Developmental Outcome for Neonates with Dysfunctional and Disorganized Sucking Patterns: Preliminary Findings

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This article reports on developmental outcome at 24 to 36 months of age for infants whose sucking patterns were evaluated during the neonatal period using the the Neonatal Oral-Motor Assessment Scale (NOMAS). This evaluation tool differentiates normal, disorganized, and dysfunctional sucking patterns based on jaw and tongue movement during nutritive sucking (NS). Developmental outcome correlated 100% with normal and dysfunctional sucking characteristics as well as with medical history and/or diagnosis. All infants who demonstrated a developmental delay at 24 months of age had a history of dysfunctional sucking during the neonatal period, intraventricular hemorrhage with abnormal neurological examination, and/or either increased or decreased muscle tone. Early identification of sucking dysfunction allows for the implementation of early treatment with the possibility of improved feeding skills. The NOMAS enables early diagnosis of infant sucking with predictable developmental outcome, which enables better therapeutic planning for the future of these infants.

Neonatal sucking has been a subject of study for many decades. In the 1960s and 1970s, different sucking patterns were found in the preterm and term infant (Cowett, Lipsitt, Vohr, 1978; Gryboski, 1965; Wolff, 1968). Differences in pressure, consumption, and the number of sucks per burst in the preterm and full-term infant have been reported (Medoff-Cooper, Weininger, & Zukowsky, 1989). The suck-swallow-breathe ratio in the continuous

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burst pattern of the mature suck observed in full-term infants has been documented (Bu'Lock, Woolridge, & Baum, 1990), as well as the sound of swallows and swallow breaths during suckle feeding (Vice, Heinz, Giuriati, Hood, & Bosma, 1990). Deglutition apnea times decreased as infants matured, which was reported to be related to gestational age rather than to feeding experience (Hanlon et al., 1997). Difficulty with neonatal sucking has been described as an early indicator of neurologic abnormalities (Hill & Volpe, 1981). Although abnormal oral-motor patterns have been identified in children with cerebral palsy (Finnie, 1975; Morris, 1982), early oral-motor dysfunction during infant sucking activity has not been investigated as a predictor of later signs of cerebral palsy or developmental delay.

Although many parameters of infant sucking have been described, an analysis of jaw and tongue movements during neonatal sucking has only been reported within the last few years. (Braun & Palmer, 1985–1986; Palmer, Crawley, & Blanco, 1993; Tamura, Matsushita, Shinoda, & Yoshida, 1998). The NOMAS categorizes nutritive sucking (NS) patterns into normal, disorganized, and dysfunctional based on jaw and tongue movement (Figure 1). Although the NOMAS has been used to describe oral-motor function during infant sucking and to categorize infant sucking patterns (Bier, Ferguson, Anderson, et al., 1993; Braun & Palmer, 1985–1986; Case-Smith, Cooper, & Scala 1989; VandenBerg, 1990), the correlation between these early sucking patterns and later developmental outcome is largely unknown. One follow-up study of infants who scored poorly on the NOMAS during the neonatal period showed that they also scored poorly on a speech and language battery at 30 months of age (Crawley, Lindner, & Braun, 1987). The authors, together with a developmental pediatrician involved in the high-risk infant follow-up clinic, performed a retrospective chart review of a group of infants to determine predictability of the NOMAS obtained during the neonatal period for developmental achievement at follow-up evaluation.

Methods

Thirty-four infants were assessed initially during the neonatal period in the normal, special care, and intensive care nurseries using the NOMAS. A retrospective chart review of medical records was conducted to determine long-term outcome. Eleven infants did not return for follow-up and were, therefore, excluded from this study. Additionally, four infants had moved away and/or had no records available after 3½ months of age, and one infant died in an automobile accident at 4 months of age. For the remaining 18 infants, developmental information was recorded in the high-risk infant follow-up clinic at approximately 6, 12, 18, 24, and 36 months of age. One of these 18 infants died at 10 months of age, but since he did receive follow-up after discharge from the intensive care nursery, he was included in this study.

Infants averaged 2.8 visits of the four possible follow-up visits that were scheduled up to 24 months of age. Evaluation of developmental skill level varied but included assessments of mental, motor, visual, speech, and feeding activity and a description of muscle tone. Follow-up evaluations were performed by the developmental pediatrician and staff of the high-risk infant follow-up clinic.

