Welcome to Phase II of the Neonatal Touch & Massage Certification

Development of the High Risk Infant in the NICU
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Objectives

- Define important changes in the brain that occur prior to term equivalent
- Define important neurobehavioral changes that occur in the NICU
- Define how factors associated with the NICU environment can be sub-optimal for the growing premature infant
- Define how current research can guide interventions in the NICU
- Describe research findings from the Washington University Neurodevelopmental Research Group (WUNDER)

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WUNDER Research Group

- Infants born less than 30 weeks gestation
  - Enrolled by 3rd day of life
  - No congenital anomalies
- Collect medical information throughout length of stay
- Bedside log to collect stressful exposures and parent visitation and holding
- Serial neurobehavioral assessment (birth, 30 weeks, 34 weeks, and term equivalent)
- Serial MRI
- Comprehensive questionnaire at discharge from the NICU
- Developmental follow-up at 2 and 4 years
  - Developmental testing
  - Parent questionnaire

In our Cohort:

- Average Gestational Age at Birth: 26.9 (±1.9) weeks
  - Range 23 weeks to 30 weeks
- Average length of intubation: 3 days
  - Range 0-92 days
- Caucasian 54%
- Single mothers 65%
- Rule out sepsis 30%
- PDA 49%
- NEC 12%
- Brain injury 29%

Premature Infants

- 12% of infants born in the US are premature
- ½ million premature infants born annually in US
- Increasing survival rates
- Myriad of problems associated with prematurity

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Premature Infants

- Necessitate care in the NICU
  - Physiological
  - Respiratory
  - Gastrointestinal
  - Poor neurological maturation
  - Poor feeding skills
  - Temperature instability

Medical Interventions

- Intubation
- Continuous positive airway pressure
- Nasal cannuli
- Intravenous lines
- Heel sticks
- Nasogastric/orogastric tubes
- Eye exams
- Suctioning

By Discharge:

- Respiratory stability
- Temperature regulation
- Oral feedings
- Caregiver role shifts completely to the parent
Premature Infants-Developmental Sequelae

- Evolution of developmental delay is evident by term equivalent
- Our cohort:
  - Compared to full term infants:
    - Poor orientation ($p<.001$)
    - Poor tolerance of handling ($p<.001$)
    - Poor self regulation ($p<.001$)
    - More sub-optimal reflexes ($p<.001$)
    - More stress ($p<.001$)
    - More hypertonicity ($p<.001$)
    - More hypotonia ($p<.001$)
    - More excitability ($p=.007$)

Consequences of Prematurity

- Cerebral palsy and other motor impairment
- Sensory processing deficits
- Behavioral problems
- Poor cognition, executive dysfunