

## Abstract

Preterm birth interrupts the precise process of fetal maturation, forcing critical neurologic growth to continue within the Neonatal Intensive Care Unit (NICU). Concern for the impact of the NICU experience on the developing brain led to a unit-based Quality Improvement (QI) project to promote best outcomes for our graduates. The objective was to implement a standard of care for neonatal neuroprotection in a large urban tertiary center. A multidisciplinary committee researched and developed the *Neonatal Neuroprotective Best Practice Guidelines* to identify optimal interventions, as well as provide physiologic rationales to reinforce importance of these practices. An educational initiative accompanied release of this document to support consistency in clinical practice and to stress the critical role that every caregiver played in a child's outcome. As the *Best Practice Guidelines* encompassed virtually all aspects of caregiving in the NICU, it was impractical to measure the impact of such a broad range of interventions in a methodical manner. The full effect of these interventions will not likely be evident until NICU graduates have grown into childhood and adolescence. These constraints limited the scope of this QI project to the practicalities of identifying neuroprotective best practice and bringing it to the bedside. When combined with evidence-based medical and nursing care, neuroprotective care represents the best means of facilitating normal development and minimizing disability for our NICU graduates.

**Key words:** Developmental care; Infant; Intensive care; Neonatal; Neuroprotection; Premature.

# NEONATAL NEUROPROTECTION

## Bringing Best Practice to the Bedside in the NICU

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Pretermaturity accounts for approximately 1 of every 10 births in the United States (Martin, Hamilton, & Osterman, 2017). The physiologic and metabolic immaturity of preterm infants is clear from the need for specialized support such as respiratory, thermal, and nutritional care. Less obvious but perhaps more vulnerable is the immature central nervous system (CNS). As aptly described by Watson (2013, p. 189), "Just as the lungs and gastrointestinal system were not prepared to develop and function outside the womb after premature birth, neither was the brain." Although incidence and severity of neurodevelopmental sequelae rises with lower gestational age (Pugliese et al., 2013), even late preterm infants may be compromised. Compared with full-term infants, late preterm infants have lower preschool reading and math scores, and they continue to be delayed at kindergarten entrance (Shah, Kaciroti, Richards, Oh, & Lumeng, 2016; Woythaler, McCormick, Mao, & Smith, 2015). Concern for the impact of premature birth on the developing CNS, and an awareness that tremendous brain growth and maturation was occurring within our neonatal care units led to a unit-based quality improvement (QI) project to ensure

that we were doing everything that we could to provide neuroprotective care.

### Term Infants: The Intrauterine Experience

The third trimester is recognized as a period of intense growth and evolution for the fetal brain and CNS. The intrauterine environment provides constant access to mother and a unique blend of chemical, hormonal, and sensory input that is crucial for normal brain development. The predictable nature of intrauterine life supports fetal REM (rapid eye movement) sleep, which is critical for neurosensory, auditory, and visual maturation. Light and noise are filtered through amniotic fluid and solid media, supporting a predetermined sequence of fetal sensory development in which hearing and vision are the last senses to mature. Boundaries of the uterine walls promote flexion and musculoskeletal development. Maternal movement and fetal activity within warm amniotic fluid offers vestibular, proprioceptive, and tactile stimulation. Nine months within this nurturing environment prepare term infants for the variety of sensory

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experiences that the extrauterine world offers (Lickliter, 2011; Malcolm, 2015).

## Preterm Infants: The NICU Experience

Preterm birth disrupts the delicate process of fetal maturation, compelling it to continue within the Neonatal Intensive Care Unit (NICU). Preterm infants are developmentally unprepared for the sensory input that ensues after birth. Abruptly separated from mother, they are exposed to unfiltered light and noise. Sleep disruptions are common. Temperature and oxygen levels fluctuate, and many infants experience the discomfort of respiratory distress or sepsis. Most touch is procedural in nature, uncomfortable at best, and painful at worst. Handling for necessary caregiving seems random, and the unpredictable nature of the NICU environment compounds the stress of prolonged maternal separation. At a critical stage of fetal neurologic development, the preterm infant undergoes sensory deprivation of the normal stimuli that would have been experienced in the womb while being exposed to the inappropriate sensory input of the NICU (Gardner, Goldson, & Hernandez, 2015).

