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Positioning the Neonate for Best Outcomes

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Positioning the Neonate for Best Outcomes

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Background

During the third trimester, the uterus provides the ideal environment for the developing fetus. The physical environment offers the perfect boundary for bone growth and the proper development of muscles, joints, and tissue. The uterus also provides the physical environment to support a position of physiologic flexion (PF), encouraging not only neuromuscular development, but also self-regulation. When an infant is born prematurely, abnormal development of the musculoskeletal system can occur, resulting in long-term effects on the functionality and integrity of muscles, motor development, and mobility. In these cases, the shape and alignment of the infant's musculoskeletal system instead is established by each position the infant experiences under our care in the neonatal intensive care unit (NICU; Sweeney & Gutierrez, 2002). As neonatal clinicians, we play a pivotal role in laying the foundation for and supporting positioning practices that will promote the integrity, control, and organization of the musculoskeletal, posture, and sensorimotor systems. We also have the responsibility to educate parents on the importance of these practices for improved outcomes.

Physiology/Pathophysiology

The initial building of the neural architecture of each sensory system occurs in the last 15 to 18 weeks of fetal life through the first 3 to 5 months of neonatal life (Graven & Brown, 2008). The third trimester supports the development of the motor system. Premature infants are deprived of uterine crowding during this time. This trimester also encourages the development of PF, a position characterized by shoulder flexion, scapular protraction, hip and knee flexion, and posterior pelvic tilt, ultimately encouraging midline orientation (Waitzman, 2007). These influences on development can impact early and future skill acquisition, such as feeding (Grenier, Bigsby, Vergara, & Lester, 2003), and if absent, later can interfere with the infant's ability to interact with and attach to caregivers (Madlinger-Lewis et al., 2014).

It is necessary to understand how prenatal experience shapes future development and to consider the different and changing experiences the infant has in the NICU. The infant has experienced a consistent pattern of sensory experiences prior to birth. When the fetus moves in the uterus, that movement generates a proprioceptive feedback loop as well as organized tactile input from changes in the pressure on the skin. During a 9-month pregnancy, the fetus has the opportunity to develop history and familiarity with the redundancy of this movement and stimulation (Lickliter, 2011; Robertson & Bacher, 1995).

The in-utero environment provides the perfect foundation for the musculoskeletal system. Fetal and neonatal movements and the development of posture contribute to the shaping of joints, skull, and spinal curvatures that lead to coordinated motor development and function. Although the major development of muscle tissue occurs prior to birth, differentiation of muscle fibers is not complete until term (Sweeney & Gutierrez, 2002). The importance of stimulation from in-utero movement also is vital for bone development. Bone formation begins in the eighth week of gestation and continues until 20 to 30 years of age. The fetus is consistently experiencing stimulation of bone formation and growth through constant foot bracing and stretching of extremities while in the uterus. Bone density decreases with inactivity; therefore, during prolonged hospital stays without physical and chemical stimulation, the infant is at greater risk for bone demineralization (Litmanovitz et al., 2003; Sweeney & Gutierrez, 2002).

Once musculoskeletal maturation occurs in the ideal environment and under ideal physiologic conditions, functional maturation, which involves posture, tone, and movement, can occur. Movement evolves during a term pregnancy within a well-contained, gravity-free world. As the infant grows, space decreases and the infant's body becomes increasingly flexed. Each time there is extension of the extremities, resistance is met that leads to recoil and a return to physiologic flexion, which is vital for normal development of body control and movement. This is the principle of activity-dependent development**.** Each time the infant extends and reaches, he or she is brought back to flexion, midline, and a contained position, which supports a calm and self-regulated infant. Neural connections are activated and strengthened and become the dominant pattern. Movement within the uterus is never static. There is a constant free-flow activity pattern with consistent recoil to midline. As the infant grows, musculoskeletal maturation progresses; caudal cephalic with flexion starts in the lower extremities at around 29 weeks and progresses to the upper extremities by 36 weeks. By the end of a term pregnancy, the infant is equipped with muscle tone and power, posture, and movement patterns that can respond to a dynamic extra-uterine world.

