Nurturing Beyond the Womb – Early Intervention Practices in Newborn Care Unit

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The survival of small and sick babies has increased over the last two decades, though at the cost of increasing the burden of neuro-morbidities. Early intervention (EI) capitalises on the unique characteristic of neuroplasticity that ameliorates the effect of insult to the developing brain during fetal and early infancy period. EI provides positive sensorimotor experiences and promotes neuro-behavioural maturation which can greatly mitigate adverse outcomes for these at-risk babies. EI includes nurturing care delivered through the antenatal period continuing into a developmentally supportive environment and family centred care for the small and sick baby in the new-born care unit and continuing up to 3 years of life. Although the concept is now well understood, these practices still lack consistency and standardization across the units.

Keywords: Developmentally supportive care, Neurodevelopment, Neuroplasticity, Nurturing care.

The quality of newborn care is presently being measured against the yardstick of intact survival, rather than merely survival. For a baby born preterm or sick, the transition from a secure and optimal intrauterine environment to that of a relatively hostile neonatal intensive care unit (NICU) environment after birth, further compounds exposure to adversities to the developing brain. The medical care of sick babies should be as close as possible to the nurturing environment of the womb, especially through the early critical period of brain development. This is the crux of the concept of early intervention.

Early intervention (EI), leveraging on experience driven neuroplasticity, is defined as the introduction of a planned program timed 'early' i.e., through the critical period of brain development, in order to favourably alter the course of future development [1]. Beginning in the antenatal period, EI spans through the first 3 years of life [2]. In the antenatal period, EI focusses on identification of risk factors which can adversely affect neurodevelopment outcomes; so that appropriate care can be delivered in ante or postnatal period. For small and sick babies admitted in the NICU, EI focusses on mitigating disability by providing positive sensorimotor experiences, developmentally supportive care (DSC), and few specific interventions which promote neurobehavioral maturation. EI practices vary across units, and lack consistency and standardization in India [3]. In this article, we discuss the principles and practices of early intervention in the newborn care unit (NBCU).

Critical Period and Neuroplasticity

Development of the brain's basic architecture, neuronal proliferation and neuronal migration to the cortical surface is pre-programmed. It occurs before 20 weeks of gestation, and is unlikely to be affected by external sensory stimulation. The period from around 22 weeks gestation onwards through the first two years of life, is the "critical period" of brain development when rapid expansion, synaptogenesis, apoptosis, myelination, neuronal organization and alignment take place. These processes are extremely sensitive to in experiences and sensory stimulation. Any biological or medical insult that occurs during this critical period like intense, stressful and unexpected sensory experiences in the NICU is detrimental to brain development and will adversely affect neuro-outcomes. The developing brain exhibits remarkable capacity to reorganize and recover after injury. Sensorimotor experiences that minimise environmental stressors, modify organization of neural circuits and impact functional recovery. Thus, EI and developmentally supportive care beginning in the NICU or NBCU not only prevent avoidable injury, but also promote neuro-behavioral maturation of the growing brain due to unique neuroplasticity (**Fig. 1**)

Principles

The principles governing EI and developmentally supportive care include:

- *Gestational age-appropriate interventions*: The timing and type of interventions prior to 40-44 weeks should

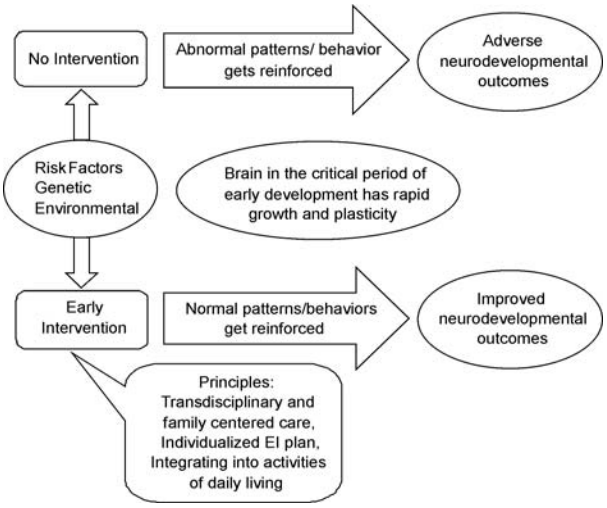

Fig. 1 Conceptual framework and rationale of early intervention. Babies with genetic, medical or environmental risk factors are at increased risk of developing adverse neurodevelopmental outcomes in absence of early intervention and developmental care, as the abnormal patterns and behavior get reinforced. However, if timely early intervention, leveraging on experience driven neuroplasticity, is provided to these babies, normal patterns and behavior can be reinforced. This may help in mitigating adverse neurodevelopmental outcomes.

mimic the intrauterine environment. Active interventions prior to term age can be a source of stress, due to unfavorable changes in catecholaminergic content of the cortical and subcortical regions. The brain should not be overstimulated as this may be detrimental [4].

