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## Strengthening the Safety Circuit: Applying Polyvagal Theory in the Newborn Intensive Care Unit

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**Abstract:** Despite the technological success of modern newborn intensive care, chronic disruptions of social connectedness due to separation can be traumatic for both babies and families. Understanding and applying principles of Polyvagal Theory can benefit babies, families, and staff by fostering ventral vagal social engagement. In addition, polyvagal-trained staff can use their own ventral vagal energies to co-regulate each other and stressed families who are sympathetically activated or in dorsal vagal collapse.

*The hospital is the most emo place I know . . . and the  
NICU is the most emo place in the hospital.*

—Research nurse and parent of a former premature newborn

### Introduction to Neonatology

IN THE UNITED STATES, there are approximately 4 million births annually. Of these, about 500,000 newborns (12%; U.S. Department of Health and Human Services, 2013) require care beyond that provided in a well-baby nursery and

may spend time in a newborn intensive care unit. The “lucky” babies have their medical needs met in the same hospital as their mothers. Many babies, however, need transport by a specialized team to a newborn intensive care unit across town, in a neighboring town, across the state, or even across state lines.

Neonatology is a new pediatric specialty and a modern technological success. In 1963, President Kennedy’s baby son, Patrick Bouvier Kennedy, born at 34 weeks, weighing 4 pounds, 10.5 ounces, died at 39 hours of age (Altman, 2013). Today, virtually all (98–99%) babies of similar size and age survive (Matthews & MacDorman, 2013).

The babies’ medical problems and severity of illness vary. Some may require only a few hours of observation. Others may need a day or two and be moved to the mother’s room before being discharged home. Still more will stay in the hospital after the mother is discharged from the hospital. More than 250,000 newborns will be hospitalized for more than a week (U.S. Department of Health and Human Services, 2013).

Many newborns needing lengthy hospitalizations are premature or have lung problems. Others have congenital or genetic problems. Still others need surgeries. A very small number of newborns experience catastrophic events during labor and delivery, prolonging their hospital stay.

Despite the successes of modern newborn intensive care, a price is paid by these babies and their families—the loss of their biologically driven connectiveness, for a few hours, days, weeks, or months. Families draw upon adaptive capacities they could not have previously imagined as they struggle to identify and meet their babies’ needs amid the beeps, alarms, and disruptions of modern newborn intensive care.

### The Expectancies of the Newborn and Young Infant

The expectancy of social engagement in mammalian species is biologically embedded. For the human newborn, this engagement typically begins when she is placed upon her mother’s chest and finds the way to mother’s breast. There she latches, sucks, and transfers breast milk as the mother’s central nervous system releases oxytocin, bringing the mother into loving synchronicity with her baby. Together they reciprocally upregulate ventral vagal tone in each other’s presence. Oxytocin’s role in ensuring survival is clear, as it clamps down the uterus, preventing the mother from hemorrhaging, lets down milk to nurture the newborn, and enhances maternal prosocial and loving behaviors (Lee, Macbeth, Pagani, & Young, 2009).

Over the next hours, days, and weeks, mother and her newborn engage in an increasingly well-choreographed dance as they make meaning of their rela-

tionship and world. (Tronick, 2010). As their relationship becomes consistent, predictable, and safe, they become securely attached to each other and critical co-regulators of the integrity of each other's autonomic nervous system.

Polyvagal Theory describes the hierarchical response of the sympathetic and parasympathetic components of the autonomic nervous system through an unconscious sense of "awareness" or neuroception, active when the newborn senses "safety," "danger," or "life-threat" (Porges, 2011). When the baby senses safety, the most highly evolved ventral vagus is active. Both mother and her baby are in synchrony and engaged with facial expressions, vocalizations, and touch that blunt the hypothalamic pituitary axis and inhibit sympathetic activity. The result is a mother–baby dyad that works well, bringing pleasure, security, and nurturance to both members.

However satisfying this pleasurable state, there are frequent interruptions in the synchronicity of the well-functioning mother–baby pair, leading to disruptions even in the best of relationships. Video microanalysis reveals that typical mother–baby pairs are in sync for affective states only one-third of the time (Tronick & Cohn, 1989). It is the *repair* of the disruption—its timing, its sensitivity, its fit, its lack of intrusiveness—that will determine how well the dyad functions over time (Koulomzin et al., 2002).

