Neurodevelopmental Care

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• I have no personal conflicts of interest to disclose.
• I have no financial relationships with the manufacturers or providers of any commercial products discussed in this CNE activity.
Learning Objectives

• Describe causative factors associated with neurodevelopmental impairments (NDIs) seen in premature infants.

• Identify five neurodevelopmental impairments seen in premature infants.

• List the six overlapping phases of fetal central nervous system (CNS) development.

• Describe the seven core measures of the Neurodevelopmental Care Model.

• Summarize the importance of the parent-infant relationship in enhancing neurodevelopmental outcomes.
Advances in treatments and technologies have occurred, but the incidence and severity of neurologic and neurodevelopmental impairments (NDIs) have not improved.

Past decade – heightened focus on neurologic development, neuroprotective strategies, and improving overall outcomes for premature and term newborns at risk for neurologic and developmental impairments

Ongoing research:
- Diagnostic studies to better understand the types of brain injuries in order to direct research for preventative protocols and predict type and severity of outcomes following brain injury
- Neuroprotective strategies to minimize effects and facilitate ongoing neurologic development for at-risk infants
Neurodevelopmental care is a philosophy and framework of relationship-based care that is *family centered* and *infant driven*.

- Parents as primary caregivers and partners in care planning
- Focuses on *parent-infant attachment*, family education, and active involvement in infant's care


- Encompasses environmental and care practice modifications to minimize stressors, protect the infant from non-physiologic stimuli, reduce noxious stimuli, and enhance comfort

- Supports the infant’s brain and sensory development to prevent or minimize neurodevelopmental impairments
Preterm births represented 9.93% of all live births in the United States in 2017.

| Preterm category definitions |
|-----------------------------|----------------|----------------|
| Category | Birthweight | Gestational age |
| Term birth | ≥2500 g | 37–42 wk |
| Late-preterm birth | <2500 g | 34–36 wk |
| Low birthweight | <1500 g | <37 wk |
| Preterm birth | <1000 g | <32 wk |
| Very low birthweight | <750 g | <28 wk |
| Extremely low birthweight | | |
| Extremely preterm birth | | |
| Micropremature | | |

Prematurity Case Review

- Female infant born via C-section at 24 1/7 weeks, 664 grams, to a 33 yo G₂P₁ mother
- Apgar scores – 3 at 1 min and 6 at 5 min
- Good prenatal care, uncomplicated pregnancy until onset of premature labor.
- Patient intubated immediately after birth and surfactant was administered
Respiratory distress syndrome, requiring:
- Conventional and high-frequency ventilation (extubated at day of life (DOL) 19
- Continuous positive airway pressure (CPAP) for 32 days
- High flow nasal cannula (HFNC) – weaned to room air on DOL 86

Hypotension – DOL 2-8, requiring hydrocortisone and dopamine

Rule out sepsis antibiotic course – Amp/Gent x 48 hrs

Apnea of Prematurity – caffeine therapy

Retinopathy of Prematurity – Stage II, resolved

Anemia – required 1 PRBC transfusion
Vulnerability of the Preterm Infant

- Tremendous cerebral cortex growth and development in 3rd trimester
  - 5-fold increase in volume between 24 – 40 weeks
  - Major CNS construction!
  - High risk for intraventricular hemorrhage (IVH)
  - Survival dependent upon intensive treatments

- NICU environmental hazards
- Prenatal - Maternal infection, placental insufficiency
- Complications of prematurity increase risk for altered neurodevelopment
Brain Development

- Neuron and glial cell proliferation
- Neuron and glial cell migration
- Neuron differentiation* – layering of neurons in specific areas of the cortex, dendrites, axons
- Synaptogenesis*
- Programmed cell death – apoptosis of neurons and synaptic pruning
- Myelination*
- Postnatal proliferation and migration
- Postnatal apoptosis of glial cells

Sensory Development

• Predetermined sequence of development:
  • Tactile – develops at 7-8 weeks
  • Vestibular – functional at by 20 weeks
  • Olfactory – functional by 24-28 weeks
  • Gustatory – functional by 24 weeks
  • Auditory – functional by 23-27 weeks
  • Visual - pupillary reflex not present until 35 weeks

• Uterine environment effectively limits and regulates the amount, type, and timing of sensory stimulation

• Development and maturation of the senses requires active use of sensory receptors and pathways
Sensory Development

• Sensory mismatching occurs due to the vast differences between the intrauterine environment and the NICU environment