## Sequelae of Prematurity

The typical NICU provides a very different environment for the continued maturation of the preterm infant's CNS. At follow-up, preterm infants show many differences from their term counterparts, suggesting alternative brain development. Cerebral palsy is perhaps the most disabling motor injury, but developmental coordination disorder is more common with motor delays, altered muscle tone, balance deficits, difficulties with visual-motor coordination, and atypical movement patterns. Hearing and visual impairment, language delays, and sensory processing issues may also occur because fetal sensory development has been interrupted by preterm birth and exposed to the unpredictable sensory input of the NICU (Malcolm, 2015; Papageorgiou & Pelousa, 2014). As the complexity of tasks and behavioral skills grow more challenging at school age, disorders of higher cortical function may become evident. Academic difficulties, cognitive impairment, learning disabilities, and problems with executive function may emerge. Emotional and behavioral issues including anxiety, autism spectrum and attention-deficit/hyperactivity disorders may affect the child's capacity to function within school and greater society (de Jong, Verhoeven, & van Baar, 2012; Johnson & Wolke, 2013; Watson, 2013).

## Historical Perspectives on Developmental Care

The impact of prematurity upon eventual outcome has long been recognized (Benton, 1940), even prior to the advent of neonatal intensive care in the 1960s. The early days of neonatal care focused upon the essentials of providing adequate respiratory, thermal, and metabolic support to permit survival. As the mechanics of providing

neonatal intensive care became more sophisticated, the focus gradually shifted from mere survival to neurologically intact survival. Various models of developmentally supportive care emerged to support the presumed neurodevelopmental needs of preterm infants.

The current approach to developmental care is based largely upon the *Synactive Theory of Development*, which led to a greater appreciation of preterm infant behavior that could be used to guide handling in the NICU (Als, 1982). *Cue-based* caregiving is dictated by different physiologic and behavioral indicators that tell caregivers to either continue handling, or to pause temporarily to avoid further decompensation and to provide for recovery. This individualized approach to caregiving is used in conjunction with a broad variety of developmental care interventions to reduce stress, and to promote both physiological stability and behavioral organization (Spruill, 2015).

Although the practice of developmental care may differ from one unit to another, "developmentally supportive care provides a framework in which the environment of care and process of delivering care are modified and structured to support the individualized needs of the developing newborn and family" (National Association of Neonatal Nurses, 2010, p. ix). Advances in neuroimaging and research have provided broader insight into third trimester brain development, and what traditionally has been viewed as simply *developmentally supportive care* is now recognized to be *neuroprotective care* (Discenza, 2015; McGrath, Cone, & Samra, 2011). The terminology may have been updated to reflect the importance of this model of caregiving, but the basic tenets of developmentally supportive and neuroprotective care remain identical.

## Neuroprotective Care

Neuroprotection includes all strategies that support the developing brain, facilitating normal development and reducing disability. In the event of neuronal injury, these interventions are intended to help the brain limit neuronal cell death and permit healing by creating functional synaptic connections and pathways (Bader, 2014; McGrath et al., 2011). The newborn brain can make both temporary and permanent changes to its synaptic neuronal connections, which are based upon sensory input from different environmental stimuli and experiences. This adaptive capacity is known as neuroplasticity, and can be either positive or negative. Because the brain is being actively "hard wired" at a rate of 40,000 connections per minute during the infant's NICU stay (Bourgeois, 1997), both functional and dysfunctional synapses are being created or deleted based upon the infant's unique experiences. As "neurons that fire together, wire together" (Shatz, 1992, p. 64), it is imperative that every effort be made to minimize negative experiences for the preterm infant. Parents and professional caregivers can work together to minimize the adverse impact of the NICU experience, hopefully reducing subsequent impairment and disability (Altimier & Phillips, 2013).



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## Neonatal Neuroprotective Best Practice Guidelines Quality Improvement Project

### Local Problem

Clinicians in our neonatal units take great pride in providing superior clinical management. Our concern: had we become so busy supporting visibly immature organ systems such as the lungs and gastrointestinal tract that we had forgotten about the brain, that fundamental and irreplaceable organ that defines each of us? As direct caregivers, there was both responsibility to provide the best possible care now for our vulnerable infants, as well as the opportunity to shape a child's future. This led to a unit-based QI project to ensure that neuroprotective best practices were an essential aspect of daily caregiving.

