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Developmental progression of feeding skills: an approach to supporting feeding in preterm infants

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Infants born prematurely, with congenital or acquired medical conditions, or who have extended stays in the neonatal intensive care unit (NICU) are at higher risk of developing feeding and nutritional problems than are full-term, healthy newborns. Because of the complex nature of feeding, it is necessary to have a thorough understanding of the developmental nature of this skill. The importance of recognizing stability in the physiologic, motor and state systems and using stability to determine both readiness to begin nipple feeding and progress in feeding, is discussed. Intervention strategies to promote stability leading to successful feeding are also described. Viewing infant feeding from a developmental skill acquisition perspective can guide the caregiver in determining how challenging it is for the infant, and therefore is useful in supporting the progression of feeding.

Key words: NICU, development, infant, preterm, feeding, stability

Introduction

Feeding disorders are thought to affect 25% of all children at some time in their lives [1,2]. However, infants born prematurely, with congenital or acquired medical conditions, or who have extended stays in neonatal intensive care units (NICU) are at higher risk of developing feeding and nutritional problems than are full-term, healthy newborns [3–10]. Many therapeutic interventions necessary for the treatment of infants in the NICU support neither positive oral experiences nor a nurturing relationship between the fragile infant and his or her parents, both of which are needed for successful feeding [11,12].

Physical growth of low birth weight infants often continues to lag behind that of their counterparts, whether they were small for gestational age, or born preterm [11,13–16]. In particular, the lower the birth weight and the more complicated the medical course, the poorer the weight gain. Deloian [11] found that low birth weight babies gained an average of 35 g per day after discharge, while extremely low birth weight babies averaged only 18.7 g per day. Kelleher *et al.* [13] demonstrated that 19.7% of low birth weight infants followed after discharge to 30 months met criteria for failure to thrive. Ernst *et al.* [14] found that 30% of infants who weighed less than 1500 g at birth remained at les than the 5th percentile in weight at 12 months corrected age. Astbury and colleagues [15] reported that, out of 235 prematurely born children seen at 2 years of age, 86% had weights below the 50th percentile, 29% had weights below the 10th percentile, and 11% had weights that were below the 3rd percentile for their age. Failure to gain adequate weight is a primary reason infants are readmitted to the hospital after discharge from neonatal intensive care units and can be related to difficulties with long-term feeding outcomes [17,18].

Attending to the oral needs of infants from birth, especially those who are ill and/or premature, may

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lead to better feeding and growth in the long term. Despite guidelines for 'successful' feeding, many infants appear to be discharged from intensive care units when they are still working on stabilizing their feedings skills [11,18]. Sustained weight gain along with competent feeding without cardio-respiratory compromise are criteria for discharge proposed by the American Academy of Pediatrics [19]. However, community professionals report seeing more medically fragile babies, with primary concerns of poor feeding and growth [11]. Because of the complex nature of feeding, it is necessary to have an understanding of the development of this skill in prematurely born infants, and to use this information in evidence-based practice.

Developmental progression of feeding

Successful feeding has recently been acknowledged as a developmental milestone for infants [20–22], and may reflect the neurological competence of the infant. An emerging body of literature regarding the development of competent oral feeding is now becoming available [12,18,23,24], and may be used to develop strategies for supporting successful feeding in the preterm infant.

Development is a process that involves an individual's ability to integrate new demands and new information, achieving stability at a new developmental level. The goal of facilitating the development of feeding skills in the NICU should be directed toward helping the infant achieve stability with each new step in the process of learning this complex skill. This includes progression from stability while being held, to sucking on a pacifier, and ultimately to nipple feeding. With each new attempt to integrate a more differentiated skill, infants often experience an instability of their underlying physiologic, motor and state stability as they integrate the demands of a new level of functioning. If their instability is too great, infants will either take longer to integrate the new demands, or will remain stable at a previously achieved level of equilibration. Recognizing instability and pacing the introduction of new information to facilitate stability assists the infant in mastering each new demand.

Increasing demands from the environment may challenge the infant's ability at each step, showing instability that is perhaps subtle. It is therefore essential for caregivers to provide consistent and predictable feeding opportunities in order to assist the infant in focusing on new feeding demands, rather than to allow contextual changes to occur which makes the infant focus on goals other than feeding. For example, external demands such as tolerating the distal (NICU, home) as well as the proximal (being held) environment, or internal demands, such as recognizing one's hunger cues, or safely coordinating swallowing during a feeding may impact the feeding experience. Providing consistent environments and feeding contexts will assist the infant to progressively achieve feeding competence.

Physiologic maturation necessary for successful feeding

The first task for the infant in developing feeding skills is to stabilize their physiologic parameters, including heart rate, breathing, oxygenation, and digestion [25,26]. Achieving physiologic stability provides positive feedback for the infant [25]. Initially, the infant begins to stabilize oxygen saturations during routine caregiving while in bed, and then while being held [27]. Maintaining physiologic stability while processing incoming stimuli during oral experiences and feeding follows. Assessing the impact of feeding on the infant's physiologic stability is therefore critical for determining the appropriateness of offering oral feeds [28].

Coordination of sucking/swallowing and breathing

Coordination of sucking/swallowing and breathing is required for oral feeding [28–31], and matures with increasing age [20–22,32–36]. Deglutition apnoea is a cessation of breathing related to successive swallowing or protection of the airway, and has been shown to decrease as the preterm infant matures, indicating that successful feeding is related to maturation rather than feeding experience [21]. Similarly, other feeding studies have indicated that the younger an infant is at birth, the longer it takes for that infant to achieve a mature

suck pattern [22]. With maturity, a more coordinated suck/swallow/breathe pattern is noted [20], usually beginning by 37 weeks post-conceptional age [36].

Infants who have had a more difficult medical course, resulting in instability of breathing, or who are born earlier, may need attention time to mature and be able to integrate the demands of sucking and swallowing with breathing [6,22]. Since bottle feeding is known to decrease transcutaneous oxygenation in preterm infants [37], facilitating adequate oxygenation, and recognizing that feeding is 'work' for the preterm infant is necessary to support appropriate feeding behaviours [38]. Preterm infants are at especially high risk for difficulties with coordinating sucking/swallowing/breathing, as are infants who are ventilated for extended periods of time [9,11,22,30,39]. Feeding difficulties continue for months after discharge for many children who had difficulty coordinating sucking/swallowing and breathing as infants in the NICU [3,6,40].

Oral motor development

The ability to progress to successful nipple feeding depends on the infant's ability to coordinate the muscles of the tongue, pharynx, and upper trunk, in order to support the safe swallow [28].

Oral-motor components of sucking change over time. At first, the infant expresses milk by compressing the nipple; then suction becomes integrated into the process [28,32]. As suction and expression become modulated, a more efficient suck is seen [28,32,41]. The sucking bursts become longer as the infant matures and is able to breathe while sucking [22,33,34]. However, if the infant is overwhelmed with too much fluid, they actually will change the shape of their tongue and their sucking to slow down the fluid [42], or drool out excess formula to avoid swallowing a larger volume [43].

Considerations for strategies to support the acquisition of feeding skills

Feeding should be viewed as a complex developmental skill which requires the integration of breathing, sucking and swallowing, in the context of overall motor stability and incoming sensory stimuli [12,44]. Yet when an infant displays difficulty with eating, therapeutic intervention is often begun, without a full evaluation of the infant's level of organization or disorganization. Viewing feeding as a developmental task that requires earlier stability of acquired skills may help professionals in determining the best way to support infant feeding [45].

Infants who have been hospitalized are often less physiologically stable than full-term counterparts at the same chronological age. Therefore, observing their ability to tolerate the demands of nipple feeding should guide the progression of feeding experiences, rather than relying on gestational age. Using volume of intake, or gestational age to guide progression is inappropriate if the infant is not able to safely swallow, or is so taxed by the event that he or she learns that feeding is too much 'work'. Many studies that address the impact of early birth and/or illness on the attainment of full nipple feedings propose that gestational age is an inaccurate and even dangerous indication of feeding readiness [21,22].