• Limited ability to process and respond to multimodal stimuli in an organized fashion

• Responsiveness to a stimulus does NOT imply that it was:

  Received, Perceived, Needed, OR Beneficial!!!
Development in the Uterus

• Uterine walls – boundaries to support flexion and musculoskeletal development
• Maternal movement and fetal activity within warm amniotic fluid offers vestibular and tactile stimulation.
• Chemical, hormonal, and sensory input essential for normal brain development
• Supports REM sleep
• Predetermined sequence of sensory development – light and noise are filtered through amniotic fluid
• Oxygen and temperature-controlled

Development in the NICU

- NICU – over-stimulating, atypical environment for development
  - **Unnatural habitat!!!**
  - Forces of gravity on developing musculoskeletal system
  - Loss of flexion, uterine boundaries, neutral thermal amniotic fluid, and attenuated light and sound
- Separation from mom – lack of constant, biologically meaningful stimuli
- Excessive light and noise exposure
- Most touch is procedure-related
- Interrupted and inadequate sleep
- Painful and invasive procedures
- Non-meaningful, often noxious stimuli at unpredictable times
- Lack of caregiver continuity – many strangers 😞
Injury or insults to major brain structures – cerebrum/cortex, cerebellum, hippocampus

Intraventricular hemorrhage (IVH)
- Affects up to 1/3 of infants born < 29 weeks gestation
- Post-hemorrhagic hydrocephalus
- Periventricular hemorrhagic infarction
- White matter injury (WMI)
  - Diffuse or punctate
  - Periventricular leukomalacia (PVL) – focal, cystic vs non-cystic

Cerebellar hemorrhage, ischemia/infarction, secondary hypoplasia

Disordered brain and sensory development

Increased risks associated with:
- medications, infection/inflammation, sepsis, high frequency ventilation, hemodynamic instability, surgery, pain, oxidative stress

Neuroprotection – Brain Sensitive Care

• Care interventions to minimize impact of an injury by helping the brain to limit cell death and create functional synaptic connections.
  • Minimize pain and stress responses
  • Maintain normal temperature
  • Maintain normal glucose
  • Avoid hypocapnia
  • Avoid hyperoxia and hypoxia
  • Maintain normal blood pressure

• Must always include **family integrated care** and a robust developmental care focus
Diagnostic Imaging:

Cranial Ultrasounds:
- DOL 3 = Normal
- DOL 10 = Gr I left IVH
- DOL 30 = resolution of IVH, questionable (PVL)
- DOL 78 = PVL, cystic structure posterior to 4th ventricle

MRI at DOL 82 = diffuse loss of cerebellar tissue with evidence of old hemorrhage

MRI at 20 months – marked bilateral cerebellar hemispheric volume loss and secondary degeneration and volume loss in the pons and cerebellum
Neurodevelopmental Outcomes

• Cerebral Palsy – associated with white matter injury (WMI)

• Grade I or II GMH-IVH versus no GMH-IVH – have similar outcomes, typically mild impairments
  • Cerebral Palsy in both groups – 6-8% (study of ELBW infants born <27 weeks)

• Progressively higher risk for adverse outcomes with:
  • Grade III IVH (20% mortality)
  • Grade III with worsening post hemorrhagic hydrocephalus (PHH)
  • Grade IV (90% mortality) – Grade III with periventricular hemorrhagic infarction (PVHI)
• Birth to pre-school age:
  • Cerebral palsy
  • Developmental coordination disorder – motor delays, altered muscle tone, balance deficits, difficulties with visual-motor coordination, and atypical movement patterns
  • Hearing and visual impairment
  • Language delays
  • Sensory Processing Disorder – 3 patterns
    • Modulation – sensory over/under-responsivity, or sensory craving
    • Motor – Apraxia, postural disorders
    • Discrimination – visual, auditory, tactile, taste/smell, position/movement, interoception

(Malcolm, 2015; Papageorgiou & Pelausa, 2014)
Neurodevelopmental Outcomes

• School Age and Adolescence:
  • Cognitive impairment, learning disabilities, and problems with executive function may emerge.
  • Challenges in functioning within the school system and community arise secondary to emotional and behavioral issues:
    • Anxiety, depression
    • Neuropsychological deficits
    • Autism spectrum
    • Attention-deficit/hyperactivity disorders