### Setting

This QI project was conducted in the NICU and Intermediate Special Care Unit (ISCU) at Swedish Medical Center in Seattle, Washington. Swedish Medical Center is the largest nonprofit healthcare provider in the Greater Seattle area. There are four other Swedish hospital locations within Seattle and the surrounding community, three of which provide childbirth and Level 2 nursery services and are linked with the tertiary center by transport team. Over 10,000 "Swedish babies" are born yearly making it the largest delivery service in Washington State. Most births occur at the Swedish-First Hill campus where high-risk perinatal and neonatal care services are concentrated. In 2016, approximately 1,000 babies were cared for in the Level 4 NICU (30 beds) and Level 2 ISCU (47 beds) at Swedish-First Hill. Most of these admissions were inborn deliveries but Swedish-First Hill also accepts candidates for therapeutic cooling, preterm infants, and surgical patients from other facilities in the greater Seattle area and Alaska.

### Intervention

A "Brain Sensitive Care (BSC) committee" was created at Swedish-First Hill to evaluate and improve the practice of neuroprotective care ("brain sensitive care") within our neonatal intensive and intermediate care units. This multidisciplinary team included dedicated representatives from the neonatology department, nurses (both advanced practice nurses and staff nurses), pediatric therapists, respiratory therapists, as well as a member of the *March of Dimes Family Support Program*. The committee

was chaired by a staff nurse from the Level 4 NICU, and met monthly over a 2-year period. The NICU management team and committee members from outlying Level 2 nurseries were kept informed of committee progress by email communications and meeting minutes. Periodic emails were used to update the team.

### Goal Setting

During initial meetings, the BSC committee rapidly came to consensus that neuroprotective care was an essential means of protecting ongoing CNS development. We recognized that every aspect of our daily interventions would continue to impact our patients throughout childhood, adolescence, and adulthood. The committee quickly agreed that our priority was, "to support best neurodevelopmental practice within our neonatal units today, and better neurodevelopmental futures for our babies tomorrow." After considerable discussion about format, it was agreed that our goal was to create a document that would serve as a standard of neonatal neuroprotective care by all caregivers.

### Assessing Current Local Practice

The BSC committee began by reviewing the history of developmentally supportive care in our units. Education about developmental care has always been part of the initial orientation for all new employees. However, many of our clinical team had different backgrounds and beliefs associated with this practice, and we suspected that there were many approaches to caregiving at individual bedsides.

The next step was to assess existing status of developmentally supportive care in our units. The committee acknowledged that the physical environment alone was a significant impediment. Our neonatal units were built prior to the introduction of single-family room design (Lester et al., 2016), and new construction was unlikely for quite some time. Both our NICU and ISCU were set up in the more traditional open-bay design with four to six beds per room. Only two of the outlying Swedish Level 2 nurseries had been constructed recently enough to have benefitted from the introduction of contemporary design. The open-bay setup makes it difficult to control both noise and lighting, and can present challenges to family-centered care because of lack of space and privacy.

Although the physical environment is one important aspect of providing neuroprotective care, individual

caregiving practices are also critical elements. Each of the multidisciplinary team members had unique perspectives to offer about the caregiving that they themselves either provided or observed, and many valuable insights were shared between the various disciplines. It was agreed that we were fortunate to have some very “seasoned” and experienced nurses along with increasing numbers of younger nurses who were less experienced but very eager to learn. After extended discussion, the committee concluded that we had many strengths in terms of the neuroprotective care that we provided, but also some areas in which improvements could be made. Early priorities for improvement included therapeutic positioning, sleep protection, strategies to reduce stress, and providing more opportunities for skin-to-skin care.

### Assessing National Practice

Once the committee had a better appreciation of the level of neuroprotective care in our own setting from a multidisciplinary perspective, we set out to ensure that we were in line with national practices and consistent with current evidence-based literature. In consultation with other NICUs, tracking relevant nursing listservs and reviewing recent literature, it was clear that neonatal neuroprotection was the focus of considerable attention nationally. Many leading NICUs were taking a more rigorous approach to neuroprotection, formally designating themselves as Neuro-NICUs. The consistent framework of these units is a four-pronged approach that includes neuroprotection, neuromonitoring, neuroassessment, and neuroimaging (Discenza, 2015). It was helpful to acknowledge that others were working on similar issues, and to confirm that we were on the right path.

### Pursuit of Evidence-Based Developmental Care

The committee’s foray into the literature revealed some interesting observations. First, the essential ingredients of providing neuroprotective care were largely unchanged from initial developmental care recommendations. Strategies to promote therapeutic positioning, limit noise and light, minimize pain and stress, and support parent–infant attachment are still as applicable today as they were when originally proposed several decades ago (Als et al., 1986; Altimier & Phillips, 2016). Second, evidence to support many neuroprotective strategies is both limited and occasionally conflicting. Developmental care has been shown to increase weight gain, reduce hospital length of stay (LOS), and enhance neurodevelopmental scores at 9 to

12 months; but many studies have been hampered by small sample sizes, absence of blinding, and the inclusion of multiple interventions (Symington & Pinelli, 2006). Some elements of developmental care, such as skin-to-skin care, oral sucrose for procedural pain, and the Newborn Individualized Developmental Care and Assessment Program have been well studied, other aspects are less tangible and more difficult to evaluate (Baley, 2015; Lawhon et al., 2013; Ohlsson & Jacobs, 2013; Stevens, Yamada, Ohlsson, Haliburton, & Shorkey, 2016).

Validating benefits of developmental care continues to be difficult because it is practiced in so many variations in different settings (Montirosso et al., 2016). Variation in definition, clinical practice, and evaluation has undermined evaluation of the scientific merit of developmental care (Coughlin, Gibbins, & Hoath, 2009). Although research aimed at validating benefits of developmental care practices has yielded conflicting or neutral results, none of these outcomes have been negative, and most have been positive. Acquiring long-term outcome data in the neonatal population requires both patience and passage of many years. The BSC committee opted to implement evidence-based “potentially better practices” (Liu et al., 2007) whenever available, recognizing that in the absence of definitive long-term data, the only option was to rely upon currently available resources and knowledge. All infants benefit from individualized nursing care that supports physiological stability and behavioral organization. Consistent with moral and ethical responsibilities, inherent respect for our patients dictate that we take measures now to manage pain and stress, reduce environmental stimulation, provide gentle handling and therapeutic positioning, protect sleep, and facilitate attachment (Goldstein, 2012; Haumont et al., 2013).

### Moving Forward

The BSC committee had begun by taking a close look at the existing level of developmental care in our neonatal units. After getting a sense for national trends and reviewing the literature for pertinent evidence-based resources, it was time to incorporate this information into our own nurseries. Consistent with our original goals, the committee set to work creating the “*Neonatal Neuroprotective Best Practice Guidelines*,” a document that would establish our standard of developmental care. The objective was an easily accessible format that would provide specific recommendations and rationales for various neuroprotective care practices. The committee recognized that although many interventions remained the same, the passage of time had brought a better understanding of third trimester brain growth and development. This fresh insight validated the vital importance of various neuroprotective strategies, and we hoped that this information would encourage more consistent compliance with our recommendations.

### Neuroprotective Core Measures

Having selected the basic format for the *Neonatal Neuroprotective Best Practice Guidelines*, the BSC committee

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focused next on essential content for the document. We elected to organize our neuroprotective care using seven core measures identified by Altieri and Phillips (2013), and their Neonatal Integrative Developmental Care Model was adapted for our use with the authors' permission. This model was chosen because it was concise, comprehensive, and readily applied to the clinical setting. Core measures include: Safeguarding Sleep, Positioning and Handling, Minimizing Pain and Stress, Protecting Skin, Nutrition, Partnering with Families, and Healing Environment. The committee used this template as a foundation, incorporating other literature and resources as indicated. We soon discovered that the broad nature of the core measures would ultimately have an impact on almost every aspect of caregiving. This led our multidisciplinary team into many extended discussions and more than an occasional detour. Some preexisting unit protocols had to be thoroughly reevaluated and updated as we went along. Addressing these issues slowed the progress of our work, and created frustration for the committee and the nurses who were waiting for release of the guidelines. Although this presented many challenges to the BSC team, it forced us to examine and ultimately improve many of our caregiving practices.