The environment of the NICU exposes infants to multiple stressors that can play a role in altering the infant's course and outcomes of normal brain and motor system development. The neonate is influenced by external experiences and stimulation of the physical environment. The physical environment involves space and

the characteristics of that space, which affects position, movement, motor development, and ultimately the ability to move (Graven & Brown, 2008).

When an infant is born prematurely, muscle tone, posture, and movement progression must adapt to gravity before the musculoskeletal system is ready to deal with these forces. The premature infant has to complete the natural process in the extra-uterine world. Without the support of the contained uterine environment, the underdeveloped infant's resting posture becomes flat, extended, and asymmetrical, with the head to one side and the extremities abducted and externally rotated (Sweeney & Gutierrez, 2002; Hunter, 2010). When newborns are positioned in different postures and positions, they experience different forces of pressure on joints and muscles that can positively influence the development of mechanoreceptors (sensory receptors that respond to mechanical pressure or changes) in preparation for coordinated movement. However, acutely ill (extremely low birth weight, extracorporeal membrane oxygenation, high frequency oscillatory ventilation, surgical) infants that are positioned in restrictive positions and subjected to prolonged resting or flat postures experience constant joint compression with minimal mechanoreceptor change. This can contribute to skeletal deformation, muscle shortening, and restricted mobility of joints (Gerard, Harris, & Thach, 2002; Hunter, 2010; Sweeney & Gutierrez, 2002; Toso, 2015). Studies show that there are substantial abnormalities in infants who were in a single position for a period of time. Muscular shortening developed early, with abnormal movement and disorganization and abnormalities of sensory motor skills. Infants also showed muscle extension of the posterior axis of the body that could affect eventual milestones such as rolling over and sitting up with support of their arms (Vaivre-Douret & Golse, 2007).

Benefits of Proper Positioning

Infant position can play a key role in the function of the pulmonary, digestive, and autonomic systems of the neonatal infant.

Respiratory Status

Prone position has been shown to increase PaO2 and tidal volume and improve chest-abdominal synchrony (Gouna et al., 2013). Findings include more central apneas, yet fewer obstructive apneas. The incidence of central apnea while prone reinforces the importance of modeling safe sleep practices prior to discharge (Bhat et al., 2006; Visscher et al., 2015). Another study (Gouna et al., 2013) compared breathing patterns in prone, supine, and lateral positions and found infants in prone and left-lateral positions had higher oxygen saturations, arterial oxygenation, and chest-abdominal wall synchrony, and concluded that prone positioning in oxygen-dependent infants could play a role in optimizing their respiratory status. A *Cochrane* review (2012) did not find statistical significance in long-term clinical benefits between positions but found improved oxygenation in the prone position. Aly et al. (2015) looked at the effect positioning had on the incidence of tracheal aspiration in ventilated infants. Infants in the right lateral versus supine position had a decrease in pepsin as a marker of gastric aspiration in tracheal aspirates.

Reflux

Left lateral positioning has been found to decrease gastroesophageal reflux (GER) episodes during the first half of the postprandial period. Prone positioning is more effective in reducing GER exposure in the late postprandial period. Right lateral position is generally beneficial in decreasing gastric aspirates, although left lateral position is more highly preferred. Positioning can be a good non-pharmacologic strategy to manage both acid and nonacid GER episodes in preterm infants (Corvaglia et al., 2013).

Pain/Stress and Self-Regulation

Swaddling or facilitative tucking (FT)—when an infant's arms and legs are flexed midline and close to their trunk—during painful procedures has been shown to be effective in the relief of acute neonatal pain and has been beneficial during some procedures (Krishnan, 2013). The relationship between self-regulatory and stress behaviors and infant position has been studied (Grenier et al., 2003). The side-lying uncontained position revealed the highest number of self-regulatory behaviors, with the fewest occurring in the prone and contained position. The highest number of stress behaviors was seen in the side-lying uncontained position. The lowest number was seen when the infant was prone and contained. In some positions, the infant may be at greater risk of experiencing stress, yet unable to perform self-regulatory motor behaviors because of muscle weakness and the effects of gravity. Self-regulatory motor behaviors in a particular position also may reveal the infant's attempt to cope with increasing stress (Grenier et al., 2003).

