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The Neurointensive Care Nursery and Evolving Roles for Nursing

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ABSTRACT

Neonatal neurocritical care is an emerging subspecialty that combines the expertise of critical care medicine and neurology with that of nursing and other providers in an interprofessional team approach to care.^{1,2} Neurocritical care of the neonate has roots in adult and pediatric practice. It has been demonstrated that adults with acute neurologic conditions who are treated in a specialized neurocritical care unit have reduced morbidity and mortality, as well as decreased length of stay, lower costs, and reduced need for neurosurgical procedures. In pediatrics, neurocritical care has focused on various primary and secondary neurologic conditions complicating critical care that also contribute to mortality, morbidity, and duration of hospitalization. However, the concept of neurocritical care as a subspecialty in pediatric practice is still evolving, and evidence demonstrating improved outcomes is lacking.³⁻⁵ In the neonatal intensive care nursery, neurocritical care is also evolving as a subspecialty concept to address both supportive and preventive care and optimize neurologic outcomes for an at-risk neonatal patient population. To enhance effectiveness of this care approach, nurses must be prepared to appropriately recognize acute changes in neurologic status, implement protocols that specifically address neurologic conditions, and carefully monitor neurologic status to help prevent secondary injury. The complexity of this team approach to brain-focused care has led to the development of a specialized role: the neurocritical care nurse (neonatal intensive care nursery [NICN] nurse). This article will review key concepts related to neonatal neurocritical care and the essential role of nursing. It will also explore the emerging role of the NICN nurse in supporting early recognition and management of at-risk infants in this neonatal subspecialty practice.

Keywords: neonatal; neurology; neurocritical care; nurse

Neonatal neurocritical care is a rapidly emerging subspecialty building on adult and pediatric critical care practice experience and combining expertise in neurology and critical care medicine.^{1,2,3,6} It has been shown that adults with acute neurologic conditions treated in a specialized neurocritical care unit have reduced morbidity and mortality, as well as shortened length of hospital stay, lower costs, and reduced need for neurosurgical procedures.⁷ In the pediatric population, neurocritical care has been expressed as a care focus to support neuroprotective concepts, rather

than a distinct care setting or unit.⁴ Brain injury is common in pediatrics, and primary neurologic disorders and neurologic sequelae of critical illness often complicate care. As is the case with adults, pediatric intensive care patients experiencing neurologic complications have greater mortality and long-term morbidity, as well as increased duration of hospital stay.⁴ However, data demonstrating the impact of neuroprotective care on patients are lacking, and researchers recognize the need to generate data that support the contribution of this care focus in terms of improved outcomes.^{4,5}

In neonatal critical care, the development of neurocritical care as a subspecialty focus is recent, and preventive and supportive practices are continually being developed and tested. In 2008, UCSF Benioff Children's Hospital recognized the need to establish a neonatal neurocritical care subspecialty practice and established the Neuro-Intensive Care Nursery (NICN).⁸ The goal of this subspecialty practice, integrated into the NICU, was to manage neonates affected by or at risk for neurologic injury. The complexity of care needs for these at-risk infants, including specialized use of therapies such as therapeutic hypothermia, bedside brain activity monitoring, and pharmacologic interventions demanded creation of an expert, interprofessional team. Under the direction of a neonatal medical director, pediatric neurologist, and neurocritical care nursing coordinator, the NICN provides care for infants with primary and secondary neurologic conditions such as stroke, hypoxic-ischemic encephalopathy (HIE), seizures, and brain malformations, as well as those at risk for neurologic complications.⁹ Among the goals of the NICN are (1) provide brain-focused care using an interprofessional team approach, (2) provide rapid seizure response through early recognition and reduced time to treat, (3) support long-term follow-up care needs for infants at risk for or recuperating from neurologic injury, and (4) generate and disseminate cutting-edge research related to neurocritical care.⁹ Since it was established, the NICN has evaluated and/or cared for more than one thousand patients.