(De Jong, V., van Baar, 2012; Johnson & Wolke, 2013; Wason, 2013)
Neurologic exams at 9 and 18 months
  - Head circumference at 2nd percentile for age
  - Symmetric facial diplegia
  - Truncal hypotonia
  - Shoulder-girdle weakness
  - Mild decreased tone in lower extremities
  - Visual and auditory response – diminished eye contact, but hearing and vision testing normal

Developmental course notable for marked delays in walking, talking, ataxic gait, oculomotor apraxia
  - Walked at 24 months
  - Speech/talking began at 30 months
  - Psychosocial concerns – diminished eye contact and verbal interaction, limited joint attention
  - At age 4, diagnosed with autism
“Early neurosensory, motor, cognitive, and behavioral impairments identified after preterm birth may or may not result in long-term challenges for children. While some are permanent disorders, others may be modifiable with intervention.”

(Rogers, E. and Hintz, S., 2016)
Principles and Elements of Neurodevelopmental Care
Self-regulating or Stability Cues

Physiologic
- Stable HR
- Stable RR
- Regular, slow respirations
- Color pink
- Tolerates feedings

Behavioral
- Body movements smooth and synchronous, relaxed posture
- Tone equal throughout body
- Arms/legs flexed
- Well-defined sleep-wake cycles
- Self-quieting behaviors: hands to mouth, sucking, clasping hands and feet, foot/leg bracing
- Attentive behaviors: alert, focused attention, orientation to voice or sound
Stress Cues

Physiologic
- Increase/decrease in RR
- Irregular respirations
- A/B/D
- Sneezing
- Hiccoughs
- Coughing
- Sighing
- Color changes: mottled, dusky, cyanosis, pallor, plethora
- Abdominal distension, spit up, vomiting, gagging, stooling

Behavioral
- Tremors
- Jitters/jerks
- Hypo/hypertonia
- Arching, flailing
- Finger splay
- Fisting
- Extended extremities
- Grimacing, frowning, staring, irritability
- Unable to modulate states
Infant States

- Deep sleep (non-REM or quiet sleep)
  - Difficult to arouse, no eye or body movements, regular breathing
- Light sleep (REM or active sleep)
  - Rapid eye movements/fluttering, irregular breathing, infant may cry/fuss in this state
- Drowsy
  - Eyes open and close, irregular breathing, may awaken further or fall back to sleep, ‘transition state”
- Quiet alert
  - Eyes brighten and widen, appear attentive, regular breathing, best state for taking in stimuli
- Active alert
  - Eyes open, with dull glazed appearance, irregular breathing, decreased threshold for internal and external stimuli, increased sensitivity
- Crying
  - Infant’s tolerance limits have been reached and exceeded
Neonatal Integrative Developmental Care Model

7 Core Measures:
1. Healing Environment
2. Partnering with Families
3. Positioning and Handling
4. Safeguarding Sleep
5. Minimizing Stress and Pain
6. Protecting Skin
7. Optimizing Nutrition

Mother/baby dyad at the center, surrounded by aspects of the healing environment and developmental care practices
Healing Environment

• Skin-to-skin care (SSC) – foundation of neuroprotective care
  • Encourage early, frequent, and prolonged SSC
• Adequate and comfortable space for parents
• Neutral thermal environment
• Gentle, slow handling
• Minimize stress and unnecessary/noxious sensory stimuli
• Encourage nurturing touch (“hand hugging”)
• Appropriate positioning, use of positioning devices, and containment during caregiving (facilitated tucking)
• Provide scent and taste of mother’s milk – scent cloths


Clinical Key for Nurses. https://www.clinicalkey.com/#!/content/journal/1-s2.0-S1055858617301373
Parents are the primary caregivers

Orient to the NICU, encourage questions, provide frequent updates and psychosocial support

SSC as soon as possible, as often as possible, for as long as possible

Encourage participation in rounds – coach parents in advocacy

Include siblings as much as possible

Post-partum depression screening and mental health support
Partnering with Parents

• Educate parents regarding neurodevelopment, infant sleep/wake states, stress cues, and ways in which they can promote good outcomes.

• Support positive interactions between parents and infant.

• Help parents become competent in infant care, building confidence towards discharge.

