

## Neonatal Intensive Care Practices Harmful to the Developing Brain

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There has been a marked increase in the survival of extremely low birth weight (ELBW) infants, but these babies have a long stay in the NICU. Strategies to decrease their neurodevelopmental impairment become very important. The maximum development of the brain occurs between 29-41 weeks. From the warm, dark, aquatic niche, where the baby hears pleasant sounds like the mother's heart beat, the baby suddenly finds itself in the dry, cold, excessively bright, noisy, environment of the NICU. Noise, bright light, painful procedures, and ill-timed caregiving activities, adversely affect the infant's development. Excessive radiation from X-rays of babies on the ventilator and CT scans also affect the brain. Medications like steroids for chronic lung disease also cause damage to the brain. Aminoglycosides and furosemide are known to cause hearing impairment. Hence a developmentally supportive, humanized care will go a long way in enhancing the developmental outcome of these babies.

**Key words:** *Brain, Development, Intensive care, Neonate, Practices.*

More and more infants with birth weight less than 1000 grams are surviving in India in tertiary care centers, but they all have a long stay in the NICU. A recent study showed a 40% incidence of neurodevelopmental impairment in ELBW infants [1]. Hence, strategies to decrease this neurodevelopmental impairment assume importance.

The mechanism underlying cerebral palsy and cognitive impairment is very complex. It is important to analyse how a particular neonatal intensive care practice in combination with other perinatal events, affects the developing brain. This "two hit" mechanism has been demonstrated in a mouse model [2]. The combination of several potential deleterious factors may exacerbate pre-existing lesions or disrupt normal programming of the developing brain [2].

In its prime, the germinal matrix releases as many as 100,000 cortical neurons per day, each of which migrates through the cortex to its specific location. At 24 weeks gestation, neuronal maturation and organization increase dramatically. But much of this

process occurs in the extrauterine rather than intrauterine environment in the preterm infant. With volumetric MRI using 3D imaging, it has been possible to show that a three-fold increase in brain volume; a four fold increase in cortical gray matter; and a five fold increase in myelinated white matter occurs between 29-40 weeks [3]. Hence, this is a period when the brain is most vulnerable to injury.

Preterm infants are in essence fetuses, who develop in an extrauterine setting, at a time when their brains are growing more rapidly than at any other time in their lifespan. From the warm, dark, protected aquatic niche of the uterus, the fetus suddenly finds itself in the dry, cold, noisy, excessively bright, chaotic environment of the NICU. However, this specialized medical and technological NICU environment is essential for its survival. Understanding the neurodevelopmental expectations of this "fetal infant" provides a basis for modification of some of the NICU practices, which inadvertently increase the stress and challenge to this immature brain.

*Noise:* The NICU can be a noisy place with noxious sounds like loud talking, banging of incubator doors, dropping of equipment on the floor, alarms etc. Preterm babies are at a particular risk for sensorineural hearing loss with an incidence of 4-13% depending on their gestational age, as compared to 2% in all newborns [4]. The US environment protective agency (EPA) has recommended a sound level of  $\leq 45$ dB. Noise level in incubators is upto 50-80dB and it is much higher in open beds. ELBW infants respond to this noise by increased heart rate, alterations in blood pressure and cerebral blood flow [5,6]. A low cost protocol of environmental and behavioral modification developed by the Bengaluru group [7] has shown good results in reducing the noise level in their ventilator room.

An interesting study showed that the noise level in the transport ambulance on country roads in UK was 120dB [8]. One can imagine the noise levels in the ambulance on the pothole ridden country roads in India!

*Pain:* The infant undergoes many painful procedures in the NICU. The heart rate decreases and the oxygen saturation decreases during the most invasive part of the heel prick [9]. The infant gives behavior clues like grimace, frown, grunting, arching, leg extension, arm on face etc. Exposure to repetitive pain causes excitotoxic damage to the developing neurons. These changes promote distinct behavioural phenotypes characterized by anxiety, altered pain and sensitivity, and stress disorders; and this may lead to hyperactive attention deficit disorders [10].