A disruption that occurs with physical separation or maternal emotional withdrawal, intense anger, or anxiety signals to the newborn that he is at risk of losing the mother's availability, the preexisting condition of his unconscious sense of safety. The baby becomes autonomically dysregulated as he senses danger—a predator is in the midst. Now, seeking the return of a "safe" base, the newborn's sympathetic nervous system mobilizes, cortisol surges, heart rate and blood pressure increase, and the baby cries in protest of his felt sense of aloneness. If the mother, sensing the baby's distress and violation of expectancies, returns, cuddles, talks softly, and soothes the baby, the baby's distress often quickly resolves, and the mother–newborn pair return to safety, synchrony, and calm as ventral vagal tone is restored.

If, however, a timely repair does not occur, or the newborn becomes accustomed to chronic lack of the mother's availability due to long-term separation, severe mental illness, or chronic failures to respond, the newborn may, instead, sink into an immobilized, life-threat state modulated by the vestigial dorsal vagus. This newborn loses tone, appears passive and apathetic, and is shut down, using minimal energy to meet his metabolic demands.

Newborns and toddlers who have been raised in institutional settings where they have physically been cared for but lack safe relationships and secure attachments often display these responses. They have exhausted their cortisol reserves, manifesting low heart rates and blood pressures. They have

learned all too early that expending energy for safety brings a poor return on investment. Ironically, their energy conservation mode of shutdown, in the short run, is autonomically adaptive, promoting their survival, however tenuous (Koss, Hostinar, Donzella, & Gunnar, 2014).

### Polyvagal Theory and the Healthy Newborn

As ventral vagal regulation and newborn behavior mature, self-regulatory capacities come online. Porges related increasing vagal myelination and development of cortical influence upon the brain stem vagal regulating areas to postpartum adaptation of the newborn (Suess et al., 2000). Distinct from earlier, reptilian species, mammalian newborns are dependent upon caregivers for nurturance and survival. This dependency is expressed through the “ingestive-vagal reflexes” of feeding, requiring an intact brain stem and the muscles of face for mastication to ingest food. Simultaneously, the latched newborn is socially engaged through the co-regulatory capacities of maternal eye gaze, head turning, vocalization, and prosody mediated through the special visceral efferents of the vagal nerve through the face-to-heart connection. The consistent availability and predictability of the mother to co-regulate the newborn reinforces the unconscious awareness (neuroception) of safety.

Ultimately, the survival of the mammalian newborn depends upon the ventral vagal mediation of the face-to-heart connection. With evolution from reptilian to mammalian species, key components such as the detachment of the middle-ear bones from the mandible allowed both for an enlarged cranium (Rowe, 1996) and for low-amplitude/high-frequency airborne sounds such as mammalian vocalizations to be processed. At the same time, the changing spatial relationships of the vagal nuclei and the nuclei of the face, neck, and head fostered development of the social engagement system that protects, nurtures, and sustains the mammalian newborn.

### Polyvagal Theory and the Premature Newborn

The premature newborn, as opposed to the healthy newborn, is challenged by the developmental trajectory of vagal myelination beginning in the third trimester of pregnancy, specifically around 32–37 weeks (Doussard-Roosevelt, Porges, Scanlon, Alemi, & Scanlon, 1997). In the 21st-century NICU, premature newborns born as early as 22–24 weeks are hospitalized many weeks before significant vagal myelination and brain stem maturity permit them to breastfeed. For these newborns, self-regulatory capacities are more limited,

and their ability to participate as fully as term newborns in meaningful co-regulation is also affected. There are, however, key strategies that enhance maternal physical and emotional proximity, such as kangaroo or skin-to-skin care, discussed later, that improve co-regulatory capacity for the vulnerable newborn (Feldman, Rosenthal, & Eidelman, 2014).

Porges developed Polyvagal Theory after a question from a neonatologist (a pediatrician who specializes in the care of critically ill newborns). The neonatologist referenced the challenge of apparent "death spells" in premature newborns where the newborn abruptly drops her heart rate significantly and without intervention and resuscitation could die. Could there, he asked, be too much of an apparently good thing, or too much vagal tone?

