Developmental Continuum of Neonatal Sucking Performance Based on the NOMAS® (Neonatal Oral-Motor Assessment Scale)

Marjorie Meyer Palmer, M.A., CCC-SLP

Preliminary Clinical Observations

Introduction

As medical technology advances and preterm infants are able to survive in ever increasing numbers with smaller birth weights, younger gestational ages, and more medically complex diagnoses, oral feeding for these infants has become a universal concern. Despite the plethora of information available on neonatal sucking and the coordination of suck/swallow/breathe in the healthy term infant, oral feeding in the preterm infant continues to be poorly understood and the normal course of maturation of efficient feeding remains controversial. It has been reported that respiration and suck are gestational age-dependent reflexes modulated in the brain stem and increasing gestational age with maturation correlates with a lower frequency of apnea and the development of sucking rhythm.[1,2,3,4,5,6] It has also been reported that experience with oral feeding results in a more rapid maturation of sucking.[7,8] Other studies have reported opposing views that early oral stimulation may not result in earlier weaning from nasogastric tube feeding;[9,10] and that stimulation of non-nutritive sucking in preterm infants accelerates oral feeding success.[11] Finally it has been reported that the process of maturation is considered to be the most responsible factor for coordination of sucking ability in the infant.[5,6,12,13] Despite this controversy (i.e., development of sucking in the preterm infant), it is generally agreed that the sucking profiles of the preterm infant are significantly different from those of the healthy term infant[14] The well coordinated feeding pattern of the healthy term infant is characterized by a 1/1/1 coordination of suck, swallow, and breathe.[15] When infants are unable to coordinate suck/swallow/breathe they may forfeit available energy necessary for feeding and be unable to continue sucking that may result in failure to thrive. Usually this in-coordination is because of an inability to maintain adequate ventilation while sucking and swallowing.[15] In 1979, Crook defined this type of in-coordination of suck/swallow/breathe as characteristic of a disorganized suck.[16]

Other infants may demonstrate a dysfunctional suck[17]that may be a possible early indicator of neurological damage.[15] A dysfunctional suck is characterized by abnormal movements of the tongue and jaw observed during early reflexive nutritive sucking that are not seen in the typically developing preterm or healthy term infant.[17,18] These movements include excessively wide jaw excursions that interrupt the intra-oral seal on the nipple, a flattened tongue configuration with an absent tongue groove, and jaw excursions that are too short to allow for an adequate degree of suction.[17] Dysfunctional NOMAS scores were associated with decreased transcerebellar diameter and lower Dubowitz scores.[19]

The NOMAS

Based upon the concepts described above, the NOMAS (Neonatal Oral-Motor Assessment Scale) was developed in 1983 and revised in 1990 (page 14) as a clinical evaluation of neonatal sucking patterns. This bedside observation tool enables the examiner to differentiate the normal, disorganized, and dysfunctional suck. The NOMAS identifies 28 characteristics of jaw and tongue movements that are observed during a two-minute nutritive sucking sample. Since 1994 professionals have been required to become reliable in the administration and scoring of this assessment in order to accurately use it to diagnosis the neonatal suck pattern in the preterm and term infant up to 44 weeks post conceptional age (PCA). Both the normal and disorganized categories on the NOMAS have demonstrated acceptable psychometric properties[20] and preliminary data suggests that the NOMAS is a "reliable assessment tool that provides an objective, standardized, and observational measure" of infants' feeding maturation.[21] In addition, Macmullen and Dulski found that the NOMAS evaluation of sucking ability correlated with gestational age, weight, and behavioral state in normal healthy newborns.[22] DaCosta et.al. reported that this observational tool is most commonly used to assess the nutritive sucking skills of infants,[23] and it has been examined more consistently and showed more consistent results in psychometric properties than other feeding assessments.[20] The performance of the infant on the NOMAS may also be useful in the prediction of later developmental outcome.[21,24]

Efficient feeding is secondary to co-ordination of the pharyngeal swallow with respiration and the episodes of deglutition apnea are reported to decrease with maturity.[25] This is representative of the maturation of the preterm infant and it has been hypothesized that "feeding is a neuro-developmental process of maturation.[5]" Based upon this hypothesis, only infants with a disorganized suck pattern are described here in order to track the maturation of sucking development.

Early Development of Sucking

Grybowski first identified the immature suck pattern of the preterm infant as consisting of short sucking bursts of 3-5 sucks per burst followed by a pause of equal duration during which swallowing and breathing occurred.[13] When an infant is not able to self-regulate in this manner, episodes of deglutition apnea resulted and these deglutition apnea events were reduced as the infant matured.[25]

By comparison the healthy full term infant will usually have the neurological maturation and respiratory support necessary to demonstrate a mature/continuous burst suck pattern. This pattern consists of sucking bursts of 10-30 sucks per burst, with swallowing and breathing occurring during the sucking burst, followed by a brief pause.[13] The average ratio of suck/swallow/

respiration has been reported to be 1:1:1.[12,15] An infant born at term must suck, swallow, and breathe in a coordinated manner during successful oral feeding. When an infant is born prematurely these skills may not yet be fully mature or coordinated.[26] In addition to the lack of neuro-developmental maturation, infants with respiratory problems, such as bronchopulmonary dysplasia, have an even more difficult time with the coordination of suck/swallow/respiration and demonstrate low sucking pressures, short sucking bursts, infrequent swallows, and prolonged episodes of deglutition apnea.[27]

Infants who are born prematurely may also be unable to regulate their cardio-respiratory system during oral feeding resulting in increased heart rate and decreased oxygenation. Attention to cardio-respiratory regulation and the relationship between feeding performance and cardio-respiratory stability in the preterm infant may provide information as to an infant's readiness to feed.[7] Adequate coordination of suck/swallow/breathe appears to be crucial for an infant to feed without episodes of desaturation, apnea, bradycardia, and/or aspiration. An alternation of the suction and expression components of suck are not sufficient, therefore, for an infant to feed safely by mouth[9] and the coordination of respiration needs to be in place for successful oral feeding to occur. It has been reported that swallowing first occurs at 13 weeks and sucking at 18 weeks in utero while the suck/swallow coordination is present at 32-34 weeks gestational age. The suck/swallow/breathe coordination necessary for a continuous burst pattern, however, usually does not occur until closer to term, at about 37 weeks post conceptional age.[12]

Evaluation of Sucking: Administration and Scoring of the NOMAS

The evaluation of the infant suck pattern was based on clinical observations as described on the NOMAS (Appendix A). This assessment consists of three diagnostic categories: normal, disorganized, and dysfunctional sucking that are based on 28 characteristics of jaw and tongue movement during the first two minutes of nutritive sucking on a bottle. The NOMAS is also used with breast feeding infants but the evaluation requires more than two minutes. Since these clinical observations were done only with bottle feeders a discussion of breast fed infants is not appropriate here.

A normal suck refers to either the self-regulated immature suck of the preterm infant, or the continuous burst pattern of the healthy term infant, both of which have been previously described, and a disorganized suck that refers to "a lack of rhythm of the total sucking activity" (suck, swallow, and breathe),[16] while a dysfunctional suck is identified by "abnormal movements of the tongue and jaw".[17]

The administration and scoring of the NOMAS is taught during a three-day course. Participants are required to observe infants at bedside in the neonatal intensive care or special care nursery during the first two minutes of a routine bottle feeding in order to accurately diagnose their suck pattern. A two-minute sample was selected to observe the best performance of the infant, since younger infants are not often able to sustain the suck well. Participants are required to pass an inter-rater reliability standard, in order to use the NOMAS as an assessment tool after completing the course.