• Support parents as they evolve into their roles as expert and advocate for their child.
Partnering with Families

• National Perinatal Association – calling for more comprehensive psychosocial support for families
  • Recommendations include interventions in 6 areas:
    • Expanding family centered developmental care
    • Peer support for parents
    • Defining the role of mental health professionals in the NICU
    • Ensuring palliative care and bereavement support services
    • Improving discharge planning and post discharge support service
    • NICU staff education in communication skills and parent support techniques
Skin-to-Skin Care

• Best habitat for preterm infant – foundation of neuroprotective care
• Patient benefits – VS stability, fewer respiratory complications, better weight gain, temperature stability, improved state regulation and sleep
• Provides sensory stimuli that is biologically meaningful to the infant and promotes neurobehavioral organization
• Maternal benefits – promotes attachment/bonding, increased milk volume, increased parenting confidence, decreased stress and anxiety
• Parents quickly learn to recognize physiologic changes and stress signals and respond appropriately.
Handling and Procedures

• Assess sleep/wake state before handling; promote smooth transitions between states.
• Prepare the infant for care-giving, speaking softly to infant before placing hands on.
• Provide 4-handed support during repositioning and care activities whenever possible.
• Utilize slow, smooth movements.
• Maintain a flexed and contained position.
• Facilitate midline alignment, bringing hands toward face and mouth.
• If stress cues are noted, pause to allow recovery.

• IVH Prevention Bundle for first 72 hours of life (babies < 30 weeks)

• Goals thereafter: Position infants in a manner to:
  • Support musculoskeletal and motor system development
  • Facilitate neurosensory development
  • Promote neurobehavioral organization, comfort, and sleep
  • Decrease stress and energy expenditure

• Mimic the intrauterine environment, providing supportive containment with positioning aids
Positioning

• Aim for containment, rather than restraint
  • Flexible enough to allow spontaneous movement, tight enough to limit excessive activity
  • Arms flexed with hands midline towards face/mouth for self-comfort

• Aim for physiologic flexion
  • Shoulders softly rounded forward
  • Hands towards midline, able to touch face/mouth
  • Hips aligned and pelvis tucked
  • Knees, ankles, feet aligned and softly flexed
  • Neck neutral or slightly flexed, no hyperextension
• Protect sleep cycles, and especially REM sleep
  • Both REM and non-REM sleep are crucial during fetal and neonatal life for the development of neurosensory function
• Allow rest periods of at least 60 minutes to complete a normal sleep cycle.
• Use spontaneous awake periods for routine caregiving whenever possible.
• Cluster cares whenever possible, unless infant unable to tolerate all measures being bundled into single session.
• Manual VS/hands-on care every 6 hours, with hourly rounding to assess activity level, needs, comfort, etc.
• Coordinate with multidisciplinary team members to determine optimal time for assessments and treatments.
• Facilitate prolonged SSC to promote adequate and normal sleep patterns.
• Promote a quiet environment without loud noises to ensure uninterrupted sleep
• Maintain dim ambient lighting between “cares”.

Safeguarding Sleep
Minimize Stress and Pain

• The timing of routine caregiving and painful procedures is important.
• Helping to provide containment during uncomfortable procedures is an ideal opportunity for parent participation.
• Allow infant to fully recover from painful stimulus before resuming caregiving.
• Comfort measures are indicated for all minor or moderately stressful procedures – containment, non-nutritive sucking, sucrose.
• Add pharmacologic agents to comfort measures whenever moderate or severe pain is anticipated.
• Judicious use of sedatives and analgesics.
Protecting the Skin

• Humidity for ELBW infants for first 1-2 weeks of life
• Appropriate positioning aids
• Assess skin from respiratory equipment, leads, etc.
• Bathing no more frequently than every 72-96 hours
• Involve parents in bathing whenever possible; swaddled bathing
• Skin at risk for compromise due to tapes, dressings, adhesives, and other medical equipment
• Improves brain development: deeper nuclear gray matter volume, better IQ scores, improved academic achievement, and working memory
• Mother’s milk or donor milk – decreases risk of NEC, sepsis, ROP
• Minimize negative oral stimulation
• Ideal: stable infants held during gavage feeds, non-nutritive sucking when feeding
• Oral feedings should be infant-driven – cue-based
• Provide a safe, functional, nurturing, and developmentally appropriate feeding experience.
The single most important element of neurodevelopmental care is the family-infant relationship. Involved, knowledgeable parents are the key to promoting better neurodevelopmental outcomes AND facilitating repair and re-wiring of neural connections after a brain insult/injury. All NICU nurses, providers, and therapists have the opportunity to positively impact the sensory, motor, cognitive, language, and emotional/psychosocial outcomes of each and every baby we interact with – for the lifetime of that patient.
Every action, Every time, with Every patient should be with Purpose and Intention.
Thank You!

Questions?

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References