As described and measured by Porges, vagal tone is reflected in the measure of respiratory sinus arrhythmia (RSA), a naturally occurring variability in the heart rate that is correlated with respiratory activity. Simply put, when we inhale, our heart rate increases, and when we exhale, heart rate decreases.

Of primary importance to the fetus and newborn is the role of RSA in determining fetal well-being, manifested by intact neuroregulation. In obstetrics, obstetricians assess and report fetal heart rate variability, the first cousin to RSA, for labor and delivery decision making. Heart rate variability, unlike RSA, is not indexed by respiratory activity. It is, however, a proxy easily measured with standard equipment. Alterations in fetal heart rate variability often prompt plans to deliver a newborn recognizing that diminished vagal tone may be an ominous sign of impending fetal deterioration.

The maturity of vagal tone influence measured by RSA increases throughout gestation and into infancy. Decreases in RSA are correlated with extreme prematurity, serious illness, and disease states (Doussard-Roosevelt et al., 1997; Suess et al., 2000). The premature newborn can experience a stressor that affects his immature vagal tone, reflected in his RSA, and can have a potentially lethal bradycardia.

Rather than the classic interpretation of an antagonistic relationship between sympathetic and parasympathetic systems, Polyvagal Theory presents an integrated and synergistic system with both parts working together in the service of survival. Chief among the adaptive mechanisms is the vagal brake, applied more or less strenuously to the intrinsic cardiac pacemaker as a self-regulatory mechanism to either decrease or increase energy expenditure. This led Porges to solve the "vagal paradox." He explained that in the absence of ventral vagal tone, reflected in diminished RSA, the neural regulation of the heart could be vulnerable to a massive dorsal vagal surge producing clinically relevant and potentially lethal bradycardia. This dorsal vagal surge

could be observed as a “death spell” in a premature newborn, shutdown in an older child, or dissociation in a trauma victim.

The preterm newborn, like the more mature newborn, communicates to us through her behaviors. Als's synactive theory of development recognized that newborns, including premature ones, have emerging developmental agendas, noting that their autonomic nervous systems, visceral responses and surrounding motor and state organizational systems are constantly interactive within and between each other. The entire system, embedded within the environment—in this case, the NICU—is a violation of the species expectation of transition from womb to mother's breast, or in polyvagal language, a disruption of the biologically embedded need for social engagement. Als focused upon the competencies of the preterm to communicate her needs through a hierarchy of behaviors and the primary caregiving role of the parents (Als, Butler, Kosta, & McAnulty, 2005).

When ventral vagal tone dominates, the newborn will be in a quiet, alert state, with regular respirations; be pink and well perfused; will have mild accelerations in her heart rate with handling; will show smooth movements of the arms and legs; and will engage in some self-soothing behaviors such as bringing hand to mouth, display an open face, and make sucking or mouthing movements. The sympathetically aroused newborn will be hyperalert or fussy, with fast respirations, significant increases in heart rate with handling, skin mottling, spitting up, hiccoughing, and extension behaviors of the extremities and hands. Finally, the premature infant whose autonomic nervous system has strong dorsal vagal influence may have significant pauses in respiration, bradycardia or a fixed heart rate, flaccid extremities, and diminished alertness.

The synactive theory highlights the opportunities to improve ventral vagal tone by facilitating dyadic connection and safety, even while the modern NICU is providing the technologic support also necessary for survival. As premature newborns mature, so should their observed behaviors be moving from dorsal vagal through sympathetic and ultimately to ventral vagal states, even if only briefly. Since full myelination of the vagus is not achieved until close to one year of age, healthy-growing premature and term newborns will develop increasing frequency and length of ventral vagal states.

### The Experience of Newborn Intensive Care for the Baby, the Family, and the Staff

Polyvagal Theory is a portal for families and caregivers to understand, both at a level of body awareness and cognition, the impact of the experience of the

newborn intensive care unit on early newborn relationships and interventions to optimize the newborn–family relationship during a stressful hospitalization.

### *The Baby's Experience of the Newborn Intensive Care Unit*

The premature or otherwise ill baby is thrust into an environment that challenges his mammalian biological imperative for connectedness. The biologically intended dyadic dance that brings mother and her newborn to connectedness is rudely interrupted for the NICU baby. The developing integrity of his autonomic nervous system is challenged by unintended violations of his evolutionary expectancies of proximity to his caregivers as well as the felt senses of safety, predictability, and reciprocity that lead to enduring connectedness.