Method

Clinical observations of sucking patterns in infants from 31 to 44 weeks PCA were undertaken. The purpose was to determine whether or not there is a correlation between developmental maturation and sucking ability, based upon the NOMAS. Only those infants who were diagnosed with a disorganized suck on the NOMAS were observed. Infants with a normal suck (i.e., no difficulty with the coordination of suck/swallow/breathe) or those infant with a dysfunctional suck (abnormal movement of the jaw and tongue during sucking[28]) were excluded. The subjects included one hundred and twenty (120) infants from the intensive care and special care nurseries. Gestational and post conceptional ages for the infants were recorded. Infants ranged in age from 31 to 44 weeks PCA. The first two minutes of nutritive sucking on a bottle at bedside were recorded on videotape during a routine nursery feeding of each subject. Infants were evaluated on the NOMAS while being fed by staff nurses in either a Level II or Level III intensive care or special care nursery. Nursing and physician agreement with respect to the infant's readiness to begin nipple feeding, was required. The nipple used for the feeding had been pre-selected by nursing staff for each infant prior to the bedside observation. All subjects were videotaped once at bedside during a three-day NOMAS Certification Course conducted in nurseries located in the United States, Canada, Asia, and Europe. A two-minute videotape of the mouth during nutritive sucking was taken using a Panasonic Palmcorder, PV-D407, after signed parental consent was obtained. In some cases the parent was available to feed the infant during the observation. The videotape was part of the course and as such was not considered to be a study at the time of the videotaping. All infants observed were medically stable and had a physician's order to proceed with bottle feeding. Because these infants were only observed as part of the 3-day NOMAS Certification Course observers were not privy to detailed medical information.

The number of infants in each group included:

31-31 6/7 weeks PCA = 2
32-32 6/7 weeks PCA = 3
33-33 6/7 weeks PCA = 6
34-34 6/7 weeks PCA = 11
35-35 6/7 weeks PCA = 18
36-36 6/7 weeks PCA = 30
37–37 6/7 weeks PCA=11
38-38 6/7 weeks PCA =11
39-39 6/7 weeks PCA =10
40-40 6/7 weeks PCA=6
41+ weeks PCA = 12

Each videotape was reviewed and the number of sucks that occurred during the two-minute sample was counted. Isolated sucks (i.e., one or two sucks occurring alone) were subtracted in order to obtain the total number of sucks contained within sucking bursts during the two minutes. Based upon the average number of sucks and the range of sucks per two-minute nutritive sucking sample, a developmental correlation was outlined. Since all infants were videotaped during a NOMAS Certification

Course, a minimum of at least four examiners evaluated each infant at bedside and inter-rater reliability for the diagnosis of the disorganized suck was established. Three of these examiners were course participants and one examiner was the NOMAS course instructor. Scoring of the suck pattern was done after the two-minute observation was completed followed by a discussion of the results.

Findings

The percentage of sucks contained within nutritive sucking bursts increased with maturation (Table 1, page 15). This is in agreement with the findings of Gewolb, Bu'Lock, Grybowski and others.[5,12,13,29,30,31] The range of sucks contained within sucking bursts during the two-minute sample also increased with maturation (Table 2, page 15). Infants at 31 weeks demonstrated from zero to eight total sucks in a two-minute nutritive suck sample; infants at 32 weeks had 10-49 sucks; and infants at 33 weeks had 23-59 sucks. Infants at 34 weeks demonstrated a range of 14-79 sucks in the two minutes. By 35 weeks PCA infants demonstrated as many as 127 sucks during the two minute nutritive sucking sample. At 36-36 6/7 weeks of age the maximum number of sucks in the first two minutes of nutritive sucking from a bottle was 123 and at 37-37 6/7 weeks was 145. The average number of sucks in the two-minute nutritive suck sample nearly doubled from 34 to 35 weeks PCA and more than doubled by 37 weeks PCA (Table 3 page 15). The average number of sucks contained within sucking bursts, the range of sucks and the maximum number of sucks in a two-minute sample of nutritive sucking increased with maturation and can be seen as a developmental continuum of sucking.

Discussion

In many nurseries both in the United States and in other countries oral feeding is usually not introduced to premature infants who are younger than approximately 34 weeks PCA. This explains the small sample size of infants available for review at 31 and 32 weeks PCA. When isolated sucks are observed, or when the infant stops sucking to breathe during the first two minutes of a nutritive suck sample, it was found not only to be a clinical symptom of a disorganized suck, but one more typically found in younger premature infants. Although the average nutritive suck is described as having one suck per second, some younger or sicker term infants may have a faster suck rate or sucks that are not accompanied by swallows and may demonstrate more than 120 sucks during a two-minute sample; while other full term infants may have a 3:1 suck/swallow ratio and also demonstrate more sucks than one per second. Additional research is needed in order to evaluate the impact of illness, medical diagnosis and respiratory difficulty on neonatal sucking and the NOMAS results, during the first two minutes of the nutritive suck. Based upon the literature it seems reasonable to suspect that the younger, sicker infants will have more difficulty with the coordination of suck/swallow/breathe, than the older healthier ones. This clinical observation of reflexive neonatal sucking over time with increasing PCA, based on the NOMAS®, does show improved coordination of suck/swallow/breathe with maturation and correlates with other studies.[3,5,6,9,12,13,15,16,22]