- As far as possible, the interventions should be delivered by parents with support from healthcare providers and therapists.
- Assessment and observation of behavior:
  - Stress behaviors like back arching, finger splaying, startle, twitch, flailing, crying, gaze aversion or autonomic disturbances like changes in heart rate and SpO_2.
  - Self-regulatory behaviors like putting hand to mouth, foot bracing, sucking on tube, putting hands to face etc. These are ways by which infants attempt to soothe themselves and reflect coping mechanisms in response to stress.

Impact of EI in the NICU

Reports vary regarding the evidence of the impact of EI due to multiple reasons: marked heterogeneity among studies; difficulties in standardization; variability in sensory exposures, dosages, timing and outcome measures; and inclusion of multiple interventions implemented inconsistently and variably over short periods of time. A systematic review of the effectiveness of newborn individualized developmental care and assessment program (NIDCAP) did not show any beneficial effect on short term medical and long-term neurodevelopmental outcomes [5]. Other studies have shown only short-term benefits of early intervention programs. A recent systematic review including 13 studies showed that developmental care in preterm babies in NICU improved mental developmental index (MDI) and psychomotor developmental index (PDI) at 12 months of age and PDI at 24 months of age. However, the benefit was not detected at 24 months of age on MDI [6]. Another systematic review on effect of motor interventions on outcomes in preterm babies showed positive effect on motor skills up to 24 months corrected age [7]. A Cochrane systematic review on early intervention programs provided after discharge, demonstrated positive influence on cognitive and motor outcomes during infancy, with only cognitive benefits persisting into preschool age [3]. Pineda, et al. [8] have recently developed the Supporting and Enhancing NICU Sensory Experiences (SENSE) program which includes intentional delivery of positive, age-appropriate sensory exposures by parents or a sensory support team every day of hospitalization. A pilot study to demonstrate the impact of SENSE program revealed improvement in maternal confidence and improved infant neurobehavioral performance [9].

PROVIDING EI IN NICU: RATIONALE, EVIDENCE AND PRACTICAL ASPECTS

The biological basis and evidence regarding various early interventions in a NBCU are given below. Implications for clinical practice have been summarized in **Table I**.

Supportive Positioning and Handling

Fetus naturally assumes flexed position in utero in third trimester. Babies born extremely preterm lack adequate muscle tone and strength which causes them to maintain their bodies in extended positions. If left unattended without supportive positioning, it may affect musculoskeletal integrity leading to misalignment of body, muscle contrac-tures leading to motor developmental delay, and/or positional deformities like plagiocephaly or torticollis due to prolonged periods of lying in the supine or a single position. The aim of good positioning is to mimic third trimester posture by promoting flexion, midline orientation, good alignment, and support for movement. Proper positioning positively affects sleep, promotes calmness and a controlled behavioral state [10]. Swaddling improves motor perfor-mance, postural development, movement across the midline, sleep, self-regulation during handling, and decreases stress [10]. The prone position facilitates flexion and early head control, improves sleep, decreases pain and stress behaviors. Supine positioning

Table I Providing Early Intervention in the Neonatal Intensive Care Unit – Implications for Clinical Practice

Supportive positioning and handling

- Containment of baby by swaddling, nesting, or other support to maintain a flexed posture
- Exposure to varying positions- prone, supine, side lying and upright
- For upright positioning, baby should face away from the caregiver with back and head against the caregiver's chest; and anterior support should be provided to the baby's chin and trunk by the caregiver's hand.
- For GERD, left lateral position after a feed and then in prone position about half an hour later. Head end elevation by 30º.
- For preventing plagiocephaly, regular change in position; head supported in midline, with neck in neutral position and slight chin tuck.
- Allow free unrestricted movements for some time at defined intervals, such as before each diaper change.
- Validated objective tools like Infant Positioning Assessment Tool (IPAT) as a guide to improve developmental positioning of babies