Rather than proximity to his parents and a small number of consistent caregivers, the NICU baby receives care from a larger number of medical, nursing, respiratory, and rehabilitation providers. The baby may be cared for in an incubator that provides some buffer to harsh light and loud, unexpected sounds, but alarms go off; staff, visitors and families speak; computers on wheels are pushed around to meet the needs of the electronic health record. There is no predictability—the baby can be sleeping quietly when a code happens at the next bed or safety alarms go off and bright lights both shine and pulsate.

The timing and nature of touch is unpredictable. A baby can be resting; however, if a care time is due, and blood work needs to be done, he may be awakened by a staff member sticking his heel to draw blood. The health care provider's intention is to appropriately monitor the baby to ensure his well-being and to avoid complications of illness or even therapies. The NICU baby never knows whether the next touch will be his mother's or father's loving cuddling and stroking or the blood draw due at 2:00 p.m. In the first days of his hospitalization, he will have an average of 12 procedures daily (Carbajal et al., 2008).

### *The Family's Experience of the Newborn Intensive Care Unit*

From an evolutionary vantage, neonatal intensive care, despite its successes, violates deeply embedded biologic expectancies of parents and their baby. The challenges for parents often begin well before the crisis of newborn intensive care hospitalization. Many struggled to conceive. Others had complicated pregnancies filled with uncertainty about outcome. For some, pregnancy was uneventful until they were rushed to an emergency cesarean section.

Rather than going from perineum to mother's chest, the typical baby who

requires neonatal intensive care is whisked away into an adjoining room where medical and nursing staff evaluate, resuscitate, and stabilize the baby. Depending upon the baby's stability and the hospital environment, babies may (or may not) see their parents before going to the NICU for further care. Only infrequently does the family hold the baby prior to transfer.

Families often experience lack of privacy in ward or bay-type units. Parents are physically and sometimes emotionally distant from their newborns. They describe fear, anxiety, anger, helplessness, and powerlessness. As one mother (Leff & Walizer, 1992) said,

I want to be with her in the NICU, but it kills me to see her so sick. . . . I'm angry, sad, frightened, exhausted all at once. . . . With whom can I be angry? Myself? My innocent baby? The doctors who practiced sound medicine? (p. 122)

Parents quickly learn that their baby's well-being depends upon the meticulous and attentive care provided by hospital caregivers. They are surrounded by neonatologists, physicians in training, advanced practitioners, nurses, and other members of the health care team. Every day, the team rounds at the bedside, armed with electronic medical records, easy access to online resources, and vast stores of knowledge to discuss the plan for the day.

In the initial days, parents are often shocked and stunned by the unexpected birth, struggling with their own medical issues, pain, and anxiety, worries about other children, and fear of the next possible impending crisis. The medical team gives a lengthy recitation of all the baby's problems, system by system. They use long words, foreign to parents. They list lots of numbers; what do they mean? They look different, set apart by their blue scrubs and white jackets. The team wraps up, summarizes briefly for the parents, and asks if they have any questions. "Is he going to be okay?" asks the mother. "It's early," says the neonatologist, who smiles gently. "We'll need to wait and see, but we're all doing everything we can to help him." The team then moves to the next bedside, often leaving a puzzled, frightened parent.

Parents of NICU babies may experience post-traumatic stress both in the NICU and potentially post-discharge. In a study of NICU parents, one third of mothers (35%) and one-quarter of fathers (24%) met criteria for acute stress disorder, and 15% of mothers and 8% of fathers met criteria for post-traumatic stress disorder (PTSD; Lefkowitz, Baxt, & Evans, 2010). Concurrent stressors and a family history of anxiety or depression were correlated with likelihood of PTSD. Of interest, there was no correlation of PTSD with the medical severity of the baby's illness.

### *The Experience of the Health Care Providers in the Newborn Intensive Care Unit*

Who chooses to work in a high-acuity setting with unpredictability, where the work can transition from calm to frenetic in a moment? All can be stable, nurses and doctors examining babies, rounding, speaking to parents, and in a flash, they must mobilize for an emergency. In polyvagal terms, they must lift the vagal brake recruiting sympathetic tone to provide energy but maintaining a calm alert state to work collaboratively to resolve the crisis. They leverage their sense of connectedness to each other, operationalized through the common goal of saving a baby.

