

NEURODEVELOPMENTAL CARE OF PRETERM INFANTS AND ITS KEY ELEMENTS

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During the past few decades, advancements in the perinatal and neonatal intensive care have led to a significant survival of premature infants. However neurodevelopmental outcomes remain the major issues of concern. Developmental care is an approach that aims to reduce the mismatches between the extra- and intra-uterine environment, decrease the stress of preterm newborns in neonatal intensive care units, and thus promote optimal neurobehavioral development of the infant.

The Newborn Individualized Developmental Care and Assessment Program (NIDCAP) model was developed as a clinical framework for the implementation of developmental care. The model focuses on detailed reading of each individual infant's behavior. By observing the infant during a routine assessment (before, during and after) and a detailed description of his/her behavioral responses, a professional can assess the ability of the infant's immature nervous system to tolerate the environment and care manipulations. Such evaluation will enable one to determine the adequacy of the environment and care to meet the infant's opportunities and needs, with subsequent corrections and adaptation. NIDCAP's aim is to support the infant in his/her interaction with the environment as an active participant in caregiving within a family.

With the help of NIDCAP approaches in neonatal care medical staff will study how to read and interpret infants' behavior, thus hearing their voices.

KEY WORDS: **developmental care; NIDCAP; preterm infants.**

Introduction

Today the number of premature births is increasing. According to the World Health Organization (2012), every year about 15 million babies are born prematurely – more than one in 10 of all babies born around the world, affecting the families around the world. In developed countries of Europe and USA the incidence varies from 5 to 12% [1, 2, 3], and may reach 40% in less developed regions [2].

During the past few decades, advancements in the perinatal and neonatal intensive care (the use of antenatal corticosteroid therapy, surfactant therapy, and improved ventilatory techniques) have led to a significant survival of premature infants with gestational age less than 32 weeks [4]. The percentage of newborns with gestational age less than 32 weeks (extremely preterm and very preterm ones) is 1-2% in developed countries [1].

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However, despite the positive results of survival, morbidity and complications associated with premature birth are growing rapidly [2, 3]. Preterm babies meet with a large number of negative factors, since the beginning of their extrauterine life passes in the NICU (neonatal intensive care unit) environment, where such factors as light, noise, highly advanced non-invasive and invasive manipulation and pain dramatically affect the whole immature organism, resulting in early short-term and long-term complications.

Neurodevelopmental outcome has become a benchmark in determining the effectiveness of medical neonatal care [5]. The incidence of disability and neurodevelopmental problems among survivors of neonatal intensive care remains high and problematic [2, 6, 7]. Severe neurological complications (cerebral palsy, moderate to severe mental retardation, epilepsy, poor motor skills, sensorineural hearing loss, blindness) still remain consistently high. Moreover, by the age of 8 years, over 50% of very low birth weight preterm children require special

educational services and 15% have repeated at least one grade in school [3, 8, 9].

However, these are not the only neurological problems. The implementation of extended follow-up monitoring, using modern methods and scales of neurological evaluation allow us to identify more and more neuro-developmental disorders in children. These disorders include learning disabilities, low average IQ scores, attention deficit, hyperactivity disorders, neuropsychological deficits, visual motor disintegration, executive function difficulty, varying temperament difficulties, language delays, emotional problems and regulatory disorders [5, 8]. 50–70% of very low birth weight premature infants suffer from these dysfunctions [3, 10].

In order to provide not only survival, but to optimize long-term health and development, it is necessary to know the features of brain development of the fetus in the intra-uterine environment and of the premature baby in the extrauterine space. The development of the brain of the full-term infant takes place in utero where the infant resides in a temperature-stable environment, receives all the nutrients, undergoes circadian rhythm, and most importantly, feels maternal presence and permanent protection [11, 12]. Prematurely born infants are deprived of all these favorable conditions in the most critical period when their brain is growing and developing most intensively [13]. At the same time, they are exposed to excessive manipulation in a high-technology medical NICU environment. The mismatch between the preterm infants' need that are necessary for brain development, and the realities of intensive care units may cause serious problems of neuro-physiological, psycho-emotional and psychosocial development.

Developmental care is an approach that uses a range of medical and nursing interventions that aim to reduce the mismatches between extra- and intra-uterine environment, decrease the stress of preterm neonates in NICUs, and thus promote optimal neurobehavioral development of the infant.