The committee approached the core measures in a standardized fashion. First, we examined existing nursery practices relevant to each core measure. The next step was to review the literature that had been assembled for each core measure, and to identify and discuss those interventions thought to be appropriate for our setting. When consensus was reached about specific interventions, a committee member developed a summary of recommended interventions along with supporting rationales. This synopsis was then reviewed and edited as necessary by the multidisciplinary committee. After finalizing all seven core measures in this manner, the document was distributed to our nursing and medical management teams for comment. Once approved by the appropriate hospital-wide committees, the completed document was published on the Swedish Medical Center intranet. Discussion of all seven core measures exceeds the scope of this article; however, the *Neonatal Neuroprotective Best Practice Guidelines* is available electronically as (Supplemental Digital Content, 1, <http://links.lww.com/MCN/A44>).

### Measuring Outcomes

As the BSC committee worked through the nuances of developing and implementing the *Neonatal Neuroprotective Best Practice Guidelines*, we also struggled to determine how to measure the outcomes of our efforts. Acquiring and evaluating data prior to and after our interventions would be the most effective tactic, but what exactly would be evaluated? Our project had grown into a major endeavor that touched on virtually every aspect of caregiving. We recognized that much of the impact of our interventions would not be seen until our babies had grown into childhood and adolescence, and that their eventual neurodevelopmental outcomes would also be

influenced by parental involvement, as well as ongoing advances in both nursing and medical management. As part of the Vermont Oxford Network (2017), our units were constantly working to upgrade the quality of caregiving. How would these alterations impact outcomes, and be teased apart from the impact of the *Neonatal Neuroprotective Best Practice Guidelines*? The BSC committee was being confronted with the same limitations as had challenged the scientific validation of developmental care strategies over the past several decades. Time constraints on the part of the BSC committee ultimately determined the extent of outcome evaluation for this QI project. Committee time was limited, and there were many aspects of care that we were trying to influence. The committee elected to focus purely on developing and implementing the guidelines. Statistics were extracted on daily weight gain and LOS from the 4 years prior to the guideline introduction with the eventual goal of comparing pre-implementation and post-implementation data.

### Challenges: Safeguarding Sleep

The greatest amount of debate and discussion focused on promoting sleep while providing safe care and supporting the work flow of the unit. We recognized that there were many barriers to adequate sleep in our neonatal units. In addition to addressing concerns about noise and lighting, we knew that routine handling often occurred on preset schedules without regard to an infant's actual sleep-wake status. Our nurseries had traditionally attempted to protect sleep by clustering caregiving, assessments, procedures, and feeding into 3-hour intervals (referred to as "care times"). Handling occurred on a predetermined schedule, even if it entailed waking a sleeping infant, but also created blocks of time when the infant should be undisturbed and presumably sleeping.

Although preset schedules were useful for organizing staff workload, our patients did not always cooperate by sleeping during the designated rest periods. There were also many infants who simply could not tolerate the concentrated handling that clustered caregiving requires. This led the BSC committee into a protracted deliberation about protecting sleep while still allowing for the level of assessment and handling warranted in an intensive care unit. After much debate, we created standing orders for *Brain Sensitive Caregiving Vital Signs* (Table 1) that encouraged handling when the infant was awake, and detailed minimum expectations for ongoing assessment, vital signs, and caregiving. Deeply entrenched nursery routines were being modified with the introduction of a single standardized order, and this generated considerable angst and trepidation.

### Implementation

The BSC committee recognized that we already had many strengths in neuroprotective care, and we wanted to be respectful of our clinical teams' expertise as we approached full implementation of the *Neonatal Neuroprotective Best*





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*Practice Guidelines.* This was especially true as many recommendations were not necessarily new, but perhaps had not been consistently followed in the past. Competing and pressing demands that ensured survival for our critically ill newborns often relegated developmental care to the background, seen as less of a priority for busy nurses. Our intention was to bring “brain sensitive care” to the foreground by emphasizing the physiologic rationales that reinforced the importance of these care practices. Our bedside providers were in an ideal position to protect the newborn’s “one brain for life” (Amiel-Tison & Stewart, 1994), but we knew that it would be challenging, and at times, both inconvenient and inefficient. The committee was also acutely aware that some aspects of the guidelines represented a significant culture change for many of our clinical team, and we aimed to provide sufficient communication and education to support a successful transition. Progress of our work was passed onto the clinical team through periodic email updates and poster presentations, but there were still rumors and apprehension about potential impact upon daily organization and work flow at the bedside.

