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Supporting Oral Feeding Skills Through Bottle Selection

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Abstract

Infants who have feeding difficulties often struggle with coordinating sucking, swallowing, and breathing, and have difficulty eating sufficient quantities for adequate growth. Speech-language pathologists (SLPs) need advanced expertise across a number of areas (e.g., development, medical, swallowing) to work effectively with these young infants, and they use a variety of strategies when treating this population. Therapists working with infants who have feeding difficulties use bottles as a primary therapy tool; how the infant tolerates the flow rate from the bottle/nipple is a major consideration. Caregivers must understand the influence of bottle/nipple flow rates on eating skills, so they can support the emerging oral skill development for these fragile infants, and help parents decide what bottle system to use in their home. Both infant and equipment factors influence bottle/nipple flow rates. This article discusses the influencing factors that need to be considered when determining the optimal flow rate for an individual infant.

Many infants struggle with eating skills in the first months of life, and some require speech-language pathologists (SLPs) to help them transition through early feeding milestones (Levine et al., 2011; Motion, Northstone, & Emond, 2001). Many of these infants begin life in the Neonatal Intensive Care Unit (NICU; Ross & Browne, 2013). The American Speech-Language and Hearing Association (ASHA) Practice Guidelines emphasize the advanced expertise necessary to provide appropriate support to infants in the NICU, with feeding being a primary area of focus (ASHA, 2004). The National Association of Neonatal Nurses (NANN) also recognizes that infants in the NICU need carefully thought-out bedside strategies to learn to eat safely (Sables-Baus et al., 2013). Preterm infants are often developing sucking/swallowing and breathing coordination, as well as integrating the sucking components of suction and expression (Gewolb & Vice, 2006b; Lau, Alagugurusamy, Schanler, Smith, & Shulman, 2000; Medoff-Cooper, 2005; Mizuno & Ueda, 2003). Medically complex infants often have difficulty with integrating breathing into the sucking burst, maintaining physiologic stability, and eating sufficient quantities to discharge home fully orally fed (Gewolb & Vice, 2006a; Jadcherla, Vijayapal, & Leuthner, 2009; Jadcherla, Wang, Vijayapal, & Leuthner, 2010; Sables-Baus, Kaufman, Cook, & da Cruz, 2012). The SLP needs to (a) understand normal development and the influence of medical comorbidities; (b) adjust expectations accordingly, and (c) be able to support the acquisition of feeding skills.

Feeding is a neurobehavioral skill, and the experiences in the NICU set the stage for future skill development that continues past discharge (Browne & Ross, 2011). Critical reviews of feeding outcomes at and post-discharge reveal that feeding remains a major focus of parents, and many infants continue to struggle with skill development (Ross & Browne, 2013; Thoyre, 2007). While volume is one measure of success, research suggests feedings that are focused on enjoyable experiences characterized by physiologic stability and motor organization (including coordination of sucking, swallowing, and breathing) may improve outcomes post-discharge (Horner et al., 2014). Feeding is increasingly viewed as a co-regulated process; one in which the decisions of the feeder can significantly improve both the experience and the longer-term feeding outcomes (Horner et al., 2014; Ross & Browne, 2002, 2013; Ross & Philbin, 2011; Shaker, 2010; Thoyre, Holditch-Davis, Schwartz, Melendez Roman, & Nix, 2012).

The NANN Oral Feeding Guidelines emphasize that bedside caregivers in the NICU need to focus on supporting breastfeeding and physiologic stability, and on providing an environment that helps the infant not only eat appropriate volumes, but also to enjoy the feeding experience (Sables-Baus et al., 2013). Research suggests that infants are more physiologically stable when they breastfeed than when they bottle feed (Dowling, 1999; Segami, Mizuno, Taki, & Itabashi, 2013). Infants breathe more frequently during sucking bursts, and have fewer episodes of oxygen desaturations when they breast feed compared to when these same infants bottle feed (Dowling, 1999; Goldfield, Richardson, Lee, & Margetts, 2006). However, in a cohort from the United States, only 52% of infants were ever breastfed during the initial hospitalization (Pineda, 2011). Therefore, it is reasonable to assume that most infants in the NICU will be offered at least one bottle feeding, and many are discharged home with either a combination of breast and bottle feedings, or solely bottle feeding.