Auditory interventions

- Ambient noise < 45 dB
- Maternal sounds (reading/ talking/ singing to baby) starting at 28 weeks PMA
- Music- classical/ womb sounds (optional/ only after 32 weeks)

Tactile interventions

- Clustering of care
- KMC and GHT prior to 32 weeks PMA
- Holding for short duration starting at 28 weeks PMA
- Massage only after 32 weeks PMA, by trained personnel

Vestibular interventions

- Gentle handling
- Care while changing diaper
- Swaddling during transfers/ transport
- Transferring the preterm baby to and from holding positions, as early as 23 weeks PMA
- Rocking from 32-33 weeks PMA for brief time initially, gradually increasing in frequency and duration by term age

Olfactory gustatory interventions

- Avoid opening pungent smelling alcohol wipes or bottles near the infant and avoid strong smelling oils for massage.
- Familiarizing the neonate with breastmilk odor by placing mother's breast pad nearby or putting a small drop of breast milk on the tongue tip or lips.
- Keeping maternal scent or breastmilk- soaked cloth near baby.
- Oro motor stimulation/ NNS from 29 weeks PMA.

Kinesthetic interventions

- Allow free unrestricted movement
- Movement imitation therapy (research area)

Visual interventions

- Dim environment until 32 weeks PMA
- Cycled light (12 hours on and 12 hours off with low intensity) starting at 32 weeks PMA.
- Avoiding direct and bright lights.
- Encouraging visual attention through human interaction starting at 36 weeks ambient lighting <646 Lux (60 fc)
- Intervention for CVI: Visual stimulation exercises with the help of high contrast (black and white) pattern charts, reflective objects and closed yellow and red LED lights for babies who do not have basic visual functions such as fixation, smooth pursuit, and saccadic movements by term equivalent age

Reducing stress and pain

- Routine assessment and documentation of pain and stress with an established pain assessment tool like CRIES, NIPS (Neonatal infant pain score) or PIPP (Premature infant pain profile).

- Non-pharmacologic (swaddling, KMC, breastfeeding) and / or pharmacologic measures (oral sucrose, topical analgesics like EMLA, non-opioid analgesics or opioid analgesics) prior to all stressful or painful procedures, according to level of pain involved.

Protecting and promoting sleep

- Provide non-emergent care giving activities during wakeful states.
- Care giving activities that promote sleep (i.e. facilitative tuck, swaddling and skin-to-skin care)
- Light and sound levels to be maintained within the recommended range.
- Cycled lights to support nocturnal sleep and facilitate development of circadian rhythm.

Nutrition

- Early enteral nutrition
- For increasing expressed breast milk availability in NICU, ensure maternal motivation, early and frequent expression of breast milk, KMC and maternal involvement in baby care, management of maternal pain if any.

Skin care

- Assessment and documentation of skin integrity using a reliable assessment tool (NSCS, NSRAS) at least once per shift.
- Protective skin dressing like Duoderm/ Tegaderm to be applied at sites of frequent taping.
- Gentle application and removal of adhesive products
- Change probe position every shift to avoid skin burns

Partnering with parents and families

- 24 hours access to baby
- Involving parents in baby care activities
- Parent education and motivation
- Assessing parental competency, confidence and well being

PMA-post-menstreal age, GERD-gastroesophageal reflux disease; CVI-Central visual impairment.

with a 'nest' containing boundaries made from rolled towels/positioning aids, has been found beneficial [11]. The supine position promotes development of visual skills, symmetrical alignment of arms and legs and self-soothing behaviors like bringing hands to mouth. The side lying position is the closest to the fetal position with minimized hip abduction and retraction of shoulders. This is associated with improved physiological stability and decreased stress responses [11]. Upright positioning after 35 weeks post menstrual age (PMA), has shown to help in spontaneous head righting and improves exploratory movements of extremities [12]. Hammock positioning has been found to facilitate midline posture and decrease stress behavior in a few studies [11]. The neonate is placed on a rectangular cloth (hammock), which is attached to the extremities of incubator. This positioning simulates intrauterine position, and thus stimulates flexion and promotes symmetry.