Because of the retrospective nature of this study, developmental measures were not prospectively controlled but included the Denver Developmental, Vineland Social Maturity Scale, and the Bayley Scales of Infant Development. A screening of vision and/or hearing was done only at the recommendation of the examining physician. Evaluation of the Bayley Scales of Infant Development yielded an MDI score (mental developmental index) as well as a score in motor performance. Other test measures such as the Vineland Social Maturity Scale reported performance in terms of mental age (MA). Summary data are expressed as mean and standard deviations. The predictive value of the NOMAS was determined by the Fischer exact test.

NOMAS™

Jaw

Normal	Disorganization	Dysfunction
__ consistent degree of jaw depression	__ inconsistent degree of jaw depression	__ excessively wide excursion that interrupt the intra-oral seal on the nipple
__ rhythmical excursions	__ arrhythmical jaw movements	__ minimal excursion; clenching
__ spontaneous jaw excursions occur upon tactile presentation of the nipple up to 30 minutes prior to a feed	__ difficulty initiating movements: __ inability to latch on __ small, tremor-like start-up movements noted __ does not respond to initial cue of nipple until jiggled	__ asymmetry; lateral jaw deviation
__ jaw movement occurs at the rate of approximately one per second (1/2 the rate of NNS)	__ persistence of immature suck pattern beyond appropriate age __ under 40 weeks PC (transitional suck)	__ absence of movement (% of time)
__ sufficient closure on the nipple during the expression phase to express fluid from the nipple		__ lack of rate change between NNS and NS (NNS=2/sec; NS=1/sec)

Tongue

Normal	Disorganization	Dysfunction
__ cupped tongue configuration (tongue groove) maintained during sucking	__ excessive protrusion beyond labial border during extension phase of sucking without interrupting sucking rhythm	__ flaccid; flattened with absent tongue groove
__ extension-elevation-retraction movements occur in anterior-posterior direction	__ arrhythmical movements	__ retracted; humped and pulled back into oro-pharynx
__ rhythmical movements	__ unable to sustain suckle pattern for two minutes due to: __ habituation __ poor respiration __ fatigue	__ asymmetry; lateral tongue deviation
__ movements occur at the rate of one per second	__ incoordination of suck/swallow and respiration which results in nasal flaring, head turning, extraneous movement	__ excessive protrusion beyond labial border before/after nipple insertion with out/down movement
__ liquid is sucked efficiently into the oro-pharynx for swallow		__ absence of movement (% of time)

Summary and impression:

Recommendations:

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Certified Examiner

Certificate # _____

Figure 1. Neonatal Oral-Motor Assessment Scale (NOMAS). (Copyright © 1990 Marjorie Meyer Palmer.)

Results

Of the 18 infants with follow-up evaluations (Tables 1 through 3), 9 demonstrated disorganized sucking characteristics, 7 had dysfunctional findings, and 2 had normal assessments as determined by the initial NOMAS scores in the nursery. The gestational age (mean $\pm$ *SD*) was 28.6 $\pm$ 4.2 weeks, and birthweight was 1159 $\pm$ 655 grams. The mean gestational age, birthweight, and Apgar scores for each group are displayed in Table 4.

Five of seven infants with dysfunctional characteristics on the NOMAS presented with developmental problems by 6 months of age (see Table 1). Three had suffered an intraventricular hemorrhage, five had bronchopulmonary dysplasia (BPD), and one was drug exposed. Three had documented postural tone differences by 6 months of age. Three infants had oral feeding problems by 12 months of age, and one infant subsequently required gastrostomy tube placement for long-term tube feedings. One infant demonstrated dysfunctional sucking on the NOMAS during the neonatal period, poor feeding and developmental delay in motor skills at a 6-months follow-up, and subsequently died at 10 months of age. The remaining six infants had persistent developmental delay in one or more areas of development by 24 months of age, that is, skills were below age level at the time of evaluation.

Of the nine infants with disorganized sucking patterns (see Table 2), four showed no developmental delay at 24 months of age, and five demonstrated persistant developmental delay in one or more areas at 36 months. Of the four infants who were not developmentally delayed at 24 months, only one had a history of a Grade 1 (left) intraventricular hemorrhage. Of the five with delayed development, four had an intraventricular hemorrhage, and one had right porencephaly. The two infants with normal NOMAS scores demonstrated normal development at 12 and 24 months of age (see Table 3).

The NOMAS prediction of dysfunctional feeding was strongly associated with developmental delay, while a normal feeding pattern was predictive for normal development, with Fisher exact test giving a two-sided $p < 0.02$ (Table 5). A disorganized score appeared to be intermediate, with 56% displaying later developmental delay. Table 6 shows clinical findings in the infants who were or were not developmentally delayed. Intraventricular hemorrhage occurred in 7 of the 12 delayed infants compared with 1 of the 6 normal infants. Gestational age, birthweight, and Apgar scores tended to be lower in the developmental delay group compared with the normal group.

Discussion

Neonatal sucking patterns as characterized by the NOMAS may serve as a predictor of later development in infants who score in both the normal and dysfunctional categories of sucking. Developmental outcome correlated with normal (100%) and dysfunctional (100%) sucking characteristics as well as the medical history and/or diagnosis (see Table 5). Seven of the infants who demonstrated a developmental delay at 24 months of age had a history of intraventricular hemorrhage with abnormal neurological examination and/or either increased or decreased muscle tone. Of the infants with a developmental delay at 24 months, five were diagnosed with visual impairment, four with hearing loss, two with cardiac disease, and six with feeding problems.

Birthweight, gestational age, and Apgar scores appear to be confounding variables in predicting abnormal oral-motor function. From our data, we cannot separate these effects. However, the NOMAS as a measure of oral-motor function now is seen to correlate with long-term (3 years) developmental abnormalities, particularly in the dysfunctional feeder, and may be a useful guide for feeding therapy

Table 1. Dysfunctional Feeders

Patient	Gestational Age	Birthweight	Birth History	Apgar Score (1 min/5 min)	6 Months	12 Months	18 Months	24 Months
1	28 weeks	850 grams	RDS, BPD, POA	6/8	tone + nystagmus	transient dystonia	NE	mild delay, walked at 18–24 months
2	28 weeks	840 grams	IVH III, ROP, RDS, BPD, hearing loss	5/7	developmental delay	OK	NE	slow
3	22–23 weeks	570 grams	DS, BPD, ROP, hearing loss	4/7	tone normal	developmental delay, feeding/ speech visual impairment	NE	27–30 at 44 months
4	28 weeks	950 grams	hearing loss, IVH II–III, GE reflux, NG tube, NEC	5/8	NE	developmental delay/motor 5–6 months; language 7–8 months; fine motor = 8 months	borderline hearing, FTT, G-tube, overall developmental delay	MA = 11 months Motor = 8 months
5	32 weeks	1380 grams	drug exposure, cocaine, tone, increased NG tube, NEC	8/9	tone increased	delay/speech	speech/language at 20 months; was at 15–18 month level	Bayley MDI +56
6	26–27 weeks	822 grams	drug exposure, ROP, BPD, IVH I	3/6	hypotonic ROP, delayed poor feeding	choking; delayed	MA = 13 months makes no sound	sucks, no chew delayed
7	24–25 weeks	750 grams	anemia, BPD, NEC, IVH II–III	4/7	poor feeding, motor delay	died at 10 months		

Abbreviations for Tables 1,2, & 3: BPD = brochopulmonary dysplasia; RDS = respiratory distress syndrome; GER = gastroesophageal reflux; IVH = intraventricular hemorrhage (followed by grade); ROP = retinopathy of prematurity; NEC necrotizing enterocolitis; PDA = patent ductus arteriosus; ASD = atrial septal defect; A + B = apnea/bradycardia; J-tube = jejunostomy tube; G-tube = gastrostomy tube; FTT = failure to thrive CP = cerebral palsy; MDI = mental developmental index; MA = mental age; NL = normal tone; + = increased tone; OK = appropriate for age; NE = not evaluated at that time.

Table 2. Disorganized Feeders

Patient	Gestational Age	Birthweight	Birth History	Apgar Score (1 min/5 min)	6 Months	12 Months	18 Months	24 Months
1	25 weeks	690 grams	RDS, BPD, GER	3/6	OK	OK	NE	OK
2	26 weeks	780 grams	RDS, BPD, S/P pneumothorax	1/1	OK, mild hypotonia	OK	NE	OK
3	30 weeks	1260 grams	Grade I IVH NEC, ileostomy	4/7	NE	OK	NE	OK
4	25–26 weeks	620 grams	RDS, BPD, Grade II IVH ROP, NEC, ASD, PDA, pulmonary stenosis	5/8	FTT	FTT, slightly delayed	NE	At 36 months, overall developmental delay functioning at 21–24 month level
5	29 weeks	1260 grams	RDS, BPD, A+B perinatal asphyxia, mild hypotonia, Grade II IVH, PDA, cystic encephalomalcia	2/2	OK	hearing loss, CP, quadraplegia, FTT	NE	CP, quadraplegia
6	34 weeks	2220 grams	mild BPD, mild ventriculomegaly	7/8	OK	OK	NE	OK MDI = 96
7	24–25 weeks	710 grams	hearing loss, ROP, II–III, BPD mild hypotonia	1/6	OK	OK	NE	At 31 months MDI = 57; delayed development; functioning at 20 months

