# INFANT STRESS IN NEONATAL INTENSIVE CARE UNIT

## RECOGNIZING AND MINIMIZING NICU STRESSORS IMPROVES OUTCOMES IN FRAGILE PRETERM INFANTS

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An emerging body of clinical research highlights the inherently stressful environment of the neonatal intensive care unit (NICU), and the growing recognition that managing pain and stress in preterm neonates enhances the likelihood of better medical and neurodevelopmental outcomes.[1-5] Many common NICU interventions have been shown to produce neonatal stress, which has negative impacts on the health of preterm infants.[1-3,6-9] Though many of these stressors cannot be avoided completely, most can be reduced or countered—and some can even be eliminated—while maintaining the best standards of care. By recognizing and monitoring infant stress, NICU staff can implement effective interventions that help their fragile patients recover and thrive.[6,10-14]

## HOW STRESS IMPACTS OUTCOMES

NICU stress has both immediate damaging effects and long-term repercussions on neonatal health, some of which the clinical community is just now starting to understand. Researchers have demonstrated that stressful events are associated with increased heart rate and blood pressure, as well as decreased oxygen levels in preterm babies.[2,8] In addition, research has shown that stress responses have been observed as early as 29 weeks gestational age, and that the magnitude of the response increases with the number of prior painful procedures.[15] Consequently, there is growing recognition that accumulated stress and the additive impact of multiple stressors occurring over time affect developmental outcomes, notably brain and behavioral health.[2,4,6,16]

***"There is mounting evidence that repeated stress, especially that occurring during the critical early period of infant development, has profound and long-lasting effects on several physiological systems, including the central nervous system."***

**—Newnham et al., 2009[2]**

### THE DEVELOPING NERVOUS SYSTEM

The cumulative effect of NICU stressors impacts several physiological systems, and occurs at a time of extreme central nervous system (CNS) vulnerability.[2,4,16] With the marked growth and development taking place in the perinatal brain, neural damage is a significant concern for all neonates—and especially premature infants[2-5]— thirty to sixty percent of very preterm patients will experience cognitive deficits and social and emotional difficulties during their lives.4 Recent research has also shown that NICU stress is correlated with MRI scores of brain injury and impaired brain structure and function[3-4], underscoring the long-term consequences of NICU stress.

***"We believe that stress, rather than simply being a marker of severe illness, is the pathway from severe illness to altered brain development."***

**—Smith et al., 2011[4]**

### SOURCES OF STRESS IN EVERY NICU

Common procedural and environmental stressors present in nearly every NICU can add to the inherent challenges of premature birth, medical condition and interrupted parenting.[1-3,6-9,17] Caregiving procedures disturb rest and often bring discomfort or pain with physiological and neurodevelopmental consequences for the infant.[2,4,18-19] Some of the ways the NICU environment itself can contribute to stress are bright lights, bustling activity and alarm and equipment noise.[1,8,12] Together with the medical conditions requiring and sometimes resulting from hospitalization, and the accompanying interruption of parental nurturing, these factors present a highly challenging experience for vulnerable neonates.[16]

***"Preterm infants in NICUs...have been bombarded by aversive stimuli, including bright fluorescent lights, noisy equipment, and painful procedures."***

**—Aucott et al., 2002[1]**

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### PROCEDURAL STRESSORS

It is important to note that the average daily exposure to stressors is greatest in the first 14 days of life.4 During their time in the NICU, neonates' fragile systems are subjected to as many as 16 stressful procedures a day—most commonly nasal and tracheal aspiration, heel lance and adhesive removal.[18] Moreover, these interventions may be administered with limited attention to pain relief.[17,20-21]

In addition, preterm infants are particularly sensitive to tactile stimulation and pain, compounding the impact of procedural stress.[16,19-20] Exposure to procedural discomfort in neonates and especially preterm babies has been implicated in sensitization of pain pathways, long-term alterations in stress response and potentially damaging effects on neural structure, function and development.[3,5,20,22-23]

Another source of vulnerability for neonates is that their skin is extremely fragile—approximately 50% thinner than adult skin[24]—and skin and soft tissue infections are common among NICU patients.[25] Consequently, a procedure as routine as adhesive removal can damage neonates' skin.[24]

Even nonpainful procedures such as a position change or administration of medicine through an existing IV can cause a stress response in preterm infants.[1-3] Reducing the number of procedures needed, while minimizing any associated pain, discomfort or risk of infection can help ease the patients' stress levels and allow more uninterrupted rest.

Studies of breathing assistance in intensive care settings suggest that systems providing more synchronized ventilation, matched to the patient's lung volume and breathing rhythm, may improve patient comfort and health outcomes.[26-28] Asynchronous ventilation has been associated with increased markers of stress and blood pressure variability, as well as increased work of breathing.[28] In contrast, synchronous ventilation has been shown to facilitate weaning and lead to shorter duration of mechanical ventilation[28], which has been shown to reduce the risk of ventilator-acquired pneumonia in NICU patients.[29]

While noninvasive ventilation is increasingly preferred, air leaks are common and have been shown to lead to asynchrony and increased work of breathing.[26,28,30-31] Ventilator equipment and software that compensate for leaks promote synchrony[31-32], which in turn lowers the work of breathing.[33-34] In addition, accurate tidal volume delivery reduces risk of ventilator-associated lung injury and ventilation-perfusion mismatch, protecting fragile patients with small lung volumes.[26-27,35]

