, ordinal scores of NNS maturation corresponded with later feeding skills. The evolution in disorganization score described here is consistent with this developmental model of ingestive behavior.

Limitations of this study include the subjective aspect of NOMAS, although efforts were made to ensure inter-observer consistency. While results showed strong consistency in infants' NOMAS scores obtained at different trials, variability in the execution of NOMAS measures may have obscured a relationship between NOMAS and feeding performance measures. In addition, while subjects had equivalent gestational age and oral feeding experience, extrinsic influences particular for each patient—nursing practice, parental involvement, age at initiation of oral feeding—may have influenced the feeding performance outcome measures used in this study.

A physical score of ingestive behavior has potential as a reliable indicator of feeding skills, as it may integrate the various patient characteristics (degree of prematurity, severity of respiratory disease, gastrointestinal motility, medical complications) that could influence oral motor development. The NOMAS constitutes one of the most widely-used feeding assessment tools for newborn premature infants in the NICU. A better understanding of the validity of the NOMAS, and of other potential predictors of feeding skills, can inform continuing efforts to promote this critical and highly variable developmental milestone of tube-fed premature infants.

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Table 1
Patient Characteristics (n = 51)

Maternal age (years)	29.2 ± 7.2 ^a
Male/Female	16 / 35
GA ¹ at birth (weeks)	30.7 ± 2.1 ^a
Birth weight (grams)	1512.3 ± 499.4 ^a
Five minute Apgar Score	9 (6, 9) ^b
Number of days on ventilator	1 (0 - 2) ^b
Number of days on oxygen	0 (0 - 7) ^b
Number of days on CPAP	2 (0 - 7) ^b
Days of Respiratory Support (ventilator, oxygen, CPAP)	5 (1 - 14) ^b
GA ¹ at IOF ²	33.3 (32.0 – 36.3) ^b
Weight at IOF ² (grams)	1619.0 (980.0, 2657.0) ^b
NOMAS Baseline Disorganization Score	4 (2, 6) ^b
NOMAS Baseline Dysfunction Score	0 (0 - 2) ^b
Timed Feeding Volume - 1	7.0 (0 – 20) ^b
Timed Feeding Volume – 2	7.0 (0 - 35) ^b

^a mean ± standard deviation

^b median and range

¹ Gestational Age

² Initiation of oral feeding

Table 2**Table 2a. Pearson correlation matrix for first three serial Disorganized and Dysfunctional NOMAS Scores**

	DISORG-1	DYSF-1	DISORG-2	DYSF-2	DISORG-3	DYSF-3
DISORG-1	1.000					
DYSF-1	0.210	1.000				
DISORG-2	0.541	0.204	1.000			
DYSF-2	0.026	0.250	0.056	1.000		
DISORG-3	0.233	0.276	0.573*	0.250	1.000	
DYSF-3	0.032	0.375*	0.096	0.612*	0.131	1.000

*p<0.05

Table 2b. Pearson correlation matrix of first three serial Disorganized and Dysfunctional NOMAS Scores with Baseline Measures

	GA at BIRTH	BIRTHWEIGHT	APGAR1	APGAR5	Respiratory Support
DISORG-1	-0.198	-0.214	-0.064	-0.019	0.304
DYSF-1	-0.134	-0.130	0.063	0.110	0.164
DISORG-2	-0.009	0.018	0.225	0.301*	0.160
DYSF-2	0.218	0.092	0.034	0.004	-0.155
DISORG-3	0.016	0.107	0.070	0.084	0.179
DYSF-3	0.163	0.134	0.015	0.084	-0.124

*p<0.05

Table 3

Cox Proportional Hazards Model relating baseline characteristics, baseline NOMAS scores, and baseline timed feeding to feeding milestones in premature infants.

Predictor	Transition Time	GA at FOF ^a
GA at birth	0.18 (0.08) ^b (p=0.03)	0.21 (0.08) (p=0.008)
Birth weight	0.001 (0.0004) (p=0.003)	0.001 (0.0004) (p=0.034)
Apgar 5	0.35 (0.19) (p=0.07)	0.32 (0.20) (p=0.10)
Days of Respiratory Support	-0.01 (0.008) (p=0.21)	-0.02 (0.01) (p=0.01)
Baseline NOMAS Scores:		
NOMAS - Disorganization	-0.018 (0.149) (p=0.90)	-0.06 (0.15) (p=0.68)
NOMAS - Dysfunction	0.070 (0.316) (p=0.83)	-0.20 (0.31) (p=0.52)
Timed Feeding (1)	0.032 (0.03) (p=0.23)	0.01 (0.02) (p=0.73)
Timed Feeding (2)	0.07 (0.02) (p=0.0006)	0.05 (0.02) (p=0.02)

^a Full Oral Feeding

^b Regression coefficient (standard error)