Infant feeding and dysphagia are both complex topics, requiring the SLP to have a high level of experience and expertise. Infants may be expected to eat when, either developmentally or because of medical instability, they lack the ability to coordinate sucking, swallowing, and breathing. Therapists often consider diet modifications (e.g., thickeners) when attempting to improve swallowing function. However, there are many other interventions that can improve the coordination of a suck/swallow/breathe sequence and support safe swallowing that do not include dietary modifications. This article focuses only on flow rate as one intervention to support suck/swallow and breathe coordination. Feeding is a neurobehavioral skill that relies heavily on maturation, and therefore bottle and nipple selection should not be a substitute for a thoughtful caregiver who understands infant behaviors, and who is competent at determining whether an infant is both stable and mature enough for oral feeding (Browne & Ross, 2011; Ross & Philbin, 2011; Shaker, 2013). The reader is reminded that quality feedings emphasize recognizing and responding to the ongoing communication of the infant, and on providing interventions if needed that focus on stability in the physiologic, motor, and behavioral state systems while facilitating appropriate volume (Browne & Ross, 2011; Shaker, 2013). Infant-driven feeding guidelines are replacing volume-driven feedings as the standard (Alberta Health Services, 2004; Sables-Baus et al., 2013; Shaker, 2010).

This article will delve into the role of the bottle and synthetic nipple selection as one way to support infant stability while eating. For ease of discussion, the term "nipple" will refer to synthetic bottle nipples. This review will not address factors such as developmentally appropriate expectations, positioning considerations, or other interventions often implemented in the NICU. Bottle design and flow rates have been shown to influence sucking parameters and physiological stability (Chang, Lin, Lin, & Lin, 2007; Eishima, 1991; Goldfield et al., 2006; Lau & Schanler, 2000; Mathew, 1990; Mathew, 1988, 1991; Segami et al., 2013). Healthy, term infants are often competent at adjusting their sucking patterns to maintain their physiologic stability and eat safely when flow rates are altered (Eishima, 1991). Preterm and/or medically complex infants are not as competent, and need bottle flow rate to be matched carefully to their emerging capabilities.

The bedside caregiver generally determines what flow rate is best for each individual infant—which is not a simple task. Recently, there was a published study that attempted to shed light on the flow rates of twenty-five single-use nipples and commercially available nipples and bottle systems (Jackman, 2013). The author used a breast pump with a standard suction rate for one minute, and measured flow rate three times for each system tested. Results indicated a wide variation of flow rates—within flow rate distinctions (slow, fast) and within trials using the same nipple/bottle system (tests 1, 2, and 3.) Additionally, when single-use nipples of the same brand were tested, there was variability in flow rates. The author concluded that the results could be used by the caregiver to determine the best bottles for the infant—both within the hospital setting and for discharge to home, despite presenting data indicating a wide variability in results (Jackman, 2013).

One reason that there was so much variability in the results of this study could be that there are multiple equipment factors that contribute to flow rate—not just the size of the nipple hole. When breast pumps are used to determine flow rate, they primarily use suction to assess only one factor known to influence flow rate: the size of the nipple hole. There are several infant factors (e.g., the strength of their suck), as well as a number of additional nipple and bottle factors that must also be considered. The following information describes the influence of both infant and bottle/nipple characteristics on flow rate, in an attempt to expand the understanding of which bottle system and/or nipple might be best for an individual infant.

Infant Factors

Caregivers must have a clear understanding of the developmental nature of feeding skill acquisition, and the influence of both compression and suction on flow rate. Both positive pressure (compression) and negative pressure (suction) are used when a healthy infant sucks fluid from a bottle (Medoff-Cooper, 2005). In development, the compression component of sucking develops prior to the acquisition and integration of suction (Lau, Alagugurusamy, et al., 2000). Volume transfer increases significantly with the acquisition and integration of suction (Lau, Alagugurusamy, et al., 2000; Medoff Cooper, Bilker, & Kaplan, 2001; Mizuno & Ueda, 2003). Therefore, when determining the best flow rate for an infant, one must consider the infant's ability to engage both compression and suction. A second infant factor that needs to be considered is the ability of the infant to alter their use of suction in response to flow rates. This was initially shown in a study in 1991 (Eishima, 1991), and has since been further validated in the preterm population by Chang and colleagues (2007). Neither compression nor an infant's ability to adjust their sucking to engage or disengage suction are considered when a breast pump is used to determine flow rates from bottle systems and/or nipples.