### ENVIRONMENTAL STRESSORS

The NICU environment is inherently stressful and research has shown that common NICU disruptions such as noise, bright lights and frequent infant handling impact neonate heart rate, respiration rate and oxygen saturation.[2,8,11-12] These physiologic signs of stress result in higher oxygen demand and calorie consumption, which can impact growth and healing.[8,12]

However, there are straightforward ways to address these stressful stimuli such as cycling lights day-to-night, instituting "quiet" times of reduced handling, and minimizing alarm noise to reduce patient stress responses in the busy NICU.[11]

***"Light, sound, and caregiving interventions are the main environmental stressors that are harmful to preterm infants in NICUs."***

**—Peng et al., 2009[8]**

Alarm noise and frequent bedside visits to check monitors can disturb patients' rest.[1-3,8,11] Prolonged response times to bedside alarms can contribute to increased stress in neonates.[11] Remote monitoring is intended to be used by healthcare professionals to remotely consult patients' status and to review other standard or critical near real-time patient data, waveforms and alarms in order to utilize this information to aid in clinical decisions and deliver patient care in a timely manner.[36]

Remote monitoring systems can reduce the need to disturb patients to check their condition—allowing more time for uninterrupted sleep—while improving staff access to vital information and reducing unnecessary clinical interventions.

## OBSERVING AND MEASURING NEONATAL STRESS

Given the growing awareness of the clinical significance of NICU stress, researchers have focused on this issue and developed protocols and scales for assessing stress in neonates[2,8,10,37] with the goal of developing standards of care to reduce stress whenever possible.

### THE NEWBORN INDIVIDUALIZED DEVELOPMENT CARE AND ASSESSMENT PROGRAM

With a focus on neurological and neurodevelopmental outcomes, Als and colleagues developed the Newborn Individualized Development Care and Assessment Program, or NIDCAP.[10] The program begins with the use of an instrument called the Assessment of Preterm Infants Behavior (APIB) to observe neonate behavior. Using this detailed observational tool, clinical staff can interpret the infant's behaviors as steady and relaxed or as representing stress or discomfort. Interventions are designed to reduce stress and allostatic load based on the APIB observations.

The NIDCAP program has demonstrated improved medical stability, earlier weaning from ventilation, earlier transition to breast and bottle feeding, shorter stays in the NICU and lower costs of care.[38] EEG and MRI measures of brain structure and function have also shown improvement in groups receiving the NIDCAP intervention.[10,38] While the NIDCAP provides a useful protocol, it requires considerable time and training to perform.

## THE NEONATAL INFANT STRESSOR SCALE (NISS)

As a first step in the standardized assessment of a range of stressors in newborns, Newnham and colleagues developed the Neonatal Infant Stressor Scale (NISS).[2] Based on a survey of physician and nurse impressions of infant responses, the NISS assigns weighted values to specific NICU procedures on a five-point scale from "a little stressful" to "extremely stressful." In this way, the rating instrument standardizes and quantifies common stressful experiences, enabling clinicians to tally a cumulative daily stress score for an infant. The authors recommend use of the NISS, in conjunction with standard observations of pain, as an aid to develop and guide clinical interventions when stress levels are too high.

## OBSERVING AND RECORDING PHYSIOLOGICAL AND BEHAVIORAL SIGNS OF STRESS

Peng and colleagues[8] have identified operational definitions of physiological stress signals in the neonate, which are closely related to pain responses, together with eight behaviors associated with NICU environmental stress. This provides a very streamlined format for busy NICU staff to observe and respond to neonatal stress.

## OPERATIONAL DEFINITIONS OF PHYSIOLOGICAL STRESS SIGNALS IN THE NEONATE

- Heart rate <100 bpm or >160 bpm, or increase in baseline of 5 bpm or more
- Respiration rate irregular, <40 breaths per minute or >60 breaths per minute, or increase in baseline of 7 breaths per minute or more
- Oxygen saturation <90%, or a decrease of 2.5% or more from baseline or last value in trend

Table 1. Behavioral signs that are significantly correlated with NICU stress

| | |
|---|---|
| 1. Grimace | 5. Finger splay |
| 2. Hand to mouth | 6. Salute |
| 3. Holding on | 7. Sitting on air |
| 4. Sucking | 8. Yawning |

***"There is an exciting potential to design the NICU . . . in a way that enhances normal CNS development, supports recovery from CNS injury and protects the developing CNS from further injury."***

**—Aucott et al., 2002[1]**

## CONCLUSIONS

Many dedicated clinical researchers have helped to raise awareness in the NICU community about the role of stress on long-term health and neurodevelopmental outcomes. These researchers have also provided the clinical community with tools to raise awareness about NICU stress, measure and assess it and design interventions to help reduce its impact. In parallel, biomedical engineers have made advances in the design of medical devices to help alleviate procedural stress on this fragile patient population. All institutions should be encouraged to implement protocols to assess and reduce stress on the neonate. Utilizing both the standardized clinical tools that have been developed, and the advances in medical device design, will provide the basis for interventions and measuring change, not only within an institution, but across institutions as well. These efforts will promote awareness and further contribute to this important body of knowledge and enhance clinical care and outcomes.

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