Understanding the impact of earlier developing skills on the more complex task of coordinated feeding is likely to relieve parents of guilt when their children have difficulty eating and growing [45]. The guilt felt by parents of children who fail to gain weight is often compounded by medical professionals, who fail to understand the impact of instability of the infant's physiologic system. Asking parents to 'get their child to eat more' is often unrealistic, given that for the vast majority of infants with feeding problems, there is an underlying physiologic reason that they are unable to eat successfully [46,47].

Identifying the stability of the individual infant while they are integrating increasing demands of the feeding experience helps both parents and professionals understand the emerging feeding competencies of the infant. Supporting the infant's own developmental strivings is an approach that has been utilized effectively in the developmentally supportive care literature, and has resulted in better medical, developmental, and feeding outcomes [26,48–52]. Supportive interventions which assist parents in reading the cues of their infant, and in supporting their infant's goal strivings has shown improved developmental outcome to 9 years of age [53]. Utilizing a similar approach with feeding appears reasonable.

Reading the infant's cues to guide progression of oral experiences

The impact of feeding on the stability of physiologic, motor, and state systems for the infant must be assessed continuously during every feeding trial [50]. The physiologic system, and especially the impact of the infant's respiratory effort, may limit the acquisition of feeding skills [3,39,54,55]. Recognizing that successful eating for preterm infants is dependent on the acquisition and stabilization of the physiologic system enables both parents and staff to identify the difficulties for each infant, and to develop supportive interventions [38,55,56]. Any disruption that negatively affects the infant's respiratory effort may cause the infant to compensate either through their motor system, with changes in their sucking pattern [42,43], or through their state system, by moving to a lower state, which is inappropriate for successful feeding [57].

Recognizing disruptions in physiologic stability enables those involved in the assessment of an infant's feeding ability to address the underlying difficulty rather than to attempt to develop a specific therapeutic intervention programme that may actually over-ride the infant's own compensatory mechanism. For instance, an infant who has difficulty coordinating sucking, swallowing and breathing may begin to move to a lower sleep state early in feeding, accompanied by a loss of motor tone, particularly in the oral motor area. Increasing the flow rate of the milk to 'help' the infant ingest more before he or she 'falls asleep' may result in a large bolus of milk being deposited in the orapharyngeal area, leading to increased apnoea and bradycardia [29–31]. Decreases in oxygenation compromise the infant's physiologic stability with a resulting loss of coordinated feeding behaviours, as the infant attempts to protect his/her airway [58]. Accumulation of these responses over time may result in refusal behaviours [55]. 'Oral aversion', for instance, is often not seen when an infant is first given a pacifier or his/her fingers for oral exploration, because these activities do not normally result in desaturation or other physiologic compromise. However, when the infant is given a task that disrupts the stability of his physiologic system, such as coordination of suck/swallow/breathe, it may provide negative feedback, and refusal may develop [22,58,59]. Infants with chronic lung disease have more feeding refusals and negatively perceived behaviours, perhaps linked to difficulty with eating and maintaining physiologic stability [40,54].

Promoting physiologic stability and positive oral experiences beginning at birth

Supporting positive feeding experiences in the intensive care nursery requires that attention be paid to supporting oral experiences from birth. This includes facilitating stability of the physiologic system, as well as offering the infant a pacifier or his or her fingers to orally explore. Additionally, providing tastes of breastmilk or formula to the infant on a pacifier or on his/her fingers, depending on the mother's choice of feeding, facilitates the infant's acquisition of new sensory stimuli during the feeding experience, prior to the start of nipple feedings. Therefore, thinking about successful breast or bottle feeding needs to begin at birth.

With the goal of continued stability in mind, beginning to offer opportunities at the breast for babies who will be breastfed, rather than with a bottle, is ideal. Infants are then able to experience a consistent environment (at their mother's breast), that allows them to nuzzle, lick, and suck, without overwhelming them with the need to tolerate large volumes or additional demands from the environment. Oxygenation has been shown to be better during breastfeeding than bottle feeding [37]. If the infant is overwhelmed by the experience or not developmentally ready to initiate feeding, he or she may fall asleep and not latch on to the breast. However, with bottle feeding, the typical reaction of the caregiver may be to put the bottle in the infant's mouth despite the clear indication of disorganization displayed by falling asleep, respiratory irregularities, or loss of muscle tone.

Techniques to support the infant's development of oral feeding skills

Interventions to support successful feeding should be used with caution, and after a thorough assessment of the infant's stability. Nursery personnel and families make a common assumption that

infants who are born prematurely or who are all ill have little energy and ability to draw milk out of the nipple. As a result, faster flowing nipples have been developed and marketed under a 'preemie' label. In fact, infants need a slower flowing nipple to support their ability to safely swallow [28–31,38]. Jaw support has also been used as a technique to help the infant draw more milk out of the nipple [60], with the flawed premise that increased volume flowing into the mouth results in an appropriate intervention. When oral manipulation such as jaw support is used to increase the flow volume, the baby often experiences too much milk to swallow which provides negative feedback and the feeding may worsen, ultimately leading to oral aversion [22]. Rather, as the infant's coordination of sucking, swallowing and breathing matures, the bolus size will increase [20,28,32,33,35] and the infant will be able to handle it effectively. Increasing volume expressed by the infant is directly related to the organization of a coordinated suck/swallow and breathe, which is related to maturation.

Many times, when stability of the physiologic system is considered the main goal, slowing the volume for an infant who is not eating well may be very successful. Slow flow nipples are now available to assist with slowing the flow. This allows the infant to manage to suck/swallow and breathe, with a flow that is not overwhelming. Once the skill of this coordination is more stable, increasing the flow rate may be appropriate, if stability of the physiologic system is maintained.

An intervention that may be successful for infants who are not able to maintain their own stability during feeding is pacing. Pacing is thought to support feeding success when it is used to slow the infant's successive swallows, with the caregiver interspersing breathing breaks. Pacing is done by either shifting the infant slightly forward every 3–5 sucks, so that the milk drains out of the nipple, or alternatively the bottle can be tilted down to achieve the same result. This imposes a break for the infant, who may be struggling with how to stop sucking in order to breathe, and ensures that the bolus of milk is not transferred to the pharynx. If this technique is not successful in maintaining oxygenation while eating, the infant may need to progress at a slower rate, by giving the infant small amounts of milk with a pacifier, while gavage feeding the infant. Once, the infant is able to show stability at this level, the infant may then be able to return to a slow-flow, paced oral feeding.

Conclusions

When infants are asked to nipple feed, the benefits must outweigh the risks. When the risks include instability in the physiologic system, the infant is likely to develop behaviour that eventually decreases the intake of food. Looking only at difficulties in the oral–motor components when assessing infant feeding discounts the complex nature of eating. Rather, looking at the steps required to fully master the art of eating takes a broad view at the physiologic, motor and state stability in assessing the infant's readiness to achieve successful feeding.

Using this framework can help caregivers evaluate each baby's developmental abilities, rather than using gestational age as an indicator for nipple feeding. Complications in the development of the stability of the state, motor or physiologic systems impacts the ability of the baby to nipple feed effectively. When the infant has difficulty with the developmental task at hand, he or she will often 'shut down', falling into a sleep state. He or she will often demonstrate instability in the motor system with a loss of tone, and in the physiologic system with a drop in oxygenation and an increase in irregular breathing. If significantly challenged, some infants may become bradycardic. Infants with a more complicated medical course may demonstrate less mature skills [6,21,22,40] and may take longer to achieve full oral feeding. Viewing infant feeding from a developmental skill acquisition standpoint can guide the caregiver in determining how difficult the challenge is for the infant, and therefore is useful in supporting the progression of feeding.

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