Ideally, health care providers spend the majority of their time in a ventral vagal state, allowing them both to care for babies, minimizing stress, and to be available to parents as a low-resistance sink for their sympathetic arousal.

However, the steady drum of high levels of stress and high sympathetic tone, for many health care providers, can result in post-traumatic stress and burnout. In a recent workplace survey of doctors and nurses in either a newborn or pediatric intensive care unit (NICU or PICU), one in six (17%) met criteria for post-traumatic stress disorder and two-thirds (66%) had lower but concerning post-traumatic stress scores. Workers reporting higher levels of emotional exhaustion and PTSD symptoms were less likely to evidence levels of resilience. (Dalia, Abbas, Colville, & Brierley, 2013).

### **Is the Experience of Newborn Intensive Care Traumatic, and If So, For Whom?**

Trauma services abound in U.S. hospitals. Helicopters lift off, ambulances are launched, and patients from infancy throughout the lifespan who sustain serious physical injury are airlifted and ground transported to the nearest Level 1 trauma center. The meaning is explicit. Everyone who has ever watched an episode of *ER* knows. All staff members are at attention to efficiently provide high-quality intensive care services to the incoming patient.

Who broadcasts "incoming trauma" when a baby is brought from the labor-and-delivery suite, the newborn nursery, or the mother's room to the newborn intensive care unit? Is neonatal intensive care hospitalization, per se, traumatic? In a typical rupture of maternal–newborn co-regulation (e.g., the phone rings, or the mother is otherwise distracted) the disruption is brief and readily repaired, as mother and newborn soon return to their connectedness. What if, however, the disruptions are persistent and frequent? What if there is no time for repair prior to the next disruption? What if these disruptions become chronic?

Should safety and a secure base not be attainable, should these disruptions of early relationships become chronic, the newborn nervous system has two options—a state of constant mobilization, sympathetic drive, energy expenditure (danger) or immobilization (dorsal vagal tone) with death feigning, shutdown, extreme energy conservation. Neither option is growth promoting or biologically sustainable. The human newborn requires the presence of the adult caregiver to provide both her safety-promoting physical needs (warmth, nutrition, protection from the environment) and emotional needs (social engagement, connectedness, co-regulation).

For the newborn whose life depends upon connectedness, trauma is a “chronic disruption of connectedness” (Porges, 2014). Newborn intensive care, though medically life saving, is often a chronic disruption that begins at or shortly after birth. Newborn intensive care disrupts the early reciprocal caregiving relationship of the newborn, her mother, and other primary caregivers—it disrupts physical proximity of mother and newborn, and often emotional proximity of newborn and primary caregivers.

When a newborn is admitted to a neonatal intensive care unit, the family system connectedness is stressed. When the disruption of connectedness becomes chronic, newborn intensive care is traumatic. How much stress and disruption is traumatic for any newborn and family is variable and highly dependent upon individual autonomic nervous system tone resulting from prior experiences, family supports, and opportunities for repair.

Extensive research literature now documents the impact of early life stresses upon brain development and function, particularly the risk for later social emotional challenges in childhood and adulthood. Particular targets of early stress include the prefrontal cortex, the amygdala, and the hippocampus (Shonkoff et al., 2012). The prefrontal cortex and associated areas are the site of executive planning, organization, and attentional focus. The amygdala is the seat of emotional regulation, and the hippocampus is involved in learning and memory. A model for appreciating the impact of severe early developmental trauma on the fetal, newborn, and infant brain derives from long-term studies of babies raised in institutional rather than home environments. Based upon noninvasive neuroimaging studies and genetic testing, a window of 15–17 months emerges as a critical time period for establishing safe and secure relationships to diminish reactivity of the limbic system and decrease long-term psychiatric diagnoses (Tottenham & Sheridan, 2009; Zeanah et al., 2009).

## The Newborn Intensive Parenting Unit (NIPU): A Ventral Vagal Informed Newborn Care Environment

How can we best create a safe and secure environment for babies who need intensive care services that promotes connectedness with their parents and family? How can we assist the families of our tiny patients feel safe and secure enough to regulate and tone their own autonomic states so they can be available to co-regulate their babies?

How can we establish therapeutic alliances that make the NICU a secure base for babies, parents, families, and staff?