Sleep

Sleep is a process critical to neurosensory development. An environment that protects sleep and its cycles is essential for development of long-term brain synapses (Graven, 2006). The surrounding environment makes a difference not only in promoting sleep, but also in infant positioning. Gerard et al. (2002) showed that infants were noted to sleep longer and with greater efficiency when in prone position and had more arousals when supine. Although prone positioning is beneficial, it is vital that the infant is placed prone only during their NICU stay and while on cardio-respiratory monitoring. It is our responsibility to transition the infant Back to Sleep and to role-model safe sleep behaviors prior to the infant being discharged (AAP Technical Report on SIDS, 2011).

Musculoskeletal Malformation and Functional Limitations

The main objectives in infant positioning are to

- provide support and posture for movement
- optimize skeletal development and biomechanical alignment
- provide controlled exposure to varied proprioceptive, tactile, and visual stimuli
- promote calmness and aid in regulating the behavioral state (Toso, 2015).

Head/Skull/Neck

Improper Position

Hyperextended neck

Premature infants are susceptible to developing two deformities of their head/skull as a result of consistent pressure on those malleable areas. Scaphocephaly is the narrowing or elongation of the anterior and posterior axis from consistent side-to-side positioning. Brain metrics including bifrontal and biparietal diameters have been shown to be highly correlated with brain tissue volume (Smith et al., 2011). The second deformity is plagiocephaly, an asymmetric flattening of the occiput with a tendency toward increase in torticollis. This has been the more recent morbidity since Back to Sleep practices were introduced (Sweeney & Gutierrez, 2002). Recent data show that head turn preference in the preterm infant is not associated with medical factors in the NICU but was associated with early neurobehavioral and asymmetric movement patterns. It also was a marker for adverse developmental outcomes at age 2 years (Dunsirn, Smyser, Liao, Inder, & Pineda, 2015).

NICUs recently have focused on head positioning as a neuroprotective strategy. Evidence-based literature reviews have shown that intraventricular hemorrhage can be caused by shifts in cerebral perfusion when normal care practices occur. This is attributed to possible venule leakage of blood from occlusion of the jugular vein when the head is turned in the side-to-side position rather than midline. Many units have adopted a "head midline," maintaining the infant in supine or side-lying positions for 72 hours (Malusky & Donze, 2011).

Extremity Malalignment

Extremity malalignment related to positional hypotonia is common in preterm infants unless there is priority placed on proper positioning during the neonatal period. The primary sites of extremity malalignment include the shoulders, hips, and feet. Scapular adduction with shoulder elevation and external rotation (shoulder retraction) can occur from a postural pattern ("W" arm position) when the infant is in supine extension (Sweeney & Gutierrez, 2002).

A hip position with excessive abduction and external rotation ("M" leg position) is associated with ilio-tibal band shortening and with ankle eversion (Sweeney & Gutierrez, 2002; Hunter, 2010).

Morbidity

Hyperextended neck

- Failure to regularly reposition head
- Preferential head turn to right
- Right lateral gaze
- Plagiocephaly (flattened occiput) and dolichocephaly

- Scaphocephaly

- Torticollis
- Hyperextended neck and retracted shoulders
- Lateral trunk curvature

Functional Limitation

- Difficulty with head centering and midline arm movement in supine position
- Limited head control in prone position and sitting
- Limited downward gaze (visual tracking)
- Right hand preference
- Delayed, decreased, or limited fine motor skills
- Delayed, decreased, or limited hand-eye coordination

Another possible adverse effect is an increased risk of developing hip dysplasia as a result of swaddling the hips in extension and adduction. Epidemiologic studies have shown that the incidence of this is highly correlated with the traditional use of swaddling for newborn infants (van Sleuwen et al., 2007). Traditional swaddling with the lower extremities fully extended and wrapped together can cause hip subluxation. A systematic review of swaddling noted that developmental hip dysplasia is more prevalent when the lower limbs are bound and not free to move. The concept of safe swaddling does not restrain hip motion, but rather allows the hips to remain in the naturally flexed and abducted position. Other contributors to external rotation may be oversized or backward-positioned

Improper Position		
Extended body with externally rotated hips and ankle eversion		
		