The bulk of the *Neuroprotective Best Practice Guidelines* were put into practice at the same time; however, some of the core measures were partially introduced in advance. A comprehensive *Infant Driven Feeding Pathway* had been implemented well before the formation of our committee, so an important piece of the *Optimizing Nutrition* core measure was already in place when we started (Kamitsuka, Nervik, Nielsen, & Clark, 2017). Early in the process of our guidelines development, the committee was granted a block of education time. This was used to highlight the importance of neuroprotective care, and to address elements of two additional core measures, *Protecting Skin* and *Positioning and Handling*. First, the committee introduced an evidence-based *Perineal Skin Care/Diaper Dermatitis Management Guideline* (Heimall, Storey, Stellar, & Davis, 2012). Next, we focused on therapeutic positioning with strategies and positioning aids to support optimal alignment and containment. We continued to work on these themes while preparing the final guidelines document, and made significant strides in both. The committee had also updated and liberalized our skin-to-skin protocol, encouraging earlier and more frequent opportunities for parents. The new protocol was circulated among clinical team, as well as a short video that demonstrated the use of “standing transfers” to facilitate safe transitions.

Immediately prior to formal release of the *Neuroprotective Best Practice Guidelines* and accompanying standing orders for *Brain Sensitive Caregiving Vital Signs*, inservices were used to address specifics of implementing the new standing order and to ease any concerns about proposed changes to long-standing nursery routines and customs. The committee was eager to reassure nurses that if any elements of the new guidelines proved to be completely impractical, we would solicit input and adapt accordingly. These sessions also stressed potential impact of neuroprotective care interventions, and the critical role that every bedside caregiver played in a child’s eventual outcome. The initial wave of inservices was followed by a second wave of half-day sessions that provided in-depth coverage of the seven core measures. A “*BSC Bedside Resource*” briefly summarizing the core measures was laminated for use at each bedside (Table 2). Copies of the entire guidelines were available as a reference tool, and committee members were available to answer questions and gather feedback.

**TABLE 1.**  
**Brain-Sensitive Care Vital Signs Order**  
**(Swedish Medical Center)**

Vital Signs and Brain-Sensitive Caregiving
New Admission: Vital signs q 30 min X 2, then 1 hr X 2, then q 3–4 hrs if stable for the first 24 hrs of life. Brain-Sensitive Caregiving thereafter if remains stable.
Transfer from Newborn Nursery >24 hours of age: Vital signs q 1 hr X 2. Brain-Sensitive Caregiving thereafter if remains stable.
Brain-Sensitive Caregiving: Vital signs twice per shift minimum (approximately every 6 hrs), preferably when infant is awake. Reassess vital signs that are not within normal limits more frequently.
Visual rounding hourly to assess for wet diaper, pain, positioning, parent needs, and condition of intravenous (IV) sites.
Record monitored information hourly between “hands on” VS for all babies with continuous IVs and/or any respiratory support.

Swedish Medical Center-used with permission

**TABLE 2.** Brain-Sensitive Caregiving: Bedside Resource (Swedish Medical Center)

Caregiving based upon infant's sleep-wake states rather than scheduled "care times" provides adequate rest and sleep for baby and is one of the most important contributions made toward positive long-term outcomes.

*New care strategies are italicized.*

### Safeguard Sleep

#### **Vital Signs and Clustering of Care if Stable 24 Hrs After Admission**

- **Vital signs** twice per shift minimum (approximately every 6 hrs), preferably when infant is awake. A full assessment, vital signs, diaper change, repositioning, oximeter site change, noninvasive positive pressure device skin break, feeding, and any indicated interventions can be done at this time
- **"Hourly visual rounding"** without awakening a sleeping infant, or when an infant is awake and appears uncomfortable (crying, restless, increased HR, etc.). Check for wet diapers, signs of pain, need for repositioning, IV sites, and parent needs
- Feedings are given at scheduled intervals (e.g., every 3 hrs)
- Assessment frequency is modified according to caregiver's professional judgment. If a VS or assessment is not within defined limits, increased "events," or rising oxygen requirements, reassess more often as needed
- RT and nurses collaborate on frequency and scheduling of noninvasive positive pressure device skin breaks
- Physicians, ARNPs, and specialty providers assess infants per their schedules