The goal of the ventral vagal informed NICU is minimizing stressors and disruptions of connectedness for babies and families while affirming and celebrating the primary caregiving relationship of the baby nested safely and securely within the family. The National Perinatal Association suggests formally recognizing this paradigm shift by renaming our care environments Newborn Intensive Parenting Units or NIPUs (Hynan & Hall, 2016). Transcending the gap between the present and the future NIPU requires significant changes, including psychoeducation for families and staff, maintaining physical and emotional proximity for parents, and supporting parents in co-regulating their babies. At full implementation, a new philosophy of care, prioritizing baby and family connectedness, is the foundation for all aspects of caregiving.

### *Providing Psycho-Education for Families and Staff*

Recognizing our own affective states is fundamental to self-regulation and participation in co-regulation. Dana's *Beginner's Guide to Polyvagal Theory* is a brief document written for a lay audience introducing the concept of neuroception and its relationship to the autonomic nervous system. It introduces the evolutionary hierarchy of dorsal vagal (reptilian, parasympathetic immobilization), sympathetic (mobilization), and ventral vagal (mammalian, parasympathetic, safe and social engagement) tone (Dana, 2015a). The simple illustrations use ladders and articulated figures, spaced either at the top (ventral vagal), in the middle (sympathetic), or at the bottom (dorsal vagal) of the ladder. Using emotional language reflecting the affective states of the position on the ladder, readers can begin identifying where on the ladder they rest in the moment or more chronically. In this simple exercise, families and staff can begin developing a common language to reflect upon their own experiences and to appreciate the triggers that may move them from ventral vagal to sympathetic and dorsal vagal states.

In addition to developing a polyvagal language culture, we need new terminology to describe the NICU experience from the baby's perspective. Most frequently, the biopsychosocial model developed by Shonkoff and colleagues (2012) elaborating the biology of stress; the continuum of positive, tolerable, and toxic stress, and the implications of "toxic stress" for the developing brain and health outcomes is referenced. This terminology is not common parlance for the lay public, and gradations of positive to tolerable and toxic stress are vague.

Trauma, however, is often chosen by parents and health care providers to describe their experience of today's newborn intensive care unit. Recent recommendations from six multidisciplinary workshops of the National Perinatal Association (Hynan & Hall, 2015) highlight the appropriateness of a trauma model in the opening paragraph of their manuscripts:

A neonatal intensive care unit (NICU) is akin to a trauma center for all participants. Fragile babies struggle to survive and grow. Parents and families worry constantly while trying to maintain optimism and hope. Staff attempt to avoid burnout while both encouraging distraught parents and acknowledging the times of poor prognosis. Distress is the companion of everyone (p. S1).

How do we create a "holding space" within the tumult and chaos of a modern NICU, where we tune and tone the regulation of the vagal nerve and embed a sense of safety and connectedness for babies, families, and staff? Prerequisites include optimizing the NICU environment to support physical and emotional proximity for the baby and family as we affirm our own connectedness and foster self- and co-regulation.

### *The Newborn Intensive Parenting Unit Environment*

The environment of the modern NICU violates many expectancies of the fetus, now newborn, for his newborn experience. Both the sick and healthy newborn need environmental stimuli that positively entrain their sensory organ systems, including sight, hearing, taste, touch, and smell. Common stressors in today's environment include parental separation, exposure to developmentally unexpected levels of light and sound, and frequent touch, both loving and potentially noxious. No single magic bullet will rescue sick babies and their families from their "companion distress." However, creating an environment and philosophy of care that celebrates the relationship of the baby and his family opens the door for developing the sensitive and enduring relationships that are the cornerstone for subsequent physical, and social, and emotional health.

The Newborn Intensive Parenting Unit design includes attention to the geographical layout; light and sound levels; diurnal cycles of babies, families and staff; and communication and workflow. There are comfortable spaces for parents to be with and care for their baby, to forge relationships with other families and staff, and to care for their own needs. Newly developing units include single-family room design, family lounges, kitchens, and laundry facilities. While meeting the needs of families, the layout also needs to account for space for staff and high-technology equipment, including computer workstations, given the requirements of the electronic health record.