PATIENTS WHO MAY BENEFIT FROM NEUROCRITICAL CARE

Advances in critical care practices have improved survival in critically ill newborns; however, rates of neurologic complications in survivors are high. It has been estimated that one-quarter of infants admitted to referral nurseries have a neurologic complication or injury. These patients with acute, subacute, or chronic neurologic conditions are likely to benefit from focused neurocritical care and the expertise of a specially trained neurocritical care team that includes nursing.^{1,2}

The neonatal population served by the neurocritical care focus of the NICN currently includes critically ill infants with confirmed neurologic injury such as HIE, stroke, or intra/extracerebral hemorrhage, as well as infants at risk for injury. To support ongoing development and delivery of both supportive and preventive NICN care practice, staff including neonatal nurses need training, targeted education, and practice experiences. Since 2008, a core team that now totals 38 NICN nurses at our institution have received specialized education and training in elements of neurocritical care practice including common neurologic conditions in the newborn, hands-on mentored performance of neurologic exams, and use of neuromonitoring tools and hypothermia equipment. The bedside nurse may be the

initial person to recognize infants who display findings of brain dysfunction or injury, and nurses educated to recognize the clinical aspects of common neurologic illnesses can help optimize care of all neonates with or at risk for neurologic impairment.^{10,11} In addition to sustained training of a core team of NICN nurses who are the primary nursing care providers for neurologic patients, all nursing staff receive education in preventive and early-recognition strategies during general orientation and continuing education activities.

Many neurologic conditions can benefit from NICN care. Neonatal encephalopathy is estimated to complicate 2/1,000 births. Although relatively uncommon, it is a major cause of neonatal mortality and long-term disability in survivors.¹² Specific disorders in the term and preterm infant that may benefit from NICN care include seizures, HIE, stroke, intra- and extracerebral hemorrhage, central nervous system (CNS) infections, vascular malformations such as vein of Galen malformations, developmental brain anomalies such as holoprosencephaly, neonatal-onset epilepsies, and genetic and metabolic disorders.

Neonates with neurologic conditions may have multi-organ system dysfunction. Thus, the approach to effective comprehensive care for NICN patients must extend beyond the brain to other organ systems as well. The hypoxia and/or ischemia that contributes to the development of HIE, for example, may also manifest in multisystem dysfunction of the pulmonary, cardiovascular, gastrointestinal, hematologic, and renal systems.¹³ An interprofessional team approach to care that can adequately address multisystem needs is essential to provide effective anticipatory care to at-risk populations. Both bedside nurses and NICN nurses confident in the ability to recognize and intervene early with neurocritical care support will contribute to effective care practice. As an example, infants with acute symptomatic seizures or with benign or malignant neonatal-onset epilepsies will likely benefit from efficient recognition and prompt management of seizures.

Beyond management of neurologic injury that has already occurred, there is a role of the NICN in establishing care recommendations for preventive brain-focused care that can be integrated into the neonatal intensive care nursery practice for other at-risk populations. Preterm infants, especially those born <28 weeks gestational age or <1,500 g birth weight have increased rates of short-term and long-term neurologic complications including intraventricular hemorrhage (IVH) and poor neurodevelopmental outcomes. The incidence of IVH increases as gestational age decreases, and severe IVH complicates 12–15 percent of very low birth weight infants <1,500 g at birth.¹⁴ The NICN nurses, nursing staff, and other members of the NICN care team have the opportunity to develop and institute supportive care practices that can likely moderate the clinical course of preterm care and potentially attenuate risks for neurodevelopmental complications.

CLINICAL GUIDELINES TO SUPPORT TEAM-BASED NEUROCITICAL CARE PRACTICE

Clinical guidelines and checklists can facilitate standardization of care, prevent omissions, and improve quality of care and clinical outcomes. This is especially important when the care involves multiple professions who may not routinely collaborate in team-based care. When creating institutional clinical guidelines or protocols that will organize team-based practice, nursing involvement is essential to ensure that the guidelines can be reasonably and readily followed at the bedside and accepted by staff. Nursing staff—with support from the NICN nurse—can play a key role in the development, dissemination, and effective implementation of guidelines and care standards for neurocritical care practice.