### Optimize Positioning and Handling

- IVH Prevention Bundle: For infants <30 weeks GA for the first 72 hrs of life
- Optimal positioning with shoulders softly rounded forward. Hands toward midline, able to touch face/mouth if possible. Hips aligned and pelvis tucked. Knees, ankles, feet aligned and softly flexed. Neck is neutral or slightly flexed, no hyperextension. Head midline, or turned slightly right or left, but not >45° to either side
- Utilize containment with all handling, caregiving and procedures. When an additional caregiver is unavailable to assist, use Dandlewraps/Roos or partial blanket swaddles
- Change infant's position slowly, no rapid or unsupported movements
- *Consider using a second person to assist with position changes for intubated babies*
- Prone positioners
  - *If between sizes, use smaller size to prevent abduction of legs and shoulders*
  - *Shoulders and hips should flex around positioner, which should end at umbilicus*
  - *Avoid turning head to full 90° angle by allowing it to rest slightly off edge of positioner*
- Dandlroos/Dandlewraps
  - *Reminder: Servo control temp probe must never be covered by fabric, and vascular access sites must be visible*
- Diaper changes
  - *Avoid raising feet above head to prevent sudden fluctuations in ICP and for reflux prevention*
- Swaddled bathing

### Protect Skin

- Use *SMC Skin Care: Premature Infant<26 Weeks* Protocol to prevent and treat skin breakdown
- Change diapers Q2-4 hrs during spontaneous awake periods to avoid diaper rash
- Avoid epidermal stripping
  - *Minimize adhesive use, and consider Duoderm "platforms" and "key holes" if frequent retaping required*
  - *Use blue silicone tape whenever possible—not for securing critical lines*
  - *Whenever possible, leave adhesives in place until adhesive bond starts to lessen*
  - *Gently remove tape with saline, water-soaked cotton balls, or silicone-based alcohol-free adhesive remover*
  - *If retaping is not required, use Vaseline to loosen tape*

### Minimize Pain and Stress

- Cue-based care is essential during clustered care to avoid overwhelming an infant
    - *Assess for stress cues, indicating the need for containment and a brief pause to allow recovery*
    - *Assess for stability cues, indicating that it is safe to continue caregiving or interaction*
- Comfort measures are indicated for all minor or moderately stressful procedures
- *Options include containment, swaddling, KC, breastfeeding, nonnutritive sucking, and/or oral sucrose*
  - Add pharmacologic agents to comfort measures whenever moderate or severe pain is anticipated
    - *Additive or synergistic effect is seen when comfort and pharmacologic measures are used together*
  - *Avoid "wind-up phenomenon" (hypersensitivity persisting after procedure causing routine caregiving to be perceived as painful) by allowing infant to fully recover before resuming caregiving activities*

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**TABLE 2. Brain-Sensitive Caregiving: Bedside Resource (Swedish Medical Center)**

Optimize Nutrition
<ul style="list-style-type: none"> <li>• Minimize negative perioral experiences such as suctioning, vigorous oral care and saline for oral care</li> <li>• Promote nonnutritive sucking at mother’s pumped breast during gavage feeds</li> <li>• Provide the taste and smell of breast milk during gavage feedings using a dipped pacifier</li> <li>• <i>Glucose should be infusing within 30–60 min after birth to meet brain’s energy demands</i></li> </ul>
Parent Partnerships
<ul style="list-style-type: none"> <li>• Encourage parents to join in infant’s care to the extent they choose whenever they desire</li> <li>• Encourage containment (“hand hugs”) for either caregiving or painful interventions</li> <li>• Empower parents to recognize and respond to infant cues appropriately</li> <li>• <i>If able to do so without awakening, teach parents to provide quiet “hand hugs” after caregiving and during sleep</i></li> <li>• <i>Promote skin-to-skin as soon as possible, often, and as long as infant remains stable per revised SMC-KC Procedure</i></li> <li>• <i>Parents may hold “between” cares as tolerated, but stress the critical need for infant to sleep as much as possible</i></li> </ul>
Healing Environment
<p><b>Temperature</b></p> <ul style="list-style-type: none"> <li>• Transfer infants from warmers to incubators with quiet motors as soon as possible</li> </ul> <p><b>Touch</b></p> <ul style="list-style-type: none"> <li>• Avoid light touch or stroking as it may be irritating due to infant’s limited ability to modulate sensory input</li> <li>• Use gentle but firm and static containment (“quiet hands”)</li> </ul> <p><b>Smell</b></p> <ul style="list-style-type: none"> <li>• Provide mother’s scent with breast pad or soft cloth</li> </ul> <p><b>Sound</b></p> <ul style="list-style-type: none"> <li>• <i>Speak as quietly as possible within patient bays, avoid loud laughter or conversations close to bedside</i></li> <li>• Empty sloshing water in ventilator/nasal continuous positive airway pressure tubing</li> <li>• Quiet alarms as quickly as possible, and remember to reset them</li> <li>• <i>Use ear muffs for infants on HFOV and in adjacent bed spaces</i></li> </ul> <p><b>Lighting</b></p> <ul style="list-style-type: none"> <li>• Use minimal amount of light needed to accurately assess and manage infant, strive for day/night cycle</li> <li>• Protect eyes from direct light during every examination, during rest periods, and after pupil dilation for eye exams</li> <li>• <i>Use heavy incubator covers with solid, dark underside to limit excessive light exposure during sleep</i></li> <li>• <i>Limit visual stimuli early on, with focus on parents faces</i></li> </ul>