These findings are worth noting from a developmental perspective because they support the infant's readiness to feed at 35 weeks PCA, later but not earlier and correlate well with much of the literature.

Conclusion

This clinical observation demonstrates trends in sucking activity and changes in sucking performance with maturation both of which are identifiable by the NOMAS. Evaluation of infant sucking, based upon the NOMAS, agrees with previous reports that the development of nutritive sucking in the preterm infant is dependent upon maturation and neurodevelopment, rather than on learned behavior.[5,6] As the infants matured they demonstrated a larger number of total sucks in a two-minute nutritive sample, a better ability to sustain the suck for two minutes, and a greater percentage of sucks contained within sucking bursts as indicated by the scores on the NOMAS. These findings correlate with other studies that have documented the changes in nutritive suck patterns that occur in preterm infants over time.[30,31]

The NOMAS is an important feeding observational assessment as it evaluates the early nutritive suck of the preterm and term infant in the intensive care/special care nursery. It allows for clinical observation at the bedside and has established inter-rater reliability among examiners both at bedside and on videotape. In addition, the administration and scoring of the NOMAS requires only two minutes and may be used as an effective screening tool for those infants who have just begun to orally feed. At this time it is unclear just how much can be predicted by the early evaluation of neonatal sucking, although a significant association has been reported between neonatal sucking patterns at 40 weeks post-menstrual age and developmental outcome at both 12 and 18 months corrected gestational age.[32] It has been suggested that a standardized instrument for neonatal sucking evaluation may offer a cost-effective early screening strategy for preterm infants who are at greatest risk for developmental delay.[33] Since the NOMAS is widely used in clinical and research environments and can be administered in just two minutes, it has been suggested that it serve as such an evaluation.[20,21,23,24,34,35]

Further studies are needed, however, in the areas of feeding progress and improvement in sucking skills of preterm and term infants in intensive care and in the area of developmental follow-up as it correlates with neonatal sucking performance on the NOMAS. Of particular interest are the infants who demonstrate clinical signs of stress during nutritive sucking on the NOMAS since those infants may be more likely to develop a sensory-based feeding aversion later. Another area of interest is the sensory aspect of neonatal sucking and the infants who demonstrate deviations in their sensory response to nipple feeding. Sensory deviations such as perseveration, habituation, and poor adaptability are identified by the NOMAS during the two-minute evaluation. It would be interesting to explore the possibility of the prediction of later sensory integration disorders, autistic spectrum disorders (ASD), and pervasive developmental disorders not otherwise specified (PDD-NOS) as well as sensory based feeding aversions based upon early neonatal nutritive sucking scores on the NOMAS.

References on page 15

Neonatal Oral-Motor Assessment Scale (NOMAS)