Review

The framework of developmental care views preterm infants as fetuses who find themselves too early and unexpectedly in a technologic hospital environment instead of the evolutionarily promised mother's womb [3, 14]. Behavioral individuality of each infant is the basis of neuro-developmental care. Each infant is seen as an active participant in all elements and at

all stages of care. An infant's behavior provides the best information to determine the care management [14, 15].

The Newborn Individualized Developmental Care and Assessment Program (NIDCAP) model was developed as a clinical framework for the implementation of developmental care. NIDCAP is a comprehensive program which includes a behavioral observation methodology and creation of individual developmental caregiving support of the infant's own developmental goals [12]. The model focuses on detailed reading of each individual infant's behavior [2]. By observing the child during a routine assessment (before, during and after) and a detailed description of his/her behavioral responses, medical staff can assess the ability of the infant's immature nervous system to tolerate the environment and care manipulations. Such evaluation will enable one to determine the adequacy of the environment and care to infant's opportunities and needs, with subsequent corrections and adaptation [2, 15].

The infant's ability to regulate and control the behavior occurs within continuous interaction with the environment (whether womb, NICU, home conditions) and is expressed through the infant's five systems: autonomic (physiological), motor, state, attention/ interaction and self-regulation. These systems are continuously interacting with one another. Each system influences and supports the other, and interacts with the environment. The autonomic system functioning is manifested in an infant's breathing quality and rate, color fluctuation, and visceral stability or instability. The functional state of motor system is estimated by the position, muscle tone and movement patterns of the face, trunk and extremities. State organization is observable in an infant's range of available levels of consciousness, their robustness and modulation of the available states, and the patterns of transition from state to state. The activity of attention/interaction system is manifested by infant's look, facial expressions and the ability to interact [3, 12, 15]. The self-regulation system is manifested in infant's ability to re-balance and bring into harmony the other systems when they have moved out of balance [2].

NIDCAP methodology was founded by Heidelise Als (psychologist from the Harvard University) in 1986 and is based on the Synactive Theory of Development. Heidelise Als has been a pioneer in helping medical staff and parents to understand how to "read" preterm infant's

behavior, especially those who need intensive care [16].

The synactive theory of newborn behavioral organization and development (synaction n., or synactive adj. (from the Greek syn "together" and the Latin actio "action," resulting in "together in action"). The synactive theory of newborn behavioral organization and development suggests that development of the human fetus, and later newborn, proceeds through the constant balancing of approach and avoidance behaviors, leading to a continuous interaction of the above mentioned subsystems and their increasingly defined delineations within the organism, and the organism's interaction with the environment at large [12, 17].

The synactive theory of infant development provides that there is no possibility for development without stimulation, but there is also no harmonious development if the stimuli lead to disorganization and stress [15]. Sensory inputs are the important and necessary parameters in fostering central nervous system development [3]. Inappropriate stimuli penetrate into all systems and destroy them, while adequate and timely stimuli promote and improve the infant's growth and development [11, 15]. The infant's response to any stimulus manifests in signs of adaptation of the foregoing systems when he or she tolerates it, or in maladaptive signs if the infant is unable to cope. The infant is able to tolerate stimuli when they are appropriate in timing, complexity and intensity in relation to the infant's thresholds of functioning. If the stimuli are too intense, complex or inappropriately in time, infant either has strategies to move away from inputs, avoid them, or suffer from them. Such behavior is considered a stressful situation for an infant [2, 12]. The aim of the NIDCAP is to support the infant in his/her growing tolerance to stimuli, and to minimize stressful events and manipulations that require energy consumption, use of calories and sometimes break the physiological homeostasis [3]. Each caregiver must recognize that for the unstable or fragile infant the best form of sensory input may necessitate a plan of reduction of surrounding stimuli [18].

Signs of autonomic system adaptation in the infant are: stable color, regular breathing and heart rate within physiological ranges and stable digestion. Self-regulatory balance of motor system is reflected by the appropriate muscle tone, harmonious and smooth movements, softly flexed posture with flexed arms and legs; hands near the face, around the mouth or inside it [12,

15]. Sleep and waking cycles develop in time to become differentiated [15, 19]. The infant actively looks for a source of stimulation and visual contact with a person who cares for him/her, the face is open, and the infant has attentive look. This stability of the systems manifests in smooth function and reflects intact organization and central nervous system control [3].