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HR=heart rate; VS=vital signs; RT=respiratory therapy; IVH=intraventricular hemorrhage; GA=gestational age; ICP=intracranial pressure; SMC=Swedish Medical Center; KC=kangaroo care; HFOV=high-frequency oscillatory ventilation.

## Post-implementation

When the guidelines and the accompanying standing orders for *Brain Sensitive Caregiving Vital Signs* had been in place for several weeks, the BSC committee posted a compilation of frequently asked questions (FAQs). Despite the wide range of core measures covered by the guidelines, most of the FAQs were about sleep and appropriate reasons to interrupt an infant’s sleep cycle. Several weeks later, we formally solicited input using a brief qualitative survey about what was working well with the guidelines, and what was less successful. Many nurses were uncomfortable allowing babies to sleep for extended periods at the start of their shift because it was difficult to do a complete assessment without handling the baby. Although the BSC committee still encouraged nurses to use spontaneous awake periods whenever possible, we supported the need to get a baseline assessment at the earliest opportunity.

Once the guidelines had been in place for about 6 months, we surveyed the clinical team again with a similar survey. The input we received was generally positive, but some challenges remained. Positive feedback focused primarily on sleep protection and the benefits presumably derived from this, for example, *babies seem more rested and calm* and *babies seem more interested in eating and have better alert periods*. Criticism was largely directed toward inconsistencies in parent communication about supporting sleep. The committee recognized that this was a valid concern, and we have since set to work to improve education for families. Additional challenges cited by nurses often related to the practical aspects involved in planning around unpredictable sleep/wake cycles, especially when managing a busy assignment with several babies. It has also been difficult for parents to schedule visits for when the baby

## Clinical Implications

- Neonatal nurses are in a unique position to have an impact on their patients over the course of a lifetime.
- Avoid noise and excessive lighting when possible to minimize the NICU environment's impact on the infant's developing central nervous system.
- Providing for adequate rest and sleep may be the single most important contribution that bedside caregivers can make toward long-term outcome.
- Use cue-based caregiving during handling or clustered care to avoid energy loss and decompensation.
- Actively engage parents early on, empowering them to become expert at interpreting and responding to their infant's cues and needs.

would most likely be awake, and to resist the temptation to awaken their sleeping child. Efforts are underway to provide more consistent messaging about safeguarding sleep. There was strong adherence to the guidelines when initially introduced, but some concerns have been raised that compliance is gradually falling. The committee has posted reminders about core measures, and is considering additional strategies to help maintain momentum.

## Conclusion

Preterm birth forces critical neurologic growth and maturation to continue within the NICU. As observed by Peter Gorski (2006), "This is a time when every experience a child enjoys or suffers is fed into their growth, and most importantly, the growth of their emotional, cognitive, social, and communicative brain." Recognizing that every care provider in our neonatal care units had the potential to have an impact on these vulnerable infants throughout entire lifetimes, this QI project aimed to ensure that neuroprotective best practices were an essential aspect of daily caregiving at every bedside. When combined with evidence-based medical and nursing care, neuroprotective care is the best means to facilitate normal development and minimize disability among our NICU graduates. ✚

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