Guidelines can provide staff with an algorithm-based approach of steps to take in the case of specific clinical conditions or deterioration, such as when seizures are suspected or for a child receiving therapeutic hypothermia. Effective guidelines will include patient eligibility, as well as recommended diagnostic tests, management solutions, and a timeline to guide actions. Having set guidelines allows the nursing staff to anticipate needs such as mobilizing electroencephalogram (EEG) or amplitude-integrated electroencephalogram (aEEG) monitors or obtaining STAT lab work such as serum glucose and calcium samples in the case of suspected seizures. A magnetic resonance imaging (MRI) guideline can help with patient safety by providing a list of steps for patient preparation, outlining the role of nursing during the scan, and ensuring safe transportation to and from the imaging locale. Pertinent guidelines (e.g., seizure guidelines) can be placed at the bedside and on the resuscitation carts for rapid access and consistent management. Finally, guidelines can help the nursing staff communicate next steps in care in a timely and consistent manner to the family at the bedside. The sidebar indicates some clinical guidelines that have been established at our institution.

BRAIN MONITORING

An aEEG is a bedside brain monitoring tool that is routinely used to assess background brain activity and to detect seizures. At UCSF Benioff Children's Hospital, the NICN nurse applies the brain monitoring leads as soon as the neonate is stabilized from a cardiopulmonary perspective. Once the EEG technician is available, the complete neonatal montage is placed around the adapted aEEG montage and plugged into the same head box. The montage used is the International 10–20 system, modified for neonates. There are various EEG lead types available; at our institution, we use the low-profile Spider EEG electrodes (manufactured by RhythmLink International, LLC, Columbia, SC) to minimize skin breakdown during prolonged monitoring, especially for infants undergoing hypothermia. The aEEG is displayed at the bedside, and, because all beds have remote

Suggested Clinical Guidelines for NICN Care

EEG = electroencephalogram
aEEG = amplitude-integrated EEG
NIRS = near-infrared spectroscopy
Seizure Management
MRI Transport and Management
Therapeutic Hypothermia
Palliative Care
Stroke
Nutritional Management During Cooling
Discharge and Follow-Up

data access, the neurophysiologist may view the full montage EEG remotely.¹⁵ At many centers, the aEEG is recorded and displayed on a separate machine that is used only for the adapted montage (e.g., BRAINZ, Natus Medical Inc., San Carlos, CA).

The NICN nurse can assist the bedside caregivers with operating the equipment and identifying at-risk patients who may benefit from brain monitoring. The aEEG interpretation is pattern recognition, and nursing staff can be trained to appropriately recognize common aEEG patterns, identify changes in background activity, and document seizures. With advanced training and ongoing clinical exposure, nursing staff, including the NICN nurses, can be well qualified to efficiently and effectively identify abnormal brain activity and respond appropriately.

SEIZURE DETECTION AND MANAGEMENT

Seizures are a common reason for seeking neurology referral because seizures typically indicate a serious neurologic issue.¹ In addition, evidence suggests that seizures themselves may contribute to neonatal brain injury.¹⁶ However, seizures in newborns are often subclinical and hence challenging to diagnose accurately¹; this supports the use of bedside monitoring to enhance seizure detection for at-risk infants. Seizures with an electrographic correlate may be recognized clinically as subtle findings such as vital sign changes, apnea or gaze deviations, or more obvious paroxysmal behaviors such as clonic movements of one or more limbs that cannot be abolished with containment.^{13,17} Recognizing behaviors that are more likely to be seizures can help with rapid diagnosis and treatment. The nurse may be the first to recognize electrographic seizures at the bedside as a change in aEEG monitoring. The NICN nurse and other nursing staff should be attentive to annotating pertinent events on the aEEG monitor tracing. This may include events that are concerning for seizure or activities likely to produce artifact including care procedures or comfort measures such as patting. Administration of medications such as sedatives or antiseizure medications may alter the aEEG background tracing,

and this should be documented on the monitor tracing as well.

For patients who are being monitored by video EEG, it is essential to ascertain that all pertinent data are captured. The video recorder must be positioned to allow for full visualization of the infant, especially the face. This can be challenging when multiple providers and family are at the bedside because the EEG camera may be inadvertently moved away from the patient. Annotating events such as suspicious infant movements or medication administration on the EEG recorder can be helpful for the reviewing neurologist.

When the bedside nurse or NICN nurse suspects seizures are occurring based on the aEEG data, he or she should determine clinical correlates and notify the team. For neonates with suspected seizures, additional nursing staff may be needed to quickly assist in stabilization of the infant, obtain serologic tests (typically STAT glucose and electrolytes among other labs), place an aEEG monitor, and notify the neurophysiology service to apply an EEG if this has not yet been requested. If seizures are confirmed, protocols for seizure management can be promptly initiated. The goal should be to administer antiseizure medications as quickly as possible. Developing a clear clinical guideline with algorithms to guide this practice in an individual institution will support added safety.