As a daily routine, babies should be exposed to varying positions and contained by swaddling, nesting, or other support to maintain a flexed posture- with hands close to or touching face, head in midline and neck slightly flexed. Swaddling can be done by making oval or U-shaped nests with linen rolls. (**Fig. 2**) In babies who develop tone abnormalities during NICU stay, specific individualized interventions by trained neonatal therapists are provided to promote appropriate positioning and normal movement patterns.

Sensory Environment, Stimulation and Interaction

Auditory: In utero, the fetal response to auditory stimuli like the maternal voice, maternal heartbeat, or muffled environmental sounds is displayed by spontaneous movements that are observed as early as 27 weeks of gestation. In the NICU, ambient aberrant noise generated by various equipments, alarms and personnel induce stress, autonomic changes and sleep disruption, sensory neural damage, and may contribute to language or auditory processing disorders [13]. Auditory interventions consist

Fig. 2 Containment of baby by nesting in supine and prone position.

of exposure to language, maternal voice recordings, and music, beginning at 30-32 weeks PMA [8]. Pineda, et al. [14] reported improved feeding behaviors and lesser parental stress with music; and decreased stress responses and better neurodevelopment at 6 months of age with maternal voice recordings [14]. Long term effects have not been reported. Ambient sound levels should not exceed an average of 45 dB. This can be achieved by holding quiet conversations at baby's bed, silencing alarms promptly, avoiding use of headphones/ earphones/ mobile phones, and handling doors and carts gently.

Tactile: Preterms <32 weeks are extremely sensitive to tactile inputs and show diffuse behavioural response, while older babies exhibit habituation to the same stimuli. The painful procedural experiences in the NICU can cause sensory integration deficits in preterm babies, which may later manifest as tactile hypersensitivity, exaggerated hand and toe grasp, or leg withdrawal. Four tactile interventions have been described in literature. First, Gentle Human Touch (GHT) which involves placing one hand over the baby's head and other hand on lower back and buttock for 10-20 minutes, which can be accomplished by mother during provision of daily care [15]. Second, massage therapy that involves gentle yet firm touch, stroking or rubbing the infant with hand using light to moderate pressure; with or without oils. Most studies on massage describe starting at around 32 weeks PMA. Third, holding for short duration and fourth, Kangaroo care (skin to skin contact) which provides a multisensory exposure and has shown to have physiological, neurobehavioral as well as psychosocial benefits [15]. Prior to 32 weeks PMA, KMC **(**started according to unit norms**)** and GHT are encouraged for providing tactile exposure [8]. After 32-33 weeks PMA, massage by a therapist taught to mother can be done for 15 minutes, 3-4 times/day. These should be clustered during care times. A minimum of 3 hours of tactile stimulation at term equivalent age is recommended [8].

Kinesthetic: Kinesthetic stimulation pertains to perception of body movements and body position like physical activity, passive movement and joint compression. Kinaesthetic sensory exposure has been proposed to facilitate normal evolution of general motor movements [8]. When infants are tightly swaddled, they are unable to demonstrate their normal writhing movements freely, which could interrupt the sensory experiences associated with them. Initiating early free movement at the earliest time point is consistent with the emergence of fetal general movements [8]. Movement imitation therapy has been used in preterm babies with cramped synchronized movements. In this process, therapists or trained caregivers gently maneuver the baby's limbs to smoothen movements and mimic normal movement sequences as far as possible.

Gustatory and olfactory senses: These senses differentiate early in development. Most preterm babies show response to olfactory input by 28 weeks. Marked alteration in oro-gustatory environment due to differences in the composition of amniotic fluid, and breast or formula milk, along with stressful procedures and placement of orogastric/ endotracheal tubes in preterm babies can lead to negative oral experiences and feed aversion. Furthermore, unpleasant odors arising from the hospital environment can negatively impact the development of smell and taste.

Non-nutritive sucking (NNS) and oro-motor stimulation (OMS): This facilitate smooth transition to oral feeds in preterm babies. Non-nutritive sucking involves sucking on emptied breast. Meta-analysis on effect of NNS demonstrated smooth transition from gavage to full oral feeding and shortened length of hospital stay [16]. Another meta-analysis on OMS reported increased feeding tolerance and improved transition from tube-feeding to breastfeeding and shorter duration of hospital stay [17]. NNS should be combined with OMS and started at 29 weeks of PMA for smooth and early transition from gavage to breastfeeding. The Premature Infant Oral Motor Intervention (PIOMI) program describes a five minutes stimulation program and involves assisted and resisted movements of oro-facial muscles; facilitated coordinated movement of cheeks, lips, gums, tongue and palate, and digital stroking of the same.