Explicitly addressed in recent recommendations are minimum space, clearance, and privacy requirements for newborns and families, whether they are cared for in open-bay style or single-family rooms; availability of family-transition rooms; ambient lighting in newborn care areas, and availability of natural daylight. The acoustic environment should prioritize speech intelligibility and privacy (White, Smith, Shepley, Committee to Establish Recommended Standards for Newborn ICU Design, 2013).

The recognition of the needs for physical and emotional proximity as well as minimizing environmental stressors led to design of single family room NICUs. A survey by the American Institute of Architects in 2015 reported that prior to 1994, single-family-room NICUs did not exist. Since then, increasing numbers of newly built or renovated NICUs have included single-family rooms in their design. By 2011, single-family rooms were present in nearly half of new hospital construction (Sung & Shepley, 2014).

The goal of single-family rooms is strengthening the developing central nervous system by promoting parental social engagement, deepening connectedness, and a sense of mutual safety and security for parents and baby. For parents and staff to be fully present, the unit philosophy of care must be welcoming, culturally sensitive, and "safe." In polyvagal terms, the NICU must facilitate ventral vagal states for parents and staff as they reciprocally engage, connect, and attune with each other and the babies.

Evolving evidence suggests that caring for a baby and family in a single-family room promoting high maternal involvement in care optimizes at least short- and intermediate-term developmental and social emotional outcomes for babies and decreases stress for mothers. Lester and colleagues (2014, 2016) reported outcomes at hospital discharge and 18 months corrected of age of two cohorts of babies born at under 30 weeks who were cared for either in open-bay or single-family rooms. In the short run, care in single-family rooms decreased stress for mothers, babies, and staff. Mothers also reported improved satisfaction with care and spent more time with their babies. Babies whose mothers had high maternal involvement in care were also discharged

sooner. If they were also cared for in a single-family room, at 18 months corrected age, they had substantive improvements in language scores.

On a sobering note, a study conducted in an urban NICU cautions us that the sensory deprivation that *may* occur without high maternal involvement may further disadvantage some newborns already at risk for poor developmental outcomes (Pineda et al., 2014). Parents must be both in physical proximity with access to their baby for co-regulation and maintain sufficient ventral vagal tone to promote co-regulation that allows them to rest in emotional proximity to their baby. Making mothers and fathers available to their babies emotionally requires addressing their own fears, worries, and prior and present traumas. Addressing these factors begins with identifying their own emotional states, whether they are “high-jacked” when sympathetically driven or “hibernate” in dorsal vagal states. These archetypes play out continuously in the NICU setting with the “hard to reach” or “infrequently present” parent who becomes “overwhelmed” or, at an extreme, even “verbally aggressive or combative” when in the NICU. For these parents, it may feel adaptive to avoid coming to the NICU when feeling states are simply too painful or devastating.

### Support and Affirm Connectedness as Parents and Babies Foster Co-Regulation

The primary strategy of co-regulation for the healthy newborn is skin to skin on his mother’s chest. The benefits of skin to skin to maintain autonomic nervous system stability and enhance the success of breastfeeding are well documented.

Intermittent skin-to-skin or kangaroo care was first used in NICUs in developing countries, where crowding and high infection rates threatened infant well-being, as a way of decreasing mortality and complications for premature babies (Conde-Agudelo, Belizán, & Díaz-Rossello, 2016). In developed countries’ NICUs, kangaroo care is associated with improved duration of breastfeeding, decreased parental stress and feelings of helplessness (Renfrew et al., 2010), and improved autonomic regulation and maternal interactions at term (Ohgi et al., 2002). A subset of newborns followed up to 10 years old had attenuated stress responses and improved autonomic functioning (Feldman et al., 2014). These newborns were more ventral vagal and were less likely to be hijacked by stress into excessive sympathetic tone.

Kangaroo care provided during painful procedures both decreases pain scores and the amount of time for the heart rate to return to baseline after a painful procedure by 60 seconds (Johnston et al., 2008; Johnston et al., 2014). Given the number of painful procedures NICU babies experience during a

day, especially during the acute phases of management, kangaroo care co-regulation holds promise as a nonpharmacologic pain therapy, along with sucrose and swaddling.