MAGNETIC RESONANCE IMAGING

Neuroimaging, specifically MRI, is often an essential part of the neonatal neurologic evaluation to help determine diagnosis and the prognosis.¹⁸ Nursing staff can be instrumental in providing safe transport of neonates to and from the MRI scanner, as well as providing ongoing monitoring and care during the procedure. To ensure patient safety, nursing staff must be knowledgeable about issues unique to MRI and transport and prepare for anticipated needs well in advance. Transport of critically ill infants to MRI requires that the nursing staff use MRI-compatible monitoring equipment and integrate information from the monitoring device into clinical decisions. Because the infant is in an environment in which metal is a safety hazard, all interventions must be thoughtfully planned so that safe use of MRI-compatible equipment can be assured. Infants undergoing MRI scanning may require sedation for the procedure, and the bedside nurse must anticipate potential apnea, bradycardia, or hypotension as a side effect of the pharmaceutical agent and be able to appropriately intervene.

To maximize efficiency when MRI is planned, the bedside nurse can have supplies and equipment ready in advance. At least one to two hours prior to the scheduled imaging study, the NICN nurse can apply MRI-compatible electrocardiogram (ECG) leads, oxygen saturation probes, and either skin surface or core temperature probes. Respiratory therapy equipment including the MRI-compatible ventilator

can be trialed and the endotracheal tube adequately secured. Additional MRI-compatible respiratory therapy equipment such as flow and self-inflating resuscitation devices and an MRI-compatible stethoscope can be gathered. Intravenous fluids can be transferred to an MRI-compatible pump and off-unit emergency medications obtained. If sedation is being considered, these medications can be retrieved from the pharmacy. Infants are at risk for temperature instability in the MRI suite. For those with suspected or confirmed brain injury, temperature must be closely monitored and kept within a normal range or within a target range consistent with the use of therapeutic hypothermia to help prevent secondary brain injury. To help maintain thermal stability and minimize patient movement artifact, an MRI-compatible papoose can be wrapped around the infant. Reducing motion artifact by restricting patient movement is critical to producing a high-quality MRI scan. Many infants can be imaged safely without sedation.¹⁹ As an alternative, the infant can be fed approximately 30–45 minutes prior to the MRI procedure and then swaddled to minimize movement. For critically ill infants who must remain NPO, however, sedation may be required to keep the patient comfortable and still. Figures 1 and 2 demonstrate preparation of an infant for MRI.

Those assuming care for the infant undergoing MRI scanning must be prepared to manage acute medical complications, such as sudden deterioration while the infant is within the MRI scanner device. Mock code practice exercises in the MRI suite can help the team, including the nursing staff and other medical, respiratory therapy, and MRI technology staff members feel prepared for emergencies. Debriefing after the procedure is another way for the team to review communication, roles, and any issues that arose.

FIGURE 1 ■ Image of preparation of infant for magnetic resonance imaging (MRI) in nursery.

FIGURE 2 ■ Image of manikin in papoose ready for magnetic resonance imaging (MRI).

THERAPEUTIC HYPOTHERMIA

Therapeutic hypothermia is a controlled, induced hypothermia strategy that is standard practice for management of HIE. It can be provided as selective head cooling or as total body cooling; both have been shown to improve clinical outcomes. Not all infants benefit from hypothermia, however, and up to 50 percent of treated cases may die or have severe neurodevelopmental disability.¹ The mechanism by which cooling works is not fully understood, but it is thought to moderate the secondary phase of neuronal injury following hypoxic-ischemic insult that is typically characterized by energy depletion and release of neurotoxic compounds.^{20,21} Since establishment of the UCSF NICN, more than 300 patients have been evaluated for the use of therapeutic hypothermia.

