Physical Therapy Practice in the Neonatal Intensive Care Unit

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ACP Conference 9.20.2015

Objectives

• Pathophysiology
  - Understand how preterm birth contributes to multi-system involvement for medically fragile neonates

• Examination and Evaluation
  - Understand principles of a neurobehavioral observation
  - Describe standardized evaluation tools commonly used in the NICU

• Interventions
  - Be familiar with evidence-base for various PT interventions in the NICU


- http://www.apta.org/NICU/

ICF Model

Extremely Low Birth Weight (<1000 grams)

Historical Evolution of NICU Care

- During the last several decades the survival of very low birth weight (VLBW) infants has increased (Wise, 2004)
- Led to development of therapy-led sensory stimulation programs (Barbosa, 2013)
- Neurodevelopmental morbidity of VLBW infants persist at school-age (Marlow, 2005; Hintz, 2005; Zwicker, 2008):
  - About 41% have ID and 30% have processing difficulties
  - About 20% have functional limitations
  - About 20% have behavioral problems and/or 2-fold higher risk of ADHD

ICF Model

Immaturity in all systems:
  - Cardiopulmonary
  - BPD / CLD, PDA, AOP
  - GI
  - NEC, GER
  - Neuro
  - IVH / PVL, BOP
  - Integumentary
  - Musculoskeletal
**Definition of Chronic Lung Disease (Parad, 2008)**

- For infants born < 32 weeks who were on oxygen for the first 28 days, at 36 weeks PMA:
  - **Mild**: no supplemental O2 requirement
  - **Moderate**: O2 < 30%
  - **Severe**: O2 ≥ 30%, or CPAP or MV

- For infants born ≥ 32 weeks who were on O2 for the first 28 days, same categorizations as above at 56 days

**Pathophysiology of CLD**

- **Inflammation**
- **Injury**
- **Scarring**
  - Collapse, fluid retention, hyperinflation
  - Cytotoxicity
  - Immature alveoli
  - Lack of surfactant

- Lung compliance
  - Airway resistance
  - Impaired gas exchange
  - V/P mismatching
  - Air trapping

- Postural changes
- Accessory muscle use
- Reduced flexion and rotation movements
- Irritability

**Radiologic Images of CLD**

- **Evolving cld (8 days)**
- **Severe cld**

Source: NICU, National Women’s Health at Auckland City Hospital

**Intraventricular Hemorrhage (IVH)**

- Bleeding originating from the subependymal cells of the germinal matrix that can enter the ventricles

- Classification system:
  - **Grade I**: GMH (germinatal matrix hemorrhage)
  - **Grade II**: IVH w/o ventricular dilation
  - **Grade III**: IVH w/ ventricular dilation
  - **Grade IV**: intraventricular and intraparenchymal bleeding

**Neuroanatomy Review**

**IVH Images**

http://www.slideshare.net/PediatricHomeService/brain-injury-in-preterm-infants
Pathophysiology of IVH

**Inflammation**
- Blood in the ventricles (IVH-I-II)
- Hemorrhagic infection
- Post-hemorrhagic ventricular dilatation (Grade IV)
- Hydrocephalus (Grade IV)

**Injury**
- Focal necrosis and cystic changes (PVL)

**Scarring**
- Cytotoxicity
- Ischemia and reperfusion
- Fragile blood vessels that don’t autoregulate well
- Collapse, fluid resorption difficulties, release of free radicals

*Focal necrosis and cystic changes (PVL)*

*Affects 15-20% of all infants < 32 weeks; 10% will have CP*

Examples of Cranial Ultrasound (CUS)

- **Grade 2 IVH**
- **Grade 3 IVH**

Epidemiology of Periventricular Leukomalacia (PVL)

**Definition:** focal necrosis in periventricular region leading to cystic changes, tissue collapse, and scarring; AND diffuse injury particularly to pre-OL's

**Incidence:** “most common substrate of neurological disabilities in the very prematurely born infant.” (Kinney, p. 81)

Perfusion Patterns

- Differences in perfusion between PT (left) and FT (right) infants
- Contributes to differences in cerebral damage and clinical presentation

Hypoxic–Ischemic Encephalopathy (HIE)

- Disrupted Autoregulation
- Hypoxemia + Metabolic Acidosis + Ischemia in Infant
  - Ischemia
  - Hypoxia
  - Lack of blood flow
  - Nuchal cord
  - Abruptio placentae
- Maternal
  - Inadequate blood carrying capacity
  - Severe anemia
  - CO poisoning
  - Maternal infection
  - Insufficient inspired oxygen
- Maternal illness
  - Maternal asthma
  - Maternal infection
  - Pneumonia

PVL

Epidemiology and Treatment of HIE

- Affects 2-9 / 1,000 live births
- Most common cause of CP and severe neurological disorders in the FT infant
- Cochrane review of hypothermic interventions (“cooling”)
  - Over 630 infants (8 RCT’s)
  - Significant reduction in mortality and neurological morbidity up to 18 months
- Recent data suggests standardized protocols for medical intervention and developmental follow-up are needed and feasible (Olsen, 2013)

Gastroesophageal Reflux (GER)

- **Definition**: movement of stomach contents into the esophagus
- **Incidence**: estimated to be about 60% of preterm infants
- **Pathophysiology**: inappropriate closing and opening of the lower esophageal sphincter due to immaturity

Ger - Presentation and Treatment

- **Clinical presentation**: irritability, poor sleep / wake cycles, excessive crying
- **Long-term complications**: R sided head rotation, decreased weight gain, food intolerance, esophagitis, and oral aversion
- **Treatment**: Histamine H2 receptor antagonists (e.g. Zantac, Pepcid), Proton Pump inhibitors (e.g. Prilosec), surgical interventions (e.g. fundoplication), and thickening feeds

Third trimester Neurodevelopment: Musculoskeletal System

- **In utero motor patterns**:
  - 12 weeks: hands to midline and face
  - 18-22 weeks: sucking and swallowing
  - 32-34 weeks: flexion tone in LE’s
  - 35 – 37 weeks: flexion tone in UE’s
  - Term (38-40 weeks): axial trunk develops

Take-Home Messages

- Preterm birth is associated with immaturity in many systems
  - Cascade of inflammation → Injury → LT tissue changes
- Medical fragility is associated with developmental vulnerability especially in neuromotor and cardiopulmonary systems
- Requires an individualized, developmentally supportive approach to determine infants’ strengths and vulnerabilities

Physical Therapy Examination and Evaluation of the NICU Infant
ICF Model

Self-Regulation

Synactive Theory of Development

• Interaction of sub-systems (Als, 1982)
  • Autonomic
  • Motor
  • State
  • Social Interaction
• Disconnect between extra and intra uterine environments
  • Family Centered Care

Self-Regulation

• THE task of the NICU infant
  • A dynamic concept
    • can change VERY quickly
  • Incorporates all other systems
  • Achieved when the challenges of the task meet the competencies of the infant

Experience of Fetal Development

• The ideal intrauterine environment is:
  • Warm and optimal for temperature regulation
  • Dark
  • Aqueous
  • Provides appropriate nutrition
  • Constant boundaries
  • Allows lungs to develop with minimal use
  • Free of elicit substances and harmful environmental triggers

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Fetal Neurodevelopment

- The aqueous, gravity-eliminated environment also allows ease of movements such as:
  - Hands to mouth
  - Hands to face and head
  - Tucking and flexing of arms and legs
- The fetus establishes a sleep-wake cycle and will experience a variety of states while supported by in-utero environment

Expectations of the Newborn

- The healthy full-term infant comes to the extrauterine environment with:
  - Mature lungs
  - Complete neural migration and more fully developed synapses and myelination in the brain
  - Good flexion tone in the upper and lower body
  - Competent sensory systems and foundation for healthy visual development
  - Optimal growth and nutritional history
  - Access to a developmentally supportive home environment and community resources

Experience of the NICU Infant

Experience of Fragile Newborn

- There is a mismatch between what the fragile newborn expects and what he experiences:
  - Lungs are immature
  - Brain has either not completed fetal maturation or may have sustained an insult
  - Limited ability to move against gravity even to bring hand to mouth or face
  - Immature sensory systems that require well-timed and modulated presentation of stimuli, and fragile and immature visual system
  - He may be withdrawing from medication (prescribed and otherwise) that Mom was taking
  - Difficulty with emotional contingency from caregivers
  - Adverse home environments (poverty, housing, nutrition, domestic violence, substance use, child abuse / neglect)

This “Mismatch” Can Lead to a Loss of Self-Regulation

The “Organized” versus “Disorganized” Infant (Als, 1986)

Principles of PT Examination and Evaluation

- The goal is to create a neurobehavioral profile –
  - A description of the infant’s competencies at self-regulation in light of participation
  - Not just a “snapshot”
- Assessment of neuromotor function
- Appropriate timing and modulation of handling
- Family-centered
Neurobehavioral Sub-Systems