If clustered care (changing diapers, taking temperature, mouth care, measuring abdominal girth) follows a painful procedure, the infant shows heightened facial, body and heart rate responses and cuddling the baby after a painful procedure is recommended [11].

*Light:* Preterm babies are exposed to bright light in the NICU as opposed to the darkness in utero. Reduced light may confer the advantage of improved sleep cycles and decreased stress [12]. A study which looked at cycled lighting *versus* dim lighting showed no difference in weight gain [13]. Direct light on

patients should be avoided, unless needed for special tasks. Blankets can be put on incubators to prevent unnecessary light exposure. Lighting used especially for hands on care areas should have a colour rendering index, which means that colours under lighting should look as natural as possible [14].

*Tactile stimuli:* Care-giving activities in the NICU can be intrusive and stress producing [15]. It may contribute to aversive behaviors and the babies may associate all touch with pain, demonstrated by squirming, crying, and recoiling of arms and legs. Talking softly to a baby before touching, gentle handling, and avoiding sudden changes in posture, will help in preventing fear of the tactile stimulus.

*Medications:* Postnatal exposure to dexamethasone is neurotoxic to the developing brain. A higher incidence of cerebral palsy in the group treated with dexamethasone (49% vs 15%) has been reported in a trial of early 3 day course [16]. Another study [17] analyzed 3 DMRI images of infants treated with postnatal dexamethasone and found significantly impaired growth of cerebral gray matter and a 30% reduction in the total cerebral tissue volume as compared to controls.

Aminoglycosides and frusemide [18] are known to cause hearing impairment. Benzyl alcohol, found in drugs such midazolam, lorazepam and diazepam is known to cause cerebral palsy and developmental delay [19]. Propylene glycol, found in the commonly used drug phenobarbitol, is known to cause central nervous depression and seizures.

*Radiation:* Radiation can both kill and modify cells. An ELBW baby who gets ventilated, gets innumerable X-rays. CT scan imparts a much higher dose of radiation. The calculated dose of radiation for a head CT is 6mSv, which is 200 times more than that of a single infantogram. Exposure to heavy radiation has been reported to lead to mental retardation [12].

#### **DEVELOPMENTALLY SUPPORTIVE HUMANIZED CARE**

The traditional NICU environment involves sensory overload and is in stark contrast to the developing brain's expectation. Hence, the idea behind

developmentally supportive care is to create a 'womb out of womb' and aim at decreasing the stress of the preterm infant in the NICU. The advent of Neonatal Individualized Development Care and Assessment Programme (NIDCAP) has led to a greater emphasis on developmental care [15,20].

Nesting, Kangaroo mother care, soft music therapy, gentle oil massage, swaddling, and cuddling the baby, will help in decreasing the stress to the baby. Opioids have been used for management of moderate to severe postoperative or procedural pain [21]. One of the most commonly used local anaesthetic cream EMLA, a eutectic mixture of 2.5% lidocaine and 2.5% prilocaine is reported to reduce the pain in heel pricks and venepunctures [22]. Paracetamol does not reduce the pain after heel prick but reduces the pain after circumcision [23]. A small amount of dextrose/sucrose given during a painful procedure is certainly effective [24,25]. Other simple measures of comforting like swaddling during and after a procedure can also reduce the pain [24].

The noise level in the NICU can be brought down by promptly attending or anticipating alarms, closing incubator doors gently, talking softly during rounds and away from patients. Use of blanket covers will muffle noise as well as decrease light. Talking softly before touching, gentle handling, avoiding sudden changes of posture will help in preventing fear of the tactile stimulus. It is better to limit the use of postnatal steroids in the ELBW infant. Ultrasound and MRI are safer modalities for evaluation of the brain.

A gentle and sensitive developmentally supportive care will go a long way in enhancing the developmental outcome of the preterm infant.

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