Table 2. *(continued)*

Patient	Gestational Age	Birthweight	Birth History	Apgar Score (1 min/5 min)	6 Months	12 Months	18 Months	24 Months
8	28 weeks	960 grams	low Carnitine hearing loss BPD, NEC, j-tube stage I bleed?	3/5	decreased activity, poor attention	decreased activity hearing loss	delayed fine motor and speech	Bayley MDI=89 at 24 months range is 18–23 months
9	31 weeks	1460 grams	Stage III IVH right porencephaly	8/8	CP; spastic diplegia on right	CP; sat at 13 months; crawls, cruises	NE	CP; spastic diplegia at 10 months, but able to walk

Table 3. Normal Feeders

Patient	Gestational Age	Birthweight	Birth History	Apgar Score (1 min/5 min)	6 Months	12 Months	18 Months	24 Months
1	31–32 weeks	1550 grams	Normal	5/7	OK	OK	OK	OK
2	40 weeks	3182 grams	Normal	8/9	OK	OK	OK	OK

OK = appropriate for age

Table 4. Summary Data

	NOMAS Result		
	Dysfunctional (*n* = 7)	**Disorganized (*n* = 9)**	**Normal (*n* = 2)**
Birthweight (grams)	880 ± 250	1107 ± 3.2	2366 ± 1154
Gestational age (weeks)	27.1 ± 3.0	28.1 ± 3.2	35.8 ± 6.0
Apgar score:			
1 minute	5.0 ± 1.6	4.1 ± 2.7	6.5 ± 2.1
5 minutes	7.4 ± 1.0	5.9 ± 2.8	8.0 ± 1.4

All values are mean ± *SD*.

Table 5. NOMAS Result Compared with Developmental Delay

Developmental Delay	Dysfunctional	Disorganized	Normal
Yes	7	5	0
No	0	4	2

and a prognostic indicator for future development. Further systematic investigations will be necessary to confirm these results.

The degree of disorganization noted during neonatal sucking did not correlate with later outcome. The fact that 44% of the disorganized feeders were developmentally age appropriate by 24 months supports the hypothesis that disorganization is commensurate with incoordination and improves with time and maturation (Crook, 1979). The disorganized feeders who exhibit subsequent developmental delay need to be studied further to determine the etiology and nature of their problems.

The identification of dysfunctional sucking patterns during the neonatal period is important not only so that early intervention and treatment can be provided but also as a predictor of later developmental outcome. In this study, all infants who demonstrated dysfunctional sucking patterns on the NOMAS presented with a developmental delay in one or more areas of development by 24 months of age. Additional outcome studies are needed to explore further the predictability of the NOMAS and correlation of dysfunctional sucking patterns in the neonate with clinical and developmental outcome.

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Table 6. Developmental Delay at 24 Months

Clinical Parameters	No (n = 6)	Yes (n = 12 until 6 months; then = 11)
Intraventricular hemorrhage	Grade I IVH	Grade I = 2; Grade II = 1; Grade II–III = 1; Grade III = 3
NEC	1 with ileostomy	1
Drug exposed		2
Abnormal neuro exam		
Increased tone		5
Decreased tone		2
Hearing loss		4
Apgar Scores (1 min/5 min) (mean + *SD*)	5.2 ± 2.7/6.7 ± 3.0	4.5 ± 2.2/6.8 ± 1.9
Gestational age (weeks; mean ± *SD*)	31.1 ± 5.5 (range = 25–40)	27.1 ± 2.9 (range = 22–32)
Birthweight (grams; mean ± *SD*)	1614 ± 949 (range = 690–3182)	931 ± 290 (range = 570–1460)
BPD	3	10
Visual impairment		5
Cardiac disease		2
Feeding problems		6

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