Vestibular: The fetus gets vestibular stimulation through maternal movements and gentle oscillations of the amniotic fluid movement. Ex-utero, babies may have inappropriate vestibular experiences due to horizontal postures, the effect of gravity or rapid changes in position while handling. Lack of normal vestibular stimulation in early development can affect general neurobehavioral organization and cause gravitational insecurities and deficits in balance and coordination. Vestibular stimulation consists of rocking and infant swings for 3-7 min at 33-34 weeks PMA [14]. Positive effects of vestibular stimulation on arousal level, visual exploratory behaviour, motor development and reflex integration have been reported [15].

Visual: Visual stimulation is potentially harmful for preterms prior to term equivalent age. The womb is dark, hence exposure to bright ambient lights is stressful for babies. Visual interventions include modifying the light environment through dim, bright or cycled light (exposure to alternate intensities of light to match the circadian rhythm). Prior to 32 weeks PMA, dim environment is favored whereas cycled lights (with low intensity 25-100 lux) can be started at 32 weeks PMA [14]. The American Academy of Pediatrics recommends ambient lighting less than 646 lux (60 lx) for any neonate.

In the last decade Cortical Visual Impairment (CVI) has emerged as the main cause of visual impairment in babies discharged from the NICU. Babies who do not have basic visual functions such as fixation, smooth pursuit and saccadic movements by term equivalent age should be provided visual stimulation with the help of high contrast (black and white) pattern charts, reflective objects and closed yellow and red LED lights (**Fig. 3**).

Reducing Stress and Pain

Exposure to repeated painful procedures in early life can lead to altered brain development with impaired cognition, behavior and emotional regulation as well as altered pain perception in later life. Strategies for pain management in NICU are described in **Table I**.

Promoting and Protecting Sleep

Undisturbed sleep is essential for weight gain and optimal brain growth. All non-emergent care giving activities should be provided during wakeful states.

Skin Care

Optimal skin care involves assessment and documentation of skin integrity by nursing staff at least once per shift. Validated tools like Neonatal Skin Condition Score (NSCS) and Neonatal Skin Risk Assessment Scale (NSRAS) can be used to document and monitor skin integrity.

Nutrition

Breastfeeding may be challenging in small and sick neonates due to mother-infant separation, motor and physiological immaturity. Human milk has a positive impact on preterm infants' neurodevelopmental outcomes. All efforts should be made to start enteral feeding in small and sick babies as early as possible, with expressed breast milk or donor human milk.

Fig. 3 Intervention for Cortical visual impairment. Visual stimulation exercises with the help of closed yellow LED lights and high contrast (black and white) pattern charts for a term baby with hypoglycemic brain injury who did not have fixation, smooth pursuit, and saccadic movements.

Partnering with Parents and Families (Family Participatory Care)

Care to small and sick neonates must be delivered by parents and supported by healthcare providers. Parents should have access to their baby in NICU, and the healthcare team should assess their emotional and physical wellbeing; and their evolving competence and confidence in handling their baby. The family must participate in activities like KMC, holding, feeding, dressing, diapering, singing etc. They must be embraced as decision maker and collaborators for baby care in NICU.

Early childhood is the most rapid period of development in a human life. The period of life from conception through birth to first few years of age are critical to a child's achieving his/her complete neuro-developmental potential. Being born too small or sick interrupts the nurturing care and environment that a fetus was enjoying being in mother's womb. This also is the critical period when the journey to unlock his/her neuro-developmental potential has begun. Nurturing care in the neonatal period is the key to optimal early childhood development. There is growing evidence that early developmental interventions with a preventive focus may improve outcomes in high-risk neonates. Further research is required to determine which interventions are most effective in improving cognitive and motor outcomes, and to discern the long term effects of these interventions. There is an urgent need for developing a structured framework for providing early intervention and developmental care in a standardized manner. For optimal outcomes, it is imperative that early developmental interventions are extended from the neonatal care unit to home post discharge.

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