- Autonomic
- Motor
- Organization of State
- Responsivity / Interaction

A framework to describe behaviors – the infants efforts and successes at self-regulation

Examination of the Autonomic System

- Breathing
- Heart Rate
- Color
- Gastrointestinal function
- Involuntary muscle actions

Examination of the Motor System

- Muscle Tone
- Active Movements
- Reflexes
- Posture and Passive movements

Source: AIMS

Examination of the Motor System

- Neonatal physical therapists are perhaps the most highly qualified members of the healthcare team to examine and interpret the motor system of a fragile infant.
- Examination should include observation of the infant’s posture at rest and active flexion movements during quiet awake periods, routine care, social interaction, and feeding.
- Functional movements should be interpreted according to the progression of active flexion patterns that emerge with increasing gestational age.
- PT examination will evaluate functional reflexes (e.g. suck, swallow, palmar and planar grasp, and early righting responses).

Examination of Behavioral States

- State Regulation: ability to smoothly move through a variety of states
  - Sleep (Deep and Light)
  - Drowsy
  - Quiet Awake
  - Active Awake
  - Crying

Examination of Behavioral States

- STATE: Increasing gestational age is associated with demonstration of more robust state organization. That is, as infants mature, they are able to transition smoothly and predictably between states.
- An infant who is 25 weeks CGA will likely spend most of the day in a light sleep state and have very brief periods of quiet awake.
- An infant who is 40 weeks CGA should have longer periods of quiet awake time, particularly prior to and following feedings.
- The NICU physical therapist plays a key role in educating parents and staff about identifying state transitions and optimizing the environment (e.g. modifications to light, sound, and interaction) to facilitate smooth transitions to and from sleep.
The “Organized” Infant

- **Autonomic**
  - Pink color, smooth respiration and heart rate
- **Motor**
  - Soft, flexed posture and smooth movements
- **State**
  - Predictable with smooth transitions

The “Disorganized” Infant

- **Autonomic**
  - Pale, mottled skin; irregular HR, tremors, reflux
- **Motor**
  - Extended postures, hyper or hypotonicity
- **State**
  - Unpredictable, difficult to interpret

Case Example 1

- Jacob is a former 27 week little boy, now 2 weeks old, corrected for prematurity.
- His NICU course was significant for 4 weeks on a mechanical ventilator and 3 weeks on oxygen therapy via nasal cannula.
- He had some feeding intolerance including difficulty digesting his formula and spitting up during and after feedings.
- He underwent several eye exams which revealed mild retinopathy of prematurity.
- He had 3 head ultrasounds which revealed a Grade II bleed.
- He was diagnosed with feeding immaturity and resolving chronic lung disease at discharge home.

Case Example 2

- Conor is a full-term infant with Down syndrome.
- He presents with cardiac defects. He was on oxygen therapy the first 48 hours of life due to respiratory distress.
- His main issues are around feeding. He demonstrates poor endurance to bottle feed successfully and consistently. He will be sent home with a feeding tube until he can become bigger and strong enough for his cardiac surgery.

Healthy Infants High-Risk

<table>
<thead>
<tr>
<th>Breathing</th>
<th>Healthy Infants</th>
<th>High-Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deep breaths, steady</td>
<td>Shallow breaths, costal</td>
</tr>
<tr>
<td></td>
<td>respiratory rate; may have</td>
<td>retractions, fluctuation</td>
</tr>
<tr>
<td></td>
<td>pauses, but recover</td>
<td>in respiratory rate from</td>
</tr>
<tr>
<td></td>
<td>quickly with no issues</td>
<td>pauses in breathing to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>rapid rate, less &quot;reserve&quot;</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>Steady</td>
<td>Prone to dips in heart rate</td>
</tr>
<tr>
<td>Color Changes</td>
<td>Mild</td>
<td>Moderate to Severe</td>
</tr>
<tr>
<td>GI Function</td>
<td>Stable or may have</td>
<td>Constipation, grunting,</td>
</tr>
<tr>
<td></td>
<td>Transient difficulty</td>
<td>reflux, feeding intolerance</td>
</tr>
<tr>
<td>Involuntary Muscle</td>
<td>Mild twitches and slight</td>
<td>More frequent startles</td>
</tr>
<tr>
<td>actions</td>
<td>tremors can be seen</td>
<td>and tremors that can</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interfere with activities</td>
</tr>
</tbody>
</table>

Why would Jacob and Conor have autonomic system difficulties?

- Medical and developmental issues that may be associated with difficulty with **autonomic function**:
  - Chronic lung disease and history of mechanical ventilation
  - Cardiac defects and history of respiratory distress
  - Patterns of poor feeding, tolerance of formula, and reflux
  - Immature neurological development is associated with tremulous movements and startles
Healthy Infants High-Risk

### Motor System Differences Between High-Risk and Healthy Infants

<table>
<thead>
<tr>
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<th>Healthy Infants</th>
<th>High-Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tone</td>
<td>Generally, strong flexor tone in LE and UE</td>
<td>Transient dystonia, flexor tone in UE might just now be developing</td>
</tr>
<tr>
<td>Active Movements</td>
<td>Bring hands to mouth and midline with minimal support</td>
<td>More extension patterns, fewer flexed, midline movements unless well-supported</td>
</tr>
<tr>
<td>Reflexes</td>
<td>Strong rooting, grasp, palmar, and plantar reflexes</td>
<td>Can vary from strong to inconsistent to weak</td>
</tr>
<tr>
<td>Passive Movements / Posture</td>
<td>Physiologic flexion</td>
<td>Scapular retraction, “frog legs”, right sided head preference</td>
</tr>
</tbody>
</table>

### Why would Jacob and Conor have motor system difficulties?

- Medical and developmental issues that may be associated with difficulty with motor system behaviors:
  - Hypotonia associated with DS
  - Transient dystonia associated with prematurity
  - Frequent extension patterns may impact ability to achieve flexed, midline orientation
  - Weak suck could impact feeding

### State Organization Differences Between High-Risk and Healthy Infants

<table>
<thead>
<tr>
<th></th>
<th>Healthy Infants</th>
<th>High-Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep (Deep and Light)</td>
<td>Longer periods of REM sleep, achieve sleep states fairly easily</td>
<td>More difficulty achieving deep sleep, may have more limited ability to protect sleep; can switch night-day cycles</td>
</tr>
<tr>
<td>Awake (Quiet and active)</td>
<td>Begin to develop nice sleep-wake cycles during early infancy</td>
<td>More difficulty achieving and maintaining awake/alert state</td>
</tr>
<tr>
<td>Crying</td>
<td>Robust, have “meaning” to parents</td>
<td>Often high-pitched, difficult to differentiate and interpret</td>
</tr>
</tbody>
</table>

### Why would Jacob and Conor have state system difficulties?

- What medical and developmental issues may be associated with difficulty with organization of states?
  - Long period in the NICU that may not have cycled lighting – Jacob may sleep all day and be awake all night
  - Difficulty with autonomic and motor systems preclude ability to achieve and maintain organization of states

### What is Responsivity?

- Visual fixation and tracking
  - Objects
  - Faces
- Alerting to sounds
  - Familiar voices
  - Unfamiliar sounds
- Simultaneous looking and listening

### Responsivity Differences Between High-Risk and Healthy Infants

<table>
<thead>
<tr>
<th></th>
<th>Healthy Infants</th>
<th>High-Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual tracking</td>
<td>Achieve and maintain eye contact fairly readily</td>
<td>May avoid eye contact, may not be able to break gaze (hyperalert), process visual information more slowly</td>
</tr>
<tr>
<td>Alerting to sounds</td>
<td>Turn toward familiar voices and sounds without “cost” to their system</td>
<td>Can either tune out sounds in the environment or demonstrate hyper-response</td>
</tr>
<tr>
<td>Looking and Listening</td>
<td>Can coordinate this complex task without too much “cost” to other systems (motor, autonomic, etc)</td>
<td>Very difficult task! Can generally do one or the other well, may need stimuli introduced slowly and one at a time</td>
</tr>
</tbody>
</table>
Why would Jacob and Conor have difficulty with responsivity?
• What medical and developmental issues may be associated with difficulty with responsivity?
  • Prolonged period in an environment characterized as busy, noisy, bright lights, etc.
  • Immature eye development or retinopathy may impact visual system development
  • There is some evidence that early exposure to light may also impact auditory development

This is the APEX of neurobehavior - Difficulty with autonomic, motor, and state organization systems preclude ability to achieve and maintain periods of responsivity

PT Examination: Case Study
• What do you observe from a neurobehavioral perspective?
  • AMOR:
    • Autonomic
    • Motor
    • Organization of State
    • Responsivity / Interaction
• What do you observe from a neuromotor capacity?
  • Posture, movement patterns, functional movements needed for social interaction and feeding

