

Developmental Care for High-Risk Newborns: Emerging Science, Clinical Application, and Continuity from Newborn Intensive Care Unit to Community

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- High-risk neonate • Developmental care • Infant development
- Attachment • Kangaroo mother care

NEURODEVELOPMENTAL OUTCOMES OF HIGH-RISK NEWBORNS

Neonatology has made astounding technological, pharmacologic, and intervention changes over the last 4 decades, resulting in the survival of earlier-born and sicker infants worldwide. However, the prevalence of major sensory and more subtle cognitive, communication, motor, and neurodevelopmental sequelae, both short and long term, have not shown concomitant improvement, particularly in the very-low-birth weight and extremely low-birth weight categories.¹⁻³ In addition, more attention has been

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directed to the identification of preterm and low-birth weight infants who also develop mental health issues such as attention-deficit and attention-deficit/hyperactivity disorders, anxiety disorders, and difficulties with emotion regulation.^{4–10} Many investigators have identified a significant proportion of prematurely born children as having behaviors consistent with a diagnosis of autistic disorder.^{11–13} In addition, recent findings of a large cohort of infants in Europe showed that infants with lower gestational ages showed crying, eating and sleeping problems, indicative of early regulatory disorders.^{14,15} The occurrence of 1 or more of these regulatory difficulties in the first few months of life were found to be predictive of later cognitive and behavioral challenges as they increased into the toddler and preschool years.¹⁶

The cause of these findings is not readily understood, but it is thought that early environmental influences on the brain during a particularly sensitive developmental period account for some of these nonoptimal neurodevelopmental outcomes. To date, no specific pharmacologic or technologic strategies have been offered to ameliorate these findings.

EMERGENCE OF DEVELOPMENTAL CARE

The practice of developmentally supportive care (DSC) has evolved over the recent decades, with variations in definition and clinical application but an overarching primary goal of improving the short- and long-term neurodevelopmental outcomes of high-risk newborns. Early recognition of the physiologic impact of the acoustic environment and handling on the high-risk newborn prompted investigations of how professionals might modify the caregiving environment in the newborn intensive care unit (NICU) to reduce stress and promote development.^{17,18} Professionals began to understand the detrimental impact of overwhelming sensory input and procedures on the developing newborn brain^{19,20} and proposed the term environmental neonatology²¹ to address this emerging science. Simultaneously, the unique behavioral organization of the high-risk newborn was being described^{22–25} and advances in knowledge of the effect of stressful environments on brain development were being articulated.²⁶ As professionals recognized the potential to reduce or modify the impact of the physical and caregiving environment on infant neurodevelopment, approaches described as DSC and neurodevelopmental therapy were introduced into the vocabulary and practice of NICU professionals.^{20,27,28} Early interdisciplinary study panels that synthesized the then current thinking regarding both the sensory as well as the caregiving environment for high-risk newborns provided a blueprint for further research necessary for a scientific foundation to improve the physical approaches and articulates developmental care approaches. The field became recognized as having empirically evaluated interventions and recommendations for interventions.^{29,30} An emphasis was also put on the incorporation of more humane caregiving for high-risk infants and their parents.^{31,32}

Further research into the impact of the caregiving environment revealed significant physiologic and behavioral disorganization responses to obviously painful and stressful procedures.^{33–36} The experience of repeated pain by the neonate can have significant short- and long-term consequences for brain organization during sensitive periods of development.^{37–39} Infant responses to being handled and to typical NICU caregiving routines and procedures such as bathing,^{40,41} weighing,^{42,43} and diaper change^{44–46} indicated that these seemingly innocuous events were also perceived as stressful to the developing infant. Although a review of pain amelioration is not addressed in this article, the reduction of painful procedures and the support of the infant during necessary noxious procedures is a priority of developmentally supportive caregiving.

EMERGING CONTRIBUTIONS OF BASIC SCIENCE TO UNDERSTANDING EARLY DEVELOPMENT

As clinical studies of DSC were developing in NICUs, developmental psychobiologists were providing an understanding of early development from a basic science perspective. Because of the differences in foci and application of basic science and clinical research, few of their studies were applied to understanding the developing human newborn. However, the contributions of these psychobiologists in the areas of sensory development, chemosensory recognition, tactile and kinesthetic development, epigenetic consequences of early birth, and the role of the early parent-infant attachment relationship (see reviews by Sullivan and colleagues; Champagne and colleagues elsewhere in this issue) have assisted NICU professionals in the application of basic science findings to clinical questions that cannot be examined in the human neonate. Their work has emphasized the potential for sensitive periods in fetal and newborn brain development. These psychobiologists have articulated the importance of experience-dependent and experience-expectant development and have contributed to our understanding of environmental influences on brain organization. They have also assisted us in the understanding of the importance of the early attachment relationship between the offspring's mother, based on unique sensory, thermoregulatory, and circadian rhythm cues (for application of these findings to NICU care⁴⁷⁻⁴⁹).