Caring for a patient undergoing therapeutic hypothermia requires that the nursing staff have a thorough understanding of HIE pathophysiology, risk factors for secondary injury, rationale for cooling therapy, and operation of the cooling apparatus. Preclinical data support the use of sedation during therapeutic hypothermia to optimize neuroprotection.²² At our institution, we use morphine sulfate for sedation. Our goal is to minimize shivering and discomfort during treatment. We typically initiate a continuous morphine sulfate infusion at 20 mcg/kg/hour at the start of the therapeutic hypothermia. Morphine pharmacokinetics during hypothermia and in the setting of asphyxia with end-organ dysfunction are not well understood, and there is concern that the pharmaceutical agent may accumulate during the course of hypothermia management. We adjust our dose based on the clinical examination and comfort of the infant, weaning daily as tolerated. We also discontinue morphine infusions at the onset of rewarming unless required to maintain comfortable ventilator support or for cases with a history of antenatal

exposure to opioids and concern for neonatal abstinence syndrome.

PALLIATIVE CARE AND FAMILY/STAFF SUPPORT NEEDS

Infants with severe neurologic injury are at risk for a shortened life span. Parents and providers together may choose to transition to a palliative care approach when a child has a neurologic condition incompatible with life or when the child with severe brain injury is expected to develop permanent severe neurodevelopmental impairments that require lifelong supportive care. The NICN nurse, in collaboration with the NICN team and intensive care nursery staff, can assist with transition of care by supporting parents; answering questions; encouraging family members to support the parents; involving hospital chaplain services; alerting the social worker to parent needs; and arranging for photographs, footprints, and other commemorative pieces. For infants who are expected to live for several weeks or months, especially those who are back-transported to a community facility or sent home for hospice care, incorporating a pediatric palliative care team early on can be beneficial. The palliative care team can help facilitate communication with the family, coordinate services for discharge and day-to-day management including pain control, and support the parents and nursing staff during an emotionally difficult time.

The complexity of meeting care needs for the NICN patient may be stressful for nursing staff, NICN nurses, and other staff. The NICN nurses and other staff who care primarily for these children may experience compassion fatigue and burnout. The acute progression to death in severely neurologically impaired neonates can be emotionally taxing.^{23,24} To support the NICN nurses and entire neonatal intensive care nursery staff, we have implemented the following strategies:

- Increased the pool of nurses with NICN nurse training to allow for breaks from the care of critically ill infants
- Provided education about more common neurologic illness such as HIE and updates on infants with good outcomes
- Enhanced communication efforts between the NICN nurse and team so that daily plans are effectively supported and include staff and the family
- Offered ethical care conferences twice monthly to discuss difficult cases
- Developed self-care retreats led by a psychologist two to three times yearly
- Supported access to a psychologist to speak with nurses and staff as needed

EFFECTIVE NEUROCRITICAL CARE TEAM COMMUNICATION AND DOCUMENTATION

Effective neurocritical care relies on assembly of an interprofessional team, dedicated training and education of these

care providers, and establishment of leadership roles that will support consistent application of guidelines and practices to optimize care.¹ In addition to expert clinical practice, effective communication among team members and between the interprofessional team and family is important for continuity of care. Daily bedside rounds are one way to ensure consistent communication and typically include the nursing, neonatal, and neurology teams as well as the family to ensure that everyone involved in the patient's care hears the same plan. At the end of the day, a nighttime plan should be determined and discussed between the team and the nursing staff. For infants who are at risk for seizures, a plan to review the monitoring data and seizure management should be discussed. Discussion might include a review of the appearance of seizures on the aEEG, when and how to contact the neurology service, and what treatment will be used. Having a plan, especially at the end of the day, assists the nursing staff and team in rapidly intervening when clinically indicated.

In addition to verbal communication, clinical assessment and brain monitoring findings should be thoroughly documented in the patient record. Changes in mental status or reflexes and aEEG patterns should be clearly documented and updated frequently. This is especially important with mental status because the infant's examination may fluctuate over time. With both verbal and written documentation, appropriate use of accurate terminology is critical. Using unambiguous descriptive terms rather than vague terminology is preferable. For example, documentation such as "when a heelstick was performed, the infant did not grimace or move" is much clearer and more useful than simply indicating the infant was "lethargic."