Given the relationship between flow rate and infant characteristics, the caregiver must first determine whether the infant has developed suction. Infants who do not have suction (e.g., infants with craniofacial disorders or some infants with neurologic disorders) need specialized bottle systems that maximize volume transfer with compression alone (Craig, Grealy, & Lee, 2000; Mizuno et al., 2006; Mizuno & Ueda, 2005). The Medela Special Needs Feeder, the Pidgeon Cleft Palate system, and the Mead Johnson Cleft Palate Nurser are examples of these specialized systems.

If an infant has the ability to use suction, bottle systems need to maximize volume transfer while at the same time supporting good suck/swallow and breathe coordination. Infants who have developed suction will purposefully disengage suction if the flow rate is too fast; the result is a decrease in volume transfer (Eishima, 1991). With good suction, the tongue amplitude during sucking is higher, the lateral edges of the tongue wrap around the nipple, and the buccal pads stabilize the nipple and help to seal off the oral cavity. In the study by Eishima (1991), infants who demonstrated good suction with a pacifier and a small-sized nipple hole changed the position and the movement patterns of their tongue when offered a nipple with a large hole and faster flow rate. With the faster flow, these infants disengaged suction, the tongue flattened, and the cheeks loosened, allowing the fluid to flow anteriorly past the lip border. In a study by Chang et al. (2007) infants took more fluid (57.5+/-8.3 ml vs. 51.6+/-9.5 ml, p=.011), had a shorter feeding time per meal (11.5+/-4.9 min vs. 20.9+/-5.0 min, p<.001), and sucked more efficiently (5.8+/-2.5 ml/min vs. 2.7+/-1.0 ml/min, p<.001) when given a nipple that supported their use of suction, compared to when they ate with a fast flow nipple. Without an understanding of whether the infant has integrated suction, caregivers may erroneously speed the flow rate when an infant is inefficient, rather than slowing the flow to encourage the infant to use suction. Across the 32 to 36 weeks gestation ages, infants increase by a factor of five the use of negative sucking pressure, with a resulting increase of tenfold in the amount of volume transferred (Mizuno & Ueda, 2003). Caregivers must begin their assessment of which bottle to offer based upon the infant; otherwise, the infant may change their oral motor patterns and negate any desired volume goal.

Equipment Factors

There are multiple bottle engineering factors that contribute to flow rates, and that combine with the infant factors to individualize each feeding opportunity. No single factor determines the flow rate. In general, equipment factors include (a) hole size; (b) pliability of the nipple; (c) shape of the nipple; (d) position of the fluid relative to the nipple hole, and (e) air exchange within the bottle.

Hole Size

The size of the hole has been tested as a factor in infant feeding, and is often described as "flow rate" (Jackman, 2013). Larger hole sizes do provide larger volumes when all other factors are held constant; however, bottle systems with similar sized nipple holes may have very different flow rates due to both the infant factors previously described, and the factors such as pliability and vacuum exchange, described below.

Pliability (Material)

Pliability of the nipple is not assessed when a breast pump is used to determine flow rate; breast pumps assess flow rate via suction. Since infants use both suction and compression, the pliability of the nipple is a factor that must be considered when assessing flow rate. Softer nipples are easier to compress (using jaw and tongue movements), maximizing the influence of positive pressure. Firmer nipples, by contrast, are less pliable and therefore require more pressure to compress. Commercially available nipples are often made of silicone —which is more durable and often firmer than the latex-free plastic that is used for most single-use nipples. Therefore, depending on the combined influence of both compression and pliability, the same nipple/system will have different flow rates for different infants.

Shape and Size

Nipples come in various shapes—orthodontic nipples and the more traditional shaped nipple. Nipples may also have different "lengths"; shorter ones allow the nipple to sit further forward in the oral cavity, whereas longer ones position the nipple further posterior. The majority of force used for compression originates from the back half of the tongue (Eishima, 1991). Additionally, nipples have varying diameters near the nipple collar. Suction is a negative pressure, which is created when the entire nipple is encased by the tongue, palates, and cheeks of the infant (Eishima, 1991). The width of the nipple near the collar alters the angle of the chin during feeding, and may also change the pressures used (Segami et al., 2013). Therefore, the shape of the nipple influences how the oral structures engage. The wider collar on the nipple may engage the masseter muscles more, similar to what is seen during breastfeeding (Gomes, Da Costa Gois, Oliveira, Thomson, & Cardoso, 2013; Segami et al., 2013). Since the width and diameter of the nipple collar are influencing factors in how infants suck, they likely also influence flow rate.

Hydrostatic Pressure in the Bottle

Hydrostatic pressure is a force seen within typical bottles, and studies by Lau and colleagues have shown that it can be eliminated when the fluid of the bottle is kept at the level of the infant's mouth during feedings (Lau & Schanler, 2000; Lau, Sheena, Shulman, & Schanler, 1997). Hydrostatic pressure "pushes" fluid out of the bottle when the fluid is elevated above the nipple. This is the reason fluid drips out of the nipple when the bottle is tipped upside-down, and does not drip when the bottle is laid on its side. By eliminating this pressure, infants have more control over the flow rate, as fluid does not come from the nipple unless the infant is actively sucking. Infants eating from a "self-paced" bottle system (e.g., once that does not flow unless the infant is actively sucking) are more coordinated; this factor has been studied in some detail by Lau and colleagues (Lau & Schanler, 2000; Lau et al., 1997).

Air Exchange

An often lost factor in clinical bedside assessment is the influence of air exchange. There is a gradual build-up of negative pressure (vacuum) within bottles that must be relieved to avoid a decrease in flow rate. This factor was also described in the studies by Lau and colleagues (Lau & Schanler, 2000; Lau et al., 1997). This is perhaps the biggest uncontrolled factor at the bedside. Many bottle systems exchange air around the collar of the bottle—between the collar and nipple itself. However, many commercially available bottles now use complicated systems to influence this negative pressure build-up. Some use internal venting systems; others have one-way venting systems or fairly large vents within the nipple itself. This factor does not influence bottles that use collapsible "bag" inserts (e.g., Kiindie, Playtex Drop-Ins), as there is no vacuum build-up with these collapsible systems. Rather, the suction draws the bag inward. For all of the other systems, the more air exchange that occurs, the faster the flow rate from the bottle. There are some bottle systems (e.g., the Controlled Flow Baby Feeder by Bionix Medical Technologies) that alter the flow rate through an increase or decrease in air exchange.

Since air exchange typically happens around the nipple collar, tightening the collar will decrease air exchange and, as a consequence, decrease flow rate; loosening the collar will increase flow. This may account for some of the variability seen in the Jackman study (2013), when the single-use nipples demonstrated variable flow rates even when the same nipple and/or three nipples from the same manufacturer were used. In research studies focused on sucking development, air exchange is carefully controlled.

Conclusion

Since there are always new bottles being created, understanding the basics of bottles and/or nipples is important to support emerging skills in the infant, and to assist caregivers in choosing a bottle for home use. However, comprehensive clinical research addressing how the bedside caregiver can both assess and provide appropriate bottle/nipples to support quality feedings is scarce. While the Jackman study adds to the information available to the bedside clinician, there are a number of additional factors that need to be considered. Clearly, more research is necessary to guide evidence-based practice for clinical use. Many of the references cited herein provide research-based information that can be used by the clinician to understand the complex interaction between both bottle/nipple factors and infant factors. However, the information is focused on assessment of oral feeding, rather than on assisting the caregiver in choosing specific flow rates to support infants in a clinical setting. A recent comprehensive review of available instrumental assessments for infant sucking development is also focused on evaluation, not treatment (Tamilia, Taffoni, et al., 2014). Researchers are also designing sophisticated equipment to measure nutritive sucking abilities in the infant (Cavaiola et al., 2014; Tamilia, Delafield, Fiore, & Taffoni, 2014). Using the available evidence, this review has focused attention on the need for this research. Additionally, this review has attempted to provide guidance for the bedside caregiver, focused on individualizing choices of bottle/nipples to meet the needs of the infant. While the therapist may be limited in their choices of synthetic nipples in the hospital, both hydrostatic pressure and vacuum effects may be manipulated to slow, or speed, the flow. Positioning the infant so that the bottle is horizontal to the mouth of the infant will mitigate the influence of hydrostatic pressure. Tightening the nipple will slow the flow; loosening will increase the flow rate. When options are available, therapists may pick a nipple that is more firm or that has a small hole to slow the flow.

Caregivers must understand how to pick bottles/nipples based upon both infant and bottle factors—as many infants in the NICU setting lack the ability to easily adjust their sucking patterns to slow the flow and may be at risk for aspiration with larger bolus amounts. Every evaluation needs to begin with understanding the capabilities of the infant, and adjustments to the equipment should be based upon the behaviors of the infant. Additionally, feedings should focus on skill development and enjoyment, which naturally lead to improved volume intake. Focusing solely on increasing the volume taken during a feeding without also focusing on skill and enjoyment may lead to infants learning that eating is uncomfortable—which may be one reason why feedings often continue to be challenging after discharge.

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