Case Study

PT Examination: Case Study
• What do you observe from a neurobehavioral perspective?
  • A
  • M
  • O
  • R
• What do you observe from a neuromotor capacity?
  • Posture, movement patterns, functional movements needed for social interaction and feeding

Standardized Assessment Tools
• Newborn Behavioral Assessment Scale (NBAS)
• Assessment of Preterm Infant Behavior (APIB)
• NICU Network Neurobehavioral Scale (NNN’s)
• Test of Infant Motor Performance (TIMP)
• General Movement (GM) Assessment
• Neurobehavioral Assessment of the Preterm Infant (NAPI)

Newborn Behavioral Assessment Scale (NBAS) (Brazelton and Nugent, 1995)
• The NBAS is the most commonly used assessment of infant neurobehavioral functioning in the world today
• Evaluates neurobehavior (28 items on a 9-point scale), reflexes (18 items on a 4-point scale); robustness of infant responses to stimuli and amount of examiner facilitation and support
  • The reflex items can be used to identify gross neurologic abnormalities but are not intended to provide a neurological diagnosis.
  • The NBAS is appropriate for use with term infants and stable high-risk infants near term age until the end of the second month of life post-term.
• The NBAS also includes a set of 7 supplementary items designed to summarize the quality of the infant’s responsiveness and the amount of examination facilitation needed to support the infant during the assessment.
  • These supplementary items were originally included to better capture the quality of behaviors seen in high-risk infants therefore making the NBAS better suited for use with this population.
### Assessment of Preterm Infant Behavior (APIB)
(Als et al, 1982)
- Based upon the NBAS, the APIB was developed for preterm and high-risk infants.
- The APIB provides a detailed assessment of infants’ self regulatory efforts and thresholds to disorganization as viewed through the infant’s behaviours.
  - The exam proceeds through a series of maneuvers, similar to the NBAS, that increase in complexity as well as tactile and vestibular demands, therefore providing the event against which the self-regulatory abilities of the infant can be challenged and measured.
- Designed for infants between 32 and 48 weeks PCA
  - To be safely examined for APIB testing, and infant must be physiologically stable enough to be brought into an examining room and handled for the duration of the assessment, typically 32 weeks PCA and older.

### NICU Network Neurobehavioral Scale (NNNS)
(Lester and Tronick, 2005)
- The NNNS is used to document and describe developmental and behavioural maturation, central nervous system integrity and infant stress responses.
- While similar to the NBAS in its content, the NNNS differs from it as the order of item administration is specified, items are skipped if the infant is in the wrong behavioural state, and deviations in its administration are recorded.
- It is therefore less focused on infant best performance and the infant-examiner interaction making the time required administering the NNNS shorter.
- Designed for the neurobehavioral assessment of medically stable drug-exposed and other high-risk infants, especially preterm infants older than 30 weeks postconceptional age to the age of 46-48 weeks postconceptional age.

### General Movement (GM) Assessment
(Prechtl, 2001)
- Used to determine neurological deviations that have a high likelihood of leading to cerebral palsy.
- Atypical movements include:
  - In the preterm period (i.e., until term): a limited movement repertoire or poor differentiation of movements.
  - From term to 8 weeks postterm: rigid and chaotic movements that lack smoothness and fluency (e.g., cramped synchronous movements).
  - From 6 weeks to 20 weeks postterm: absent or abnormal fidgety movements.
- Excellent (i.e., 90%) inter-rater reliability.
- Persistence of cramped synchronous movements and the absence of fidgety movements has been shown to be a valid predictor of cerebral palsy with 95% sensitivity and 96% specificity.
- More information about the GM Assessment can be found at http://general-movements-trust.info/5/home.

### Neurobehavioral Assessment of the Preterm Infant
(Korner, 1991; Noble 2012)
- Designed to monitor early infant development and evaluate the effects of interventions in the neonatal period.
- Appropriate for infants 32 weeks to term age.
- Consists of 7 domains: motor development, scarf sign, plop/sile angle, attention and orientation, percent sleep, irritability, and vigor of the infant’s cry.
- Has good inter-rater reliability and stability of the domains over time, strong construct validity and detects changes over time in neonatal neurobehavioral development in response to intervention.
- More information about the NAPI can be found at: http://med.stanford.edu/NAPI/.
Which instrument is “best”?
(Noble, 2012)

• A recent systematic review investigated neuromotor and neurobehavioral assessment instruments for preterm infants up to four months corrected gestational age.