THE ROLE OF NURSING IN PREVENTIVE AND SUPPORTIVE NEUROCRITICAL CARE

Nursing care for infants at risk for neurologic injury includes performing a neurologic assessment and monitoring vital signs, laboratory values, and the effects of medications on the neurologic system. A baseline neurologic assessment should be performed at the beginning of the nursing shift. Key components of the nursing assessment include evaluation of mental status and responses to routine care and procedures. Mental status can be assessed by carefully noting how the infant responds when approached for care. The arousal response of the infant during routine care procedures is important to determine; excess sleepiness, lack of arousal, or irritability may be an important clinical finding suggesting neurologic injury. The quality of the infant's cry is another important observation in the neurologic exam. Appropriate response to noxious procedures should be determined; a newborn who does not expectedly respond to painful procedures with withdrawing and/or grimacing is of concern. Careful observation during routine procedures can further inform the neurologic exam. Absence of an expected gag reflex during suctioning or when passing a nasogastric tube is an important neurologic exam finding. When attempts to solicit a suck reflex are made, it is

important to determine the presence as well as strength and coordination of suck and swallow.

The neurologic assessment must be made in context of any medications that have been administered. For example, sedatives or analgesics such as morphine sulfate that have been prescribed regularly for infants undergoing therapeutic hypothermia may interfere with examination data. For infants whose encephalopathy is progressing, comfort needs must be balanced with the ability to detect mental status changes. In addition to the use of medications, severity of illness and the degree of pain can also impact the neurologic examination. Both pain and critical illness can compromise the infant's ability to make vigorous movement, and respiratory distress can limit the infant's ability to have a forceful cry or remain in an alert state. Frequent nursing assessment of the neurologic status, when carefully documented and communicated to the interprofessional team, can help inform management and assessment of prognosis.

In addition to ongoing assessment, nursing care also involves anticipating risk factors that might worsen neurologic status. Vigilant monitoring of the infant's temperature, blood pressure, blood chemistries, and glucose can help prevent secondary or iatrogenic neurologic injury. For example, infants receiving vasopressors are at risk for blood pressure fluctuations when the dosage is adjusted or when the syringe is changed and dosing is momentarily interrupted. These factors could result in an infant experiencing a sudden change in blood pressure that can have detrimental physiologic effects.

Nurses typically spend more time with the family than other care providers and are often approached with questions and the need for clarification from parents regarding neurologic conditions. When parents are informed that their infant has injury to a particular area of the brain and the infant might be at risk for motor or cognitive deficits, the news can be overwhelming. Parents might not remember the precise information about the injury or why special services are being recommended. However, based on experience with neurocritical care patients, attendance at family meetings, and training in neuroanatomy and developmental outcomes, the NICN nurse can review information with the family and reinforce the importance of high-risk infant and neurology follow-up and outpatient therapies.

EVOLVING ROLE OF THE NICN NURSE

The role of the NICN nurse, a specially trained neurocritical care nurse, addresses both routine neonatal nursing care and care requirements specific to the neurocritical care patient. The NICN nurses have responsibilities in early recognition/detection, prompt mobilization of supports, management of equipment, ongoing monitoring, and care and support of the family. As leaders, they collaborate with NICN nursing leadership and contribute to consistent application of guidelines and support a team culture of brain-focused supportive care.¹ They are also essential in contributing to the development of standards of care, generating data related to care practice, and

interacting with the neurocritical care interprofessional team. Early recognition of signs and symptoms of brain injury is critically important and includes attentiveness to changes in mental status and the neurologic exam as well as effective recognition of seizures. The NICN nurses must appropriately mobilize the interprofessional team as well as equipment to optimize efficient care. This may include securing equipment such as the cooling blanket, EEG/aEEG, or NIRS monitors as well as soliciting the support of additional personnel. The practice at UCSF Benioff Children's Hospital is to staff two NICN nurses per 12-hour shift in anticipation of newly admitted or identified neurocritical care patients.

The NICN nurses must be confident in their ability to perform frequent neurologic assessments and both document and communicate essential information to the interprofessional team. Essential information to effectively communicate includes the infant's state of arousal during care as well as baseline irritability, tone, movements, and response to painful procedures. Neurocritical care patients may be managed with pharmaceutical agents that affect performance on a neurologic assessment, such as sedation during therapeutic hypothermia or anesthesia for procedures. It is essential that the NICN nurse be aware of the impact of all care treatments including effects of medications when interpreting infant behavior.