Supporting parents as primary caregivers also asks health care providers to rethink what tasks in the NICU are accomplished by families, rather than nursing staff. In a recent pilot project, a Family Integrated Care (FIC) model was tested for stable recovering babies whose parents could spend at least 8 hours a day in the hospital. Families received daily education sessions, attended rounds, and provided care to their newborns including feeding, bathing, dressing, and skin-to-skin care (kangaroo care). Nurses continued to provide technical tasks including suction, placement of feeding tubes, and so on. Parents also did basic charting and maintained a record of their own learning. Newborns who received FIC showed improved weight gain, increased breastfeeding rates at discharge, and a trend toward decreased infection. Mothers who participated had decreased maternal stress scores. The study is now being replicated in 20 sites in Canada (O'Brien et al., 2013).

### Polyvagal Theory Can Help Caregivers Connect Among Themselves and With Babies

Polyvagal Theory is the neurobiological foundation of our autonomic nervous system responses to our neuroception of safety, danger, and life-threat. As a tool, Polyvagal Theory can assist families and staff to understand their own emotional responses and the responses of the others (staff, extended family, etc.), and as a barometer to measure the changing ecosystem around them. Polyvagal Theory also assists families and staff to understand babies who are trying to communicate their needs in the only language available to them: their behavior.

A deep understanding of Polyvagal Theory asks caregivers to focus their own efforts to connect with families as they "befriend," "attend," "tune," and "tone" their own and the families' autonomic nervous systems. In "befriending," staff and families learn to notice and name their own emotional states and their Polyvagal Theory correlates. Recognizing and accepting their own places on the ladder is a conduit for connection early in NICU relationships that will deepen and strengthen throughout the hospitalization. Imagine as a parent, you arrive in the NICU for the first time and are greeted by a nurse with a gentle smile who congratulates you on the birth of your baby and emphasizes the importance of your relationship before getting into an explanation of all the tubes and wires.

As we "attend," giving close and thoughtful attention, we bring percep-

tion to neuroception, considering the triggers for entering or maintaining self-states and resources that can assist transitioning from a dorsal vagal or sympathetically driven states to a ventral vagal place of ease. You now hear the nurse inquire about your feelings and concerns. The nurse reads the shock on your face as you try to return her congratulatory smile. You feel comforted as you say to yourself, "She gets it. I am terrified."

The nurse then brings over the doctor to speak with you about your new baby. The doctor sits down next to you and speaks slowly. She refers to your baby by her given name, Emma, and conveys quiet confidence as she provides basic information and answers your questions. Somehow, her calm "tunes" your own rattled, chaotic autonomic nervous system. You feel yourself, however slightly, moving up the ladder.

The doctor explains that she will be caring for your baby and you during the week and says she hopes you will join daily work rounds, where the team discusses each baby and makes a plan for the day. She tells you how important your role is in Emma's care and that your input is vital to the team. For just a moment, the chaos recedes and the discussion feels like a neural exercise in "toning" your vagal nerve (Dana, 2015b).

## The 21st-Century Neonatal Intensive Care Unit

The 20th century saw the development of the field of neonatology, dedicated to supporting and caring for the sickest babies from birth to discharge (or death). Early in the history of neonatology, parents surrendered their babies to the wonders of a new technology that offered hope of survival for babies who would previously have died. With survival improving dramatically, the next frontier for neonatology is optimizing the newborn experience for both babies and their families, setting the stage for their ongoing relationships in the community.

Understanding the experience of the sick baby, his family, and the NICU staff through a polyvagal lens creates a common language for building connections to support the baby and family. Attending to our own neuroception, our unconscious awareness of our safety (or not) recognizes the elephant in the room, the implicitly perceived parent and baby experience, seen but not acknowledged by all parties. Only when we acknowledge our own safety circuits, understand our own triggers for moving down the ladder, and address our own resources for moving up the ladder will we, as staff caregivers, be able to provide the supports and kindness our patients and their families crave. "Physician heal thyself" has never been more fundamentally true than in the intensive care setting. Whether the patient is a tiny baby, a child, a previously

healthy adult, or an elderly parent, the evolutionary seeds for his needs were sown when first the middle-ear bones detached from the mandible, eye-to-eye contact was established, and maternal vocalizations and prosody became the portal to social engagement and connectedness, permitting the survival of the species.

Only when we connect to our own place on the ladder and recognize the ladder rung on which our staff sit and to which our parents cling tenuously will we be able to provide the right stuff. We are wizards of technology; let us become wizards of the human spirit.

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