Jaw

Normal

_____ Consistent degree of jaw depression

_____ Rhythmical excursions

_____ Spontaneous jaw excursions occur upon tactile presentation of the nipple up to 30 minutes prior to a feed

_____ Jaw movement occurs at the rate of approximately one per second (1/2 the rate of NNS)

_____ Sufficient closure on the nipple during the expression phase to express fluid from the nipple

Disorganization

_____ Inconsistent degree of jaw depression

_____ Arrhythmical jaw movements

_____ Difficulty initiating movements:

___ Inability to latch on

___ Small, tremor-like start-up movements noted

___ Does not respond to initial cue of nipple until jiggled

_____ Persistence of immature suck pattern beyond appropriate age

___ Under 40 weeks PC (transitional suck)

Dysfunction

_____ Excessively wide excursions that interrupt the intra-oral seal on the nipple

_____ Minimal excursions; clenching

_____ Asymmetry; lateral jaw deviation

_____ Absence of movement (% of time)

_____ Lack of rate change between NNS and NS (NNS = 2/sec; NS = 1/sec)

Tongue

Normal

_____ Cupped tongue configuration (tongue groove) maintained during sucking

_____ Extension-elevation-retraction movements occur in anterior-posterior direction

_____ Rhythmical movements

_____ Movements occur at the rate of one per second

_____ Liquid is sucked efficiently into the oro-pharynx for swalllow

Disorganization

_____ Excessive protrusion beyond labial border during extension phase of sucking without interrupting sucking rhythm

_____ Arrhythmical movements

_____ Unable to sustain suckle pattern for two minutes due to:

___ Habituation

___ Poor Respiration

___ Fatigue

_____ Incoordination of suck/swallow and respiration which results in nasal flaring, head turning, extraneous movement

Dysfunction

_____ Flaccid; flattened with absent tongue groove

_____ Retracted; humped and pulled back into oro-pharynx

_____ Asymmetry; lateral tongue deviation

_____ Excessive protrusion beyond labial border before/after nipple insertion with our/down movement

_____ Absence of movement (% of time)

Summary and impression

RECOMMENDATIONS: _____

_____

_____

_____

_____

_____

_____
Licensed Examiner

_____
License #

Table 1. Percentage of total sucks contained withinsucking bursts

Post-Conceptual Age (PCA)										
31-31 6/7 weeks	32-32 6/7 weeks	33-33 6/7 weeks	34-34 6/7 weeks	35-35 6/7 weeks	36-36 6/7 weeks	37-37 6/7 weeks	38-38 6/7 weeks	39-39 6/7 weeks	40-40 6/7 weeks	41+ 6/7 weeks
0	89%	89%	87%	98%	96%	97%	98%	99%	99%	98%

Table 2. Developmental Maturation of Suck Range of sucks in two-minute nutritive suck sample (minus isolated sucks)

Post-Conceptual Age (PCA)										
31-31 6/7 weeks	32-32 6/7 weeks	33-33 6/7 weeks	34-34 6/7 weeks	35-35 6/7 weeks	36-36 6/7 weeks	37-37 6/7 weeks	38-38 6/7 weeks	39-39 6/7 weeks	40-40 6/7 weeks	41+ 6/7 weeks
0-8	10-49	23-59	14-79	23-127	18-123	30-145	23-116	29-99	23-87	44-111

Table 3. Average number of sucks in two minute nutritive suck sample

Post-Conceptual Age (PCA)										
31-31 6/7 weeks	32-32 6/7 weeks	33-33 6/7 weeks	34-34 6/7 weeks	35-35 6/7 weeks	36-36 6/7 weeks	37-37 6/7 weeks	38-38 6/7 weeks	39-39 6/7 weeks	40-40 6/7 weeks	41+ 6/7 weeks
0	22	29	33	64	53	68	60	68	60	74

References

1. Richards SD, Ritchie S, Hobbs GR, Mandich M, Sheth RD. Neonatal suck reflex pattern does not predict apnea. *Journal of Child Neurology*. 1999; 14, 9: 614-616.
2. Neiva FC, Leone CR. Development of sucking rhythm and the influence of stimulation in premature infants. *Pro Fono*. 2007; 19, 3: 241-248.
3. Dodrill P, Donovan T, Cleghorn G, McMahon S, Davies PS. Attainment of early feeding milestones in preterm neonates. *Journal of Perinatology*. 2008; 8: 549-555.
4. De Castro AG, Lima Mde C, de Aquino RR, Eickmann SH. Sensory oral-motor and global development of preterm infants. *Pro Fono*. 2007; 19, 1: 29-38.
5. Gewolb IH, Vice FL. Maturational changes in the rhythms, patterning, and coordination of respiration and swallow during feeding in preterm and term infants. *Developmental Medicine and Child Neurology*. 2006; 48, 7: 589-599.
6. Gewold IH, Vice FL, et.al. Developmental patterns of rhythmic suck and swallow in preterm infants. *Developmental Medicine and Child Neurology* 2001; 43, 1: 22-27.
7. Chang YW, Chang YJ. The relationship between oral feeding and cardiorespiratory regulation of premature infants. *Hu Li Za Zhi*. 2008; 55, 3: 5-10.
8. Pickler RH, Best AM, Reyna BA, Gutcher G, Wetzel, PA. Predictors of nutritive sucking in preterm infants. *Journal of Perinatology*. 2006; 26, 11: 693-699.
9. Lau C. Development of oral feeding skills in the preterm infant. Archive of *Pediatrics*. 2007; 14, 1: S35-S41.
10. Bragelien R, Rokke W, Markestad T. Stimulation of sucking and swallowing to promote oral feeding in premature infants. *Acta Paediatrica*. 2007; 96,10: 1430-1432.
11. Poore M, Zimmerman E, Barlow SM, Wang J, Gu F. Patterned orocutaneous therapy improves sucking and oral feeding in preterm infants. *Acta Paediatrica*. 2008; 97,7: 920-927.
12. Bu'Lock F, Wooldridge MW, and Baum JD. Development of coordination of sucking, swallowing, and breathing. Ultrasound study of term and preterm infants. *Developmental Medicine and Child Neurology*. 1990; 32, 8: 669-678.
13. Grybowski J. Suck and swallow in the preterm infant. *Pediatrics*. 1969; 43: 96-102.
14. Medoff-Cooper B, Weininger S, Zukowsky K. Neonatal sucking as a clinical assessment tool: preliminary findings. *Nursing Research*. Abstract only. Lippincott-Raven Publishers.
15. Van der Meer A, Holden G, van der Weel R. Coordination of sucking, swallowing, and breathing in healthy newborns. *Journal Pediatric Neonatology*. 2005; 2,2: NT69-NT72.
16. Crook, CK. The organization and control of infant sucking. *Advances in Child Development and Behavior*. 1979; 14: 209-252.
17. Palmer MM, Crawley K, Blanco IA. The Neonatal Oral-Motor Assessment Scale: a reliability study. *Journal of Perinatology*. 1993. 13,1: 28-35.
18. Hill A, Volpe JJ. Disorders of sucking and swallowing in the newborn infant: clinicopathologic correlations. *Progress in Perinatal Neurology*. Philadelphia, Pa: Saunders. 1981.
19. Zarem, C., Kidokoro, H., et.al., Psychometrics of the Neonatal Oral-Motor Assessment Scale. *Developmental Medicine and Child Neurology*. 2013. 55, 12: 115-1120.
20. Howe TH, Lin KC, Fu CP, Su CT. A review of psychometric properties of feeding assessment tools used in neonates. *Journal of Obstetrics and Gynecology and Neonatal Nursing*. 2008; 37, 3: 338-349.
21. Church PT, Keller CE, Gilbert, J et.al. Serial Neonatal Oral-Motor Assessment Scale (NOMAS) as a measure of feeding readiness. Presented at the *American Academy of Cerebral Palsy and Developmental Medicine*, Boston, Ma; 2006.
22. Macmullen NJ, Dulski LA. Factors related to sucking ability in healthy newborns. *Journal of Obstetrics and Gynecology and Neonatal Nursing*. 2000; 29,4: 390-396.
23. da Costa SP, van der Schans CP. The reliability of the Neonatal Oral-Motor Assessment Scale. *Acta Paediatrica*. 2008; 97: 21-26.
24. Tsai SW, Chen CH, Lin MC. Prediction for developmental delay by Neonatal Oral-Motor Assessment Scale in preterm infants without brain lesion. *Pediatrics International*. 2009.
25. Hanlon MB, Tripp JH, Ellis, RE et.al. Deglutition apnoea as indicator of maturation of suckle feeding in bottle-fed preterm infants. *Developmental Medicine and Child Neurology*. 1997; 39,8: 534-542.
26. Miller JL, Kang SM. Preliminary ultrasound observation of lingual movement patterns during nutritive versus non-nutritive sucking in a premature infant. *Dysphagia*. 2007; 2: 150-160.
27. Mizuno K, Nishida Y, Taki M, et.al. Infants with bronchopulmonary dysplasia suckle with weak pressures to maintain breathing during feeding. *Pediatrics*. 2007; 120, 4: 1035-1042.

Continued on page XX