Optimized triage is often the first role of the NICN nurse. Triage typically begins as soon as a call from a community hospital or the delivery room alerts the team to an infant with an acute neurologic condition. The NICN nurse is essential to quickly mobilize appropriate staff, equipment, and supplies and to access pertinent protocols in anticipation of the individual needs of the patient. With equipment quickly mobilized and the team alerted, and upon admission of the patient, the NICN nurse can rapidly apply neuroprotective therapies if indicated. For example, in cases of HIE, shorter time to onset of therapeutic hypothermia is associated with better outcomes.^{21,25,26} This strategic mobilization can optimize rapid stabilization of basic physiologic functions (including blood pressure, glucose, oxygen, acid-base, and electrolyte status) and help prevent secondary injury.

A dedicated NICN nurse is most important during the first days of critical illness, when the risk of acute symptomatic seizures is highest and care focused on preventing secondary injury through attention to basic physiologic needs has the greatest impact. At UCSF Benioff Children's Hospital, infants with acute neurologic illness such as seizures or encephalopathy requiring therapeutic hypothermia typically receive 1:1 nursing care and are managed by a NICN nurse. This low patient-to-nurse ratio allows time to perform a comprehensive neurologic assessment and interval examinations throughout the shift, evaluate supportive data such as lab indices or bedside monitoring data, discuss findings with the interprofessional team, communicate with the family, and document in the medical record. Staffing with at least two NICN nurses per 12-hour shift allows for one NICN nurse to care for the infant, while the second NICN nurse can be a

resource or available for a second NICN admission. At UCSF Benioff Children's Hospital, approximately one-third of the nursing staff is currently trained as NICN nurses.

EDUCATION AND TRAINING OF THE NICN NURSE

Specialized training in recognition and appropriate management of the at-risk neurocritical care patient is essential for the NICN nurse participating in neonatal neurocritical care practice.^{1,2} Didactic courses and hands-on practice opportunities that instill essential information and support clinical skill acquisition are important to the development of competency and confidence in this critical care role.^{11,27,28} At our institution, education and training through classroom sessions and hands-on practice experiences help prepare the NICN nurse to care for neonates with neurologic illness. Didactic classes are organized and provided by the NICN nursing coordinator in association with the nursery nurse educator and cover fundamentals of neurologic care, including

- Performing a comprehensive neurologic assessment
- Brain anatomy and physiology
- aEEG pattern recognition
- HIE
- Neonatal seizures, recognition, and management
- Metabolic disorders with possible neurologic correlates
- Perinatal stroke
- Palliative care for infants with neurologic injury
- MRI transport logistics
- Therapeutic hypothermia
- Care of the NICN family

Hands-on practice experiences include setting up and operating cooling equipment, aEEG and video EEG, near-infrared spectroscopy (NIRS), MRI equipment, and transport processes. In addition to didactic training and hands-on practice experiences, the NICN nurse completes a module and posttest to reinforce acquisition of core concepts of neurocritical care. The NICN nurse trainee is then paired with an experienced NICN nurse to assist with care for an infant undergoing neurointensive care. After this mentored training experience, the new NICN nurse is assigned to care for an infant undergoing therapeutic hypothermia on the second day of cooling and then progresses to assuming responsibility for a newly admitted cooling patient and a cooling patient undergoing rewarming. Following this immersive experience, the NICN nurse learns to accompany neurocritical care patients to the MRI scanner.

During the initial period of developing competency in NICN skills, staffing assignments ensure that an experienced NICN nurse is paired with a novice. This balance of experience allows the seasoned NICN nurse to support by answering questions, providing feedback, reinforcing expectations, and providing expert modeling. Competency in NICN nurse skills is maintained by regular assignment to neurocritical care patients, optimally one patient every one or two months. In addition, the NICN nurse receives ongoing feedback from

peers and the NICN nurse coordinator. Self-assessment of learning needs is expected, and the NICN nurse participates in yearly evaluation specific to neurologic skills and quarterly meetings of the NICN team to discuss difficult cases and education and support quality improvement.

CONCLUSION

This article describes the development and support of a unique practice model of specialized neurocritical care that has the potential for substantial impact on the neonate experiencing or at risk for neurologic injury. Nursing, and specifically the NICN nurse, is integral to the implementation of this concept of subspecialty care practice. With specialized education and training in care needs and therapeutic strategies for the at-risk neurocritical care patient, this expert nursing provider can assume a pivotal role in supporting comprehensive care practice.

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