• Several instruments have strong clinimetric properties: Prectl’s Assessment of General Movements, the Test of Infant Motor Performance, Neurobehavioral Assessment of the Preterm Infant
  • The NNNS and APIB have strong reliability and validity, yet their utility seems best suited for research.
  • The GMs, TIMP, and NAPI are valid and reliable instruments and appear to be most appropriate for use clinical settings.
  • The GMs has the best prediction of future outcome

• What about treatment planning?

Take-Home Messages

• The ‘mismatch’ between what the infant expects and what he experiences can lead to a loss of self-regulation

• The role of the PT is to recognize successes and vulnerabilities at self-regulatory attempts
  • Guide individualized, developmentally supportive interventions
  • Always in the context of the family

Physical Therapy Interventions in the NICU

Promotion of Self-Regulation and Motor Outcomes

How is PT Intervention in the NICU managed?

• When do you start PT?
• How often should you see babies?
• For how long?
• How do you progress them through a developmental and therapeutic program?

References

• APTA NICU Clinical Competencies and Clinical Training Models (Sweeney et al, 2009)
• NICU Clinical Decision-Making Algorithm (Sweeney et al, 2009)
• NICU PT Care Plan (Byrne & Campbell, 2013)

NICU Care Plan
(Byrne & Campbell, 2013)
**NICU Care Plan**  
(Byrne & Campbell, 2013)

**Physical Therapy Interventions in the NICU**

Promotion of Self-Regulation and Motor Outcomes

**Evidence-Based PT Interventions**

- Newborn Individualized Developmental Care and Assessment Program (NIDCAP)
- Positioning
- Sensory Stimulation
- Massage
- Newborn Behavioral Observation system (NBO)
- Environmental Modifications

**Interventions**

- Interventions to promote self-regulation:
  - Integrated individualized, developmental care programs (e.g. NIDCAP & NBO)
  - Positioning
  - Sensory and Kinesthetic Stimulation

- Interventions implemented by PT’s to improve neuromotor outcomes

**Newborn Individualized Developmental Care and Assessment Program (NIDCAP)**

- The NIDCAP is a comprehensive, interdisciplinary and family-centered program that includes:
  - Direct observation of the infant – prior to, during, and after a caregiving experience
  - A summary report detailing the infant’s competencies and areas of vulnerability, with recommendations to support the infant’s difficulties with self-regulation

**Efficacy of NIDCAP**  
(Symington & Pinelli, 2006; Ohlsson and Jacobs 2013)

- NIDACP is a broad intervention that has several core components:
  - Clustering of nursing care
  - Reduction of environmental stimuli
  - Promotion of social interaction and BF
  - Swaddling, containment, and proper positioning

- Results of the 2006 Cochrane review suggest limited short or long-term benefit
  - But the authors suggest methodologic considerations affect their conclusions

- Preliminary findings of 9-year-olds suggest better executive function and cerebellar volume in intervention group vs. controls (McAnulty, 2013)
Quality of Developmental Care Improves Neurobehavior
(Montirosso, 2012)

• Quality of Developmental Care measured by 2 scales
  • Infant-centered: parents can spend the night, routine K-care, duration of K-care, nursing interventions
  • Pain Management: pharmacological, sedation during MV, blood collection, assessment scales

• Higher scores were significantly associated with more optimal neurobehavior on the NNN’s (stress, hypotonicity, regulation, etc)

Positioning

Which Now Term Baby Spent His Last Trimester in the NICU?

Baby A

From: Piper, 1994 Motor Assessment of the Developing Infant

Baby B

From: Sweeney, 1995

Principles of Positioning for Preterm Babies
(Vergara, 2004)

• Provide containment and a sense of security for a smoother adjustment to the extrauterine environment

• Discourage extension and promote flexion to achieve postural and movement pattern that resemble those of healthy full-term infants

• Optimize physiologic stability and neurobehavioral organization to enhance self-regulation

• Promote hand→mouth activity to enhance the infant’s ability to self-calm

Principles of Positioning for Preterm Babies (Vergara, 2004)

• Maintain proper body alignment to prevent postural asymmetries

• Expose the infant to a variety of postures to prevent the development of fixed postural patterns

• Maintain skin integrity and prevent skin breakdown

• Maximize the infant’s developmental potential and engagement in family-expected age-appropriate activities
Evidence for Efficacy of Positioning for Preterm Babies

- Infants contained during heel sticks and suctioning had lower HR, improved O2 saturation and fewer signs of neurobehavioral stress (Sweeney, 2002)
- Use of gel pads and frequent position changes associated with significantly decreased incidence of plagiocephaly (Sweeney, 2002)
- Several randomized studies suggest that prone positioning is associated with increased midline orientation, improved oxygenation, less GER (Monterosso, 2001; Balaguer et al, 2013)
- SWADDLING effect seem persistent. A recent Cochrane review addressed nesting and swaddling. No evidence was found that nesting shortened length of stay or lead to greater weight gain. But, one study found that swaddling was associated with more mature performance on a standard neurobehavioral examination.