• Improper diapering (too large or placed backward) leading to hip abduction	• Externally rotated ankle eversion	• Extended body

Morbidity	Functional Limitation
• Shoulder external rotation and retraction • Muscle tightening of the neck extensors • Scapular retraction • Increased neck tone and arching • Hip abduction • External rotation • Knee flexion • External tibial torsion • Ankle eversion	• Decreased ability for hand-to-mouth activity • Inability to prop in prone position needed for head control, rolling over, and crawling • Delayed transitioning in and out of prone position and sitting • Hip stability for four-point crawl • Wide base gait and excessive out-toeing • Difficulty rolling over • Pronation in standing—immature flat foot pattern with delayed heel-to-toe pattern • Delayed walking

Improper Position	Morbidity	Functional Limitation
Tight swaddle		
	• Lack of ability to discover and push against boundaries • Lack of ability to move hands to mouth • Lack of bone and muscle development	• Decreased ability for hand-to-mouth activity • Poor range of motion • Contractures • Decreased ability to self quiet

diapers. The infant's hips should be positioned in slight flexion and abduction during swaddling or diapering. The infant's knees also should be maintained in slight flexion (Schwend, Shaw, & Segal, 2014).

Goal of Supportive Positioning and Positioning Practices

It can be challenging for neonatal caregivers to support the neonate's low postural tone when medical equipment and interventions are necessary for care. Positioning for these infants can reinforce positions of extension of the neck, trunk, and extremities. The goals of safe infant positioning are to

- support proper posture and movement
- optimize skeletal development and biomechanical alignment
- provide controlled exposure to varied proprioceptive, tactile, and visual stimuli
- support physiologic stability and a calm and regulated behavioral state
- support optimal neuro-motor development (Sweeney & Gutierrez, 2002; Vaivre-Douret, Ennouri, Jrad, Garrec, & Papiernik, 2004; Chizawsky & Scott-Findlay, 2005).

Caregiver practice for positioning principles and positioning supports should facilitate the following:

- flexed, midline, and contained position
- head and neck in midline and neutral
- shoulders rounded to promote hands toward midline
- trunk in "C" curve
- pelvis in posterior tilt (rounded lower back)
- symmetrical hip and legs in flexion and neutral rotation
- foot support for bracing (Sweeney & Gutierrez, 2002; Hunter, 2010).

Neonatal positioning guidelines and practices should support optimal positioning and infant sleep while performing essential caregiving activities. When developing guidelines for positioning practices, the following elements are recommended:

- standardized appropriate positioning strategies with use of alternative positioning supports. Infants positioned with alternative supports rather than traditional positioning methods (blanket rolls) have less asymmetry at hospital discharge (Madlinger-Lewis et al., 2014).
- infant positioned and handled in flexion, containment and alignment during all caregiving activities
- infant position is assessed with every experience and modified to support symmetric development
- positioning supports are utilized and transitioned until removed in preparation for Back to Sleep
- tummy-to-play practices are integrated into care as the infant demonstrates physiologic flexion of the upper body in supine
- promote outcomes that reduce motor changes after hospital discharge (Coughlin, Gibbins, & Hoath, 2009; Toso, 2015; Lacina et al., 2015).

Transitioning to Safe Sleep

Back to Sleep practice is vital for safe care and is a practice that should be taught to all parents of newborn and preterm infants prior to discharge. The 2011 American Academy of Pediatrics Safe Sleep policy statement states: "Preterm infants are at increased risk of SIDS, and the association between prone sleep position and SIDS among low birth weight infants is equal to, or perhaps even stronger than, the association among those born at term. Preterm infants and other infants in the NICU should be placed in the supine position for sleep as soon as the infant is medically stable and significantly before the infant's anticipated discharge, by 32 weeks' postmenstrual age…." The resource for this recommendation (Committee on Fetus and Newborn, 2008) states that "hospitalized preterm infants should be kept predominantly in the supine position, at least from the postmenstrual age of 32 weeks onward, so that they become acclimated to supine sleeping before discharge." Because of this recommendation, units have established guidelines that wean infants from developmental supports at 32 weeks post conceptual age or when placed in an open crib.