EMERGENCE OF ENVIRONMENTAL DESIGN CHANGES

The environment in which newborns live and grow influences their development and is an integral contributor to how developmental care is provided. The physical environment, including light, sound, temperature, activity, and space has an impact on development, just as the caregiving environment has an impact. Recognizing the emerging science of healing environments and their contribution to optimal health outcomes, interdisciplinary consensus panels for NICU design have developed evidence-based standards for developmentally supportive environments.^{29,30} Provision of optimal developmental care requires sufficient environmental modification for infants to have ready access to their familiar and unique mothers (and fathers) who are able to provide a consistent, intimate, regulatory secure base for development. Incorporated into the NICU design standards are recommendations for enough space, supports, and considerations for restful, private, and nurturing caregiving by the baby's family. Single family room design is now emerging as the optimal environment for neonates and their family^{29,50} (also see article by White elsewhere in this issue).

The caregiving environment for newborns is ideally provided by the mother's body. For several decades kangaroo mother care, otherwise known as skin-to-skin care, has been used to provide an early regulatory and nurturing experience for newborns. Recent research has provided ample data on the safety and efficacy of this approach even with high-risk newborns.⁵¹⁻⁵³ A combination of a family-centered environment, individualized developmental care, and almost exclusive kangaroo mother care in a Swedish NICU has demonstrated a significant reduction in length of hospitalization.⁵² Promoting the family's presence for the entire length of stay could be the catalyst of this synergistic approach to NICU developmental caregiving and could result in more competent parenting over the continuum of the first days, weeks, and months of the infant's life.

DSC IN THE NICU

The term developmental care is frequently associated with the work of Heidelise Als, a pioneer in neurodevelopmental assessment and intervention for preterm infants.

Als and colleagues have provided the most theoretically driven, systematically applied, and rigorously evaluated developmental care approach to date. Described as individualized DSC, their approach incorporates regularly scheduled observations of the individual infant's behavioral communication before, during, and after a caregiving intervention and, using those observations, summarizes the infant's developmental goals and provides recommendations for caregiving (for a comprehensive description, go to www.nidcap.org). The Newborn Individualized Developmental Care and Assessment Program (NIDCAP) provides comprehensive and in-depth training in this approach.⁵⁴ Elements of NIDCAP address modification of the sensory environment, including the bed space and bedding; being responsive to the infant's communicated strengths, needs, and goals; and integration of the parent into the intimate care of the infant. Throughout the training and application of the approach, emphasis is on supporting a nurturing and growth-promoting relationship between caregivers and infants, professionals, and family members as well as among professionals.

Als and colleagues⁵⁵⁻⁵⁷ have demonstrated comprehensive research into the application and outcomes of the NIDCAP work. NIDCAP studies have shown advantageous medical, neurobehavioral, and brain structure and function effects for very-low-birth weight infants in the newborn period⁵⁸⁻⁶¹ and consistency into adolescence.^{62,63} Buehler⁶⁴ showed neurodevelopmental benefits for a later-born and higher weight group of infants using the NIDCAP approach. More recently, Als and colleagues⁶⁵ demonstrated that brain structure and function as well as behavioral organization in intrauterine growth-restricted infants were enhanced after application of the NIDCAP.

Other investigators have replicated the NIDCAP approach in larger populations of infants than were included in Als and colleagues' original studies. Peters and colleagues⁶⁶ found that length of hospitalization and incidence of chronic lung disease was reduced in NIDCAP-treated infants and, at 18 months' corrected age, the children were less likely to have a disability. However, in another large study, Maguire and colleagues⁶⁷ did not find similar beneficial results of NIDCAP. The question of a dose response has been offered because the infants in this study were transferred to outlying hospitals much more quickly than in other related research and may not have had repeated NIDCAP observations and ongoing intervention. Considerable interest has been generated regarding the NIDCAP individualized developmental care approach, prompting several comprehensive reviews of research findings.⁶⁸⁻⁷⁰ All reviews call for more research of individualized developmental care that can address limitations in the current studies and determine factors that have led to a variety of positive short-term outcomes. Regardless of the acceptance of the benefits of NIDCAP from a scientific perspective, in clinical practice there have been no detrimental effects noted by the application of this approach in NICUs. Instead, the infusion of the NIDCAP work into NICU caregiving practices is experiencing global implementation.

THE EARLY INTERVENTION CONTINUUM

DSC could be perceived to be on a continuum of early intervention that starts with good prenatal care, including attention to the mother's physical and mental health and continues throughout the hospital NICU stay and then after the infant has been discharged to the community. James Heckman,⁷¹ a Nobel laureate in economics, has postulated that investment in early intervention can produce long-term benefits to not only the individual and the family but also the society. His recent

antenatal investment hypothesis proposes an economic rationale for intervention even to the antenatal period to have the best personal, social, and government economic return.⁷²

Results of a variety of early intervention studies have cumulatively documented the importance of nurturing and responsive relationships between children and their primary caregivers⁷³ and have resulted in children whose socioemotional development is supportive of optimal cognitive development and behavioral regulation. An increasing number of early intervention studies for high-risk infants have provided a continuum of developmental care from NICU to home. Rauh and colleagues⁷⁴ developed the Mother-Infant Transaction Program (MITP), which provided mothers of high-risk very-low-birth weight newborns guidance in interacting with their infants during 7 one-hour sessions in the NICU and then 4 home visits during the infant's early months. These guidance sessions were similar in basic concepts to the individualized developmental care strategies used in NIDCAP programs and based on the support of the ongoing mother-infant dyadic relationship. Seven- and 9-year outcomes revealed significantly higher achievement scores and general cognitive outcomes favoring the infants who received the intervention compared with those who did not.^{75,76} Recently, several European and Australian early intervention programs have adapted the MITP approach to their settings and have demonstrated more optimal parent-infant interactions,⁷⁷ cognitive scores at 5 years,⁷⁸ behavioral and brain organization, and a reduction of parent stress.⁷⁹⁻⁸¹ Other early intervention programs not started until after discharge have also shown positive effects on achievement scores and behavior. The Infant Behavior Assessment and Intervention Program, adapted from the NIDCAP approach in the NICU,⁸² has shown motor improvements at 24 months.⁸³ Other studies that have focused on the mother-infant relationship have described less maternal depression and anxiety in the mothers after intervention, likely influencing not only the relationship but also infant developmental outcome.^{58,82} Of note is a report on the 18-year follow-up of the Infant Health and Behavior Project, which provided intensive home- and center-based intervention after discharge from the NICU; this study found more optimal achievement outcomes for higher-birth weight children than those born at a lower birth weight.⁸⁴ Taken together, these developmentally supportive early intervention approaches may prove to have positive effects on the mother-infant relationship, behavioral regulation, and later cognitive and motor function.

Intervention for high-risk newborns has typically been segmented into either NICU developmental care or home- or center-based early intervention services. It may be that providing a continuum of care, using similar theoretical foundations and intervention strategies that focus on early parent-infant relationships, will prove to provide neuroprotection in the respective caregiving environments. It is well known that children in families who experience multiple social and economic risk factors suffer cognitively and behaviorally when compared with children whose families do not experience similar risks.⁸⁵ Provision of developmentally appropriate, family supportive, early intervention begins with excellent prenatal preparation for parenting and prevention of early birth. Sensitive individualized DSC provided in the NICU should also support the competent parenting through enhanced parent-infant relationship and continue throughout the early months after discharge. This provision of a continuum of care may provide the answers to the questions regarding possible benefits for optimizing infant neurodevelopmental outcomes.⁸⁶ It is essential for NICU professionals to ensure collaboration with community resources, evaluation of infants for the development of their Individual Family Service Plan, and follow-up with the community early intervention team.^{87,88}

ASSESSMENT OF NEURODEVELOPMENTAL OUTCOMES

Most neurodevelopmental outcome studies focus primarily on cognitive, communication, and motor functioning. However, many of the neurobehavioral evaluation instruments used perinatally are not reliably predictive of later outcomes,⁸⁹ may not be sensitive enough to distinguish more subtle developmental deficits,^{89,90} or do not assess early regulation as a contributing factor in the infant's development. Longer-term outcomes of developmentally supportive intervention provided in the NICU, perhaps more subtle than are currently measured by typical outcome measures, may not be distinguishable with currently used evaluation instruments. Current research that provides more sensitive and rigorously evaluated early assessments is beginning to predict later outcomes.^{89,91} Redefining what outcome or outcomes may reflect optimal neurodevelopment and resulting brain organization may help the field to determine the most appropriate developmentally supportive intervention that is needed. For example, better techniques of determining the impact of early regulatory disorders of feeding, crying, and sleeping along with appropriate evidence-based intervention programs may not only enhance the infant's organization during a potentially sensitive period of brain development but also affect the caregiving relationship between the infant and the mother.

SUMMARY

Neonatology has invested much in technological, pharmacologic, and medical intervention strategies which have improved the survival of increasingly younger and sicker newborns. However, improving neurodevelopmental and socioemotional outcomes has been elusive. DSC aims to ameliorate these potential consequences and contribute to better brain organization during periods of rapid growth and development. DSC for high-risk newborns focuses on understanding the baby's communicated developmental goals and supporting his or her attempts to become organized at a higher level of development. It also respects and advocates for the mother's (and father's) availability to be the infant's best regulator, comforter, nurturer, and protector. Developmental care is informed by and integrates knowledge from basic developmental science, contributions of environmental design, the sensory impact on brain development, and clinical studies of the effect of NICU caregiving on infant organization. Individualized developmentally supportive caregiving provided by the NIDCAP approach is the most rigorously studied and organized program to support relationship-based intervention. More extensive and thorough research needs to be conducted to determine the specifics of benefits and risks of optimizing infant neurodevelopmental outcomes. It seems prudent to provide similarly designed and theoretically similar approaches across NICUs and home intervention for continuity and family support.

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