Neuromotor Implications of Prone Positioning

- Unopposed activity of the trapezius and rhomboids leading to retracted scapulae
- Shortening of the iliopsoas and adductor brevis leading to elevated pelvis, hip ER and abduction
- Shortened cervical rotators leading to head preference and positional plagiocephaly

Examples of Developmentally Supportive Positioning

The "T" position – roll under head and abdomen.
From Developmental and Therapeutic Interventions in the NICU

The inverted T – vertical roll under abdomen and horizontal roll under hips / pelvis

The " Pretzel": C-spine alignment

Roll under head / neck, posterior to back, between legs and midline
Examples of Developmentally Supportive Positioning

The "Pretzel": Hip Alignment

Same as previous slide, but rolls up and over hip to reduce "frog legs"

The "Nest": From: http://www.small-beginnings.com/images/preemienest2.jpg

Supine position that offers constant proprioception and maintains flexed, midline orientation of extremities.

Sensory Stimulation (Symington & Pinelli, 2006)

• Infants hospitalized in the NICU do not undergo sensory deprivation, but rather a mismatch between the environment and their sensory capacities
• A review of the literature on sensory stimulation investigated vestibular, auditory, visual, and tactile modalities
• Associated with faster transition to full nipple feeding and reduced length of stay.


• A meta-analysis reviewed the effect of "gentle slow stroking of various parts of the infants body" (as a single modality)
  • Typical protocol: 3x/d for 15m, 5d (e.g., Hernandez-Reif et al, 2007)
• The results suggest a positive effect:
  • Better weight gain
  • Shorter LOS
  • Better NBAS scores (neurobehavioral profile)
  • Possibly fewer post-natal complications

PT interventions in the NICU (Spittle, 2007)

• A Cochrane review of early motor and cognitive interventions of infants included 5 studies where PT's provided intervention in the NICU
  • Intervention largely consisted of NDT
  • Outcomes included the AIMS and TIMP as well as other less well-known measures of GM function
  • There was little evidence to support PT interventions in the NICU
    • However, in most cases "controls" were receiving PT
  • There was no measure of post-NICU follow-up
  • "NDT" may best targeted at high-risk infants

PT Intervention

• How would you intervene to improve neurobehavior and neuromotor function?
  • A: physiologic stability / reflux?
  • M: posture, movement patterns, and functional movements?
  • O: awake / alert state?
  • R: social interaction and feeding?
PT Interventions: Case Study

ICF Model

Parenting a NICU infant / graduate

• Increased maternal depression and anxiety (Doering, 1999)
  • Lack of social support, family functioning, and perceived control explained significant amount of symptoms
  • Thought to be more substantial for parents of preterm infants due to a constellation of: maternal psychosocial and infant’s neurological immaturity
  • Difficulty with contingent responses
  • Frontal lobe activity and vagal nerve reactivity

Family Needs During and Post NICU

• Research (Shiekh, 1993; Cleveland, 2008) on needs of families upon discharge from hospital consistently cites several themes:
  • Parental empowerment
  • Knowledge about infant development
  • Emotional support
  • Guided participation

The Newborn Behavioral Observations (NBO)

• Highlights the infant’s efforts, successes, and vulnerabilities at self-regulation
  • A standardized tool of 18 elicited maneuvers examining neurobehavior, including the motor system
Visual Tracking

Responding to Voice

Lower Extremity Tone

Effects of the NBO

- Parents of infants in the NBO group demonstrate more favorable perceptions of their ability to read and respond contingently to their infant’s cues (p<.05).

Source: McManus BM, Nugent JK. A neurobehavioral intervention incorporated into early intervention service delivery and service provider perceived confidence to work with families of high-risk members. Journal of Behavioral Health Services and Research.

Effects of the NBO

- Therapists in the NBO group demonstrate more favorable perceptions of their confidence (p<.05).