It would be easy if we could say all premature infants are alike. We know that is not true. Rather, our approach should be to ask questions that address each infant's physiologic and neurodevelopmental needs as we develop weaning guidelines from developmental supports, such as

- Does a baby born at 23 to 25 weeks gestation have the same needs at 32 weeks that a 30- to 31-week infant has at 32 weeks?
- Do high-risk infants get the sleep needed for infant growth when developmental supports are removed and the infant is consistently placed supine?
- Should our goal be to look at each infant's maturational needs rather than at the definitive gestational age and wean supports accordingly?
- Can an interdisciplinary plan be created to remove supports based on an infant's individual needs and the goal of Back to Sleep 1 to 2 weeks prior to discharge?

Parent and Family Integration and Partnership

Becoming a parent is an emotional experience and one of great anticipation in normal circumstances. However, most parents are not ready for the premature birth of their infant. Providing education and information to parents about their infant's condition is vital in relieving anxiety in the foreign world of the NICU. As healthcare professionals, we have a responsibility to educate, support, and encourage parental bonding and attachment through everyday experiences. Potential steps toward this goal are to

- empower parents to assume the role of parent and advocate (Melnyk et al. 2006)
- provide neurodevelopment education and support focusing on the following:
- comfort and security through consistency of presence
- providing positive and nurturing experiences
- providing touch, positioning, and handling that is supportive, such as skin-to-skin care
- partnering with staff to decrease infant's stress and pain
- recognizing the importance of sleep to growth and brain development (Craig et al., 2015)
- help parents identify infant stress and engagement cues. Parents trained in recognizing stress cues and providing care that decreases those behaviors had more sensitivity to their infants and responded appropriately to their cues (Milgrom et al., 2013; Craig et al., 2015).
- help parents identify calming positions and measures for care practices, such as FT (Cignacco et al., 2010)
- encourage skin-to-skin care and supportive touch and positioning when holding and feeding

- educate parents on safe sleep practices.

Proper developmental positioning does not end at discharge. As healthcare providers, we have a pivotal role in educating and encouraging parents to continue shaping their infant's musculoskeletal system during the first year of life, when maximum plasticity occurs. Elements of teaching and role modeling include

- preventing plagiocephaly by changing the direction of the infant's head in the crib
- placing head and trunk rolls in car seats and swings to maintain the head in midline
- emphasizing the importance of tummy time to strengthen the neck, arms, and trunk for the milestones of rolling, sitting, and standing
- discussing the importance of developmental follow-up programs and incorporating their recommendations
- encouraging parents to report signs of head flattening, lateral head tilt, strong head turn preference, or asymmetrical arm use (Craig et al., 2015).

Implications/Summary

An important goal of individualized supportive care is to support self-regulatory abilities (i.e., active efforts on the part of the infant to regulate autonomic functions, motor control, states of arousal, and availability for interactions with others, within the context of a dynamic environment; Als, 1982). One strategy is promoting positioning that promotes flexion, hand-to-mouth, and grasping and tucking motions to enhance self-regulation by encouraging stability of the motor system (Lawhon & Melzar, 1988; Lotas & Walden, 1996; Yecco, 1993).

Neonatal nurses manage a variety of aspects of care in the NICU that assist in physiologic stability, neuroprotection, and infant sleep. Neonatal therapists utilize proper positioning to promote self-regulation that helps provide support to the infant's motor system. Therapists also are concerned with positions that will ensure appropriate joint alignment and maximize the infant's performance and encourage developmental skills (Grenier et al., 2003). Although the focus of care is different across these two disciplines, the strengths of each can build a supportive foundation for a mature and functional musculoskeletal system (Zarem et al., 2013).

One of the most powerful things neonatal caregivers can do is simply listen and observe the language of infants' movement and cues. When we protect infants from experiences we know are adverse to their neurodevelopment, we provide neuroprotective care with our touch, positioning, and environmental protection. When we know and understand that every touch, position, and care we provide can change the outcome of an infant, we begin to care differently.

Future Research

- Interdisciplinary healthcare professional perceptions of importance of positioning to outcomes
- Positioning tools
- Standardized positioning practices and strategies

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