Signs of autonomic system stress in the infant are: skin discoloration (pale, marble, red, cyanotic), breathing disorders (apnea, tachypnea) with or without desaturation, unstable heartbeat (bradycardia or tachycardia), functional gastrointestinal disorders (hiccups, regurgitation, vomiting) and neurological disorders (tremors, convulsions, yawning, sighing). Motor signs of stress include: muscle hypotonia, extension of the trunk (arching), outward movements of limbs (splaying, airplanning, saluting, sitting on air) and tongue extensions. Sleep and waking cycles are not properly differentiated, with the infant avoiding stimulation and visual contact, there is lack of visual concentration. In general, extension behaviors are thought to reflect stress, and flexion behaviors are thought to reflect self-regulatory competence. Diffuse behaviors are thought to reflect stress, and well-defined behaviors are thought to reflect regulatory balance [12, 15]. Such stress reactions may indicate that environmental stimuli of light or noise or even caregiving events such as turning the infant or changing the diaper, may be overwhelming [3]. To overcome these stressful situations infant spends the energy that he needs to maintain his homeostasis [3, 15].

Another behavioral scenario is possible when the infant cannot respond to environment or handling stimuli. The infant may lie in the bed, limp and flaccid, unable to put any energy into responding to caregiver; or just develop minimal ranges of responsiveness [15, 17].

The ability to regulate or control the infant's autonomic, motor and state organization is a requirement of early development and it is called self-regulation [20]. Early self-regulation is accomplished in the mother's body as a fetus, and continues over the course of the first three years of life after birth. The first tasks of self-regulation involve the regulation of physiological function as breathing, heart rate regulation, maintenance of visceral control, body temperature and homeostasis and day-night cycles regulation. Later the infant learns to calm himself and relax even after mild stress. As an infant matures in the context of daily interactive care from consistent primary caregivers, self regula-

tion becomes the task of learning to control motor behaviors, sleep-wake cycles, attention and interaction [3, 15, 20, 21]. Eventually, these capacities merge into emotional regulation. The premature baby often needs external assistance in self-regulation. Parents and caregivers become the infant's "co-regulators" and support infants by accurately reading and interpreting the infant's behavioral signals [3].

How assess and interpret the child's behavior according to NIDCAP? Developmental specialists observe an infant's behavior weekly or every other week throughout the hospitalization, starting with the phase of the infant's initial stabilization. During each observation, the developmental specialist systematically records an infant's behavior for approximately 20 minutes before a planned medical or nursing caregiving interaction and continues to observe throughout the duration of the interaction and for approximately 20 minutes after it. Ninety-one behaviors, including autonomic (breathing, heart rate, color changes and visceral signs), motor (postures, muscle tone fluctuations and movements) and state organization behaviors (levels of arousal, patterns of transitions between states, and clarity and robustness of sleep and awake states) are monitored every 2 minutes. Behaviors are conceptualized as regulatory and as stress according the foregoing signs of adaptation and disadaptation and are interpreted as indices of the infants' current strength and vulnerabilities respectively [14].

After the observation the developmental specialists write descriptive neurobehavioral reports and suggestions, which describe the infant's strengths, current sensitivities and apparent goals and thresholds to stress, and the infant's self-regulatory efforts at rest and during care manipulations. It helps to structure caregiving procedures to the infant's sleep/wake cycle, adapt or modify the environment and care according to the child's needs with the aim to maintain the infant's well-regulated behavioral balance in an effort to promote the infant's strengths and simultaneously to reduce the infant's self-regulatory vulnerability [2, 14]. As the infant matures, these recommendations are modified appropriately [22].

Key elements for implementation of individualized developmental family-centered care NIDCAP : 1) provision of sensitive care and handling for baby, 2) creation of a calm NICU environment, 3) parental involvement in infant care, their support, 4) presence of infant developmental specialist [3].

Provision of sensitive care and handling for the infant based on an accurate reading of infant behavioral signals and respect for the message that the infant communicates, along with recognition that the infant actively participates in all aspects of neonatal care [3].

a) Structure the infant's 24-hour day in accordance with the individual infant's sleep-wake cycles, state of alertness, medical needs and feeding competence. It may be necessary to divide or to combine procedures (eg. medical examination and care manipulations), to offer pauses according to the child's behavioral responses or to perform care with two persons. This approach provides infant's tranquility and thus promotes his/her growth [15].

b) Non-nutritive sucking supports infant's physiological stability, improves sleep/waking cycle and reduces time of hospitalization [23].

c) Infant's flexed position reduces stress reactions, improves self-regulation, physiological stability and sensory stimuli tolerance and prevents the skeletal deformities [24, 25].

d) Positioning in the "nests" provides flexed position of the whole body with pelvic support (physiological position of the fetus), which prevents the formation of pathological extension position and hypertonus [24, 25].

e) Swaddling reduces physiological distress, maintains temperature homeostasis, improves motor development and optimizes the sleep/waking cycle [26].