ICF Model

NICU Design
National Standards for NICU Design
(White et al, 2013)

  - Noise levels > 45 dB is of concern
- American Association for Pediatrics for Guidelines for Perinatal care
  - Between 10 and 60 lux for care areas
  - 650 lux for observation and 1080 lux for procedures
  - Light directed toward the infant’s eyes should be avoided

Sound Levels in the NICU
(Bremmer et al, 2003)

<table>
<thead>
<tr>
<th>Noise Source</th>
<th>Target Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermostat moving in another on the incubator</td>
<td>75 dB</td>
</tr>
<tr>
<td>Neonatal monitor</td>
<td>55 dB</td>
</tr>
<tr>
<td>Using incubator top or warming surface</td>
<td>70–75 dB</td>
</tr>
<tr>
<td>IV pump tone</td>
<td>65–70 dB</td>
</tr>
<tr>
<td>Turning on and off</td>
<td>65–70 dB</td>
</tr>
<tr>
<td>Operating patient data of incubator</td>
<td>65–70 dB</td>
</tr>
<tr>
<td>Closing an radiant warmer</td>
<td>70–75 dB</td>
</tr>
<tr>
<td>Changing a radiant warmer</td>
<td>70–75 dB</td>
</tr>
<tr>
<td>Dropping level of saturation</td>
<td>65–70 dB</td>
</tr>
<tr>
<td>Pitching tones of neonatal data of the incubator</td>
<td>65–70 dB</td>
</tr>
<tr>
<td>Raising radiant to stimulate apnea</td>
<td>70–75 dB</td>
</tr>
<tr>
<td>Victim of radiant</td>
<td>110–140 lux</td>
</tr>
</tbody>
</table>

Adapted from Gilliland (1999); Babigh, Khagya, and Brown (2003)

Modifying the Environment: What is the Evidence?

Cycled Lighting
(Rivkees et al, 2004 Morag and Ohlsson 2013)

- The source of the human body’s circadian rhythms lies in the suprachiasmatic nuclei (SCNs)
  - The central oscillator in the human biological clock (left and right anterior hypothalamus)
- Results showed that infants exposed to the cycled lighting had activity patterns that coincided with light-dark periods, but this effect was most dramatic closer to and post D/C
  - Could be a “sleeper” effect: cycled patterns primed the visual-SCN pathways and effects did not show until this system was fully developed (40+ weeks)
- Intervention had mediating effects
  - Parents: carried over protocol at home
  - Staff: altered their behavior when caring for infants

Strategies to Reduce Sound
(Almadhoob & Ohlsson 2015)

- Research on interventions to reduce sound in the NICU have focused on:
  - Staff education (Johnson, 2003)
  - Renovations (Byers, 2006) and equipment changes (Brandon, 2007) in the NICU
  - Quiet hour (Johnson, 2003)

_Each significantly reduced sound, but not to recommended levels_

- None addressed staff conversation

Are Single-Patient Rooms Better than Open Units?

- SPR have benefits and limitations for fragile babies and families (Pineda, 2014; Pineda, 2011)
- Babies and families in single-patient rooms experience more:
  - Visitation during weeks 2 and 3
  - Stress (controlling for social supports)
  - At term: decreased amplitude of ECG for cerebral maturation scores
  - At 2 years of age (corrected): lower language scores and a trend toward lower motor scores
Conclusions

• Preterm infants are at high-risk for neurodevelopmental complications

• You are the early early intervention – brain development and lung maturation are occurring in your hands
  • You have the potential to positively shape a baby’s developmental trajectory

Conclusions

• EBP PT interventions in the NICU should be:
  • Comprehensive:
    • Developmentally supportive positioning
    • Promotion of infant’s social interaction with caregivers using carefully modulated sensory experiences
    • Facilitated handling for high-risk infants
    • Oral feeding as a developmental task
  • Environmental modification to reduce excessive noise and light
  • Interdisciplinary
  • Rigorously implemented and evaluated

Resources

• Reference and Resource Sheet
• APTA, Pediatric Section
• Practice guidelines & Clinical decision-making algorithm
• NICU Residency Programs
• NBO/NBAS Training - http://www.brazelton-institute.com/
• Medical Information
  • https://www.ucsfbenioffchildrens.org/pdf/manuals/49_IntraventricularHem.pdf

Thank You!

Questions????

The NBO

• The NBO is a relationship-building tool that offers support to families during a non-normative transition – the birth of a high-risk infant
  • Allows for a shared experience of infant’s strengths and areas of vulnerability
  • Validates parental concerns

• Focuses on self-regulatory skills of the infants and the co-regulatory capacity of the parents
  • Ability to adapt to the changing needs of the environment
  • Ability to read and respond contingently to infant’s cues