Creation of a calm NICU. It is necessary to create a supportive, gentle environment for the most fragile infants (pic. 1, 2)

a) Noise reduction (reduction of alarm volume, decreased ringtone volume of telephones, modification of individual and collective behaviors - quiet conversation, avoiding the noisy gestures, individual rooms, installation of a sound measurement device. Sound levels shall



Pic. 1. Incubators in the NICU are covered to reduce the light and noise, to simulate day-night cycle.



Pic. 2. The device for monitoring the volume of sounds in hospital wards (green – normal, yellow – loud, red – noise).

not exceed 45 dB and hourly L10 of 55 dB; transient sounds should not exceed 70 dB; equipment in NICU should have noise levels of 40 dB [27, 28].

b) Reduction of the light level (avoiding direct illumination into the infants' eyes, except during examination, incubator cover adapted to the infant's awakening, individual illumination lamps at each incubator, providing circadian rhythm with decreasing light intensity at night, access to daylight) [3, 27].

Parental involvement in infant care, their support.

a) Early parental involvement in caregiving and participation in all care with day-and-night access in the NICU [15].

b) Skin-to-skin contact with mother or father, including children who need invasive and non-invasive respiratory support. Such contact has significant advantages for both the infant (temperature homeostasis, respiratory stability with a decrease in apnea and brady-

cardia, calm and lasting sleep, feeling of safety, positive dynamics of body weight, decreased risk of nosocomial infections) and mother (improving of lactation, stress reducing, sense of paternity) [15, 29, 30], (pic. 3, 4, 5, 6, 7).



Pic. 4. Kangaroo mother care of the ELBW infant with nCPAP.



Pic. 3. Kangaroo mother care ("skin-to-skin" contact) of the preterm infant with nCPAP.



Pic. 5. Kangaroo mother care of the twins.



Pic. 6. Kangaroo father care of triplets.



Pic. 7. Relaxing in skin-to-skin contact after breast-feeding.

Developmental care supports the relationship between the child and the family [12]. For the human species, parents are the familiar, constant and steady connection in an infant's life. They assure their infant's safety, and assure their child's development of trust and as a whole person [2]. The core principle of NIDCAP is the collaboration with each infant and the infant's parents as the primary caregivers and co-regulators; and the main goal of developmental care in the NICU and throughout the hospital stay is to improve child and family comfort and outcomes.

The presence of infant developmental specialist. The developmental specialist conducts regular NIDCAP observations and staff/parent teaching, provides consistency of developmental support to medical staff, family and the infant, articulates and adjusts the NICU

in the accordance with the developmental needs of the infant [3].

Positive aspects of developmental care. The studies have documented the beneficial effect of NIDCAP in terms of shorter intensive care and overall hospital stay, decreased time on the ventilator, decreased oxygen days, shorter duration of parenteral feeding, shorter transition periods to full enteral feeding, better average daily weight gain, lower total hospital charges and effect in enhancing neurodevelopmental outcome [11, 31- 4]. Some research has also documented that the NIDCAP approach enhances brain structure and function

when measured by sophisticated medical techniques such as EEG and MRI [35].

NIDCAP also has significant benefits for parents. The studies of H. Als and other developmental specialists show the reduction in parenting stress and enhanced parent perception of the infant [31, 36, 37]. Except for short-term positive effects, neonatal care according the NIDCAP has also long-term effects on the infant's neurological development, behavior and mother-child interaction [34, 36].

Conclusions

As survival of high risk infants has continued to improve, greater emphasis has now been placed on improving neurological outcomes and quality of life. The implementation of individualized developmental care encourages the shift from a protocol-based task and schedule oriented framework of NICU care to an individualized and relationship-based framework of care. The introduction of NIDCAP in the neonatal departments will reduce the mismatch between intra-uterine environment and NICU by taking into account the individual infant's current thresholds of behavioral organization, diminishing stress, and supporting each infant's strengths and competencies. With the help of NIDCAP approaches in neonatal care all staff will study how to read infants' behavior, to hear their voices and understand them. Our smallest and most fragile patients should feel comfort and a sense of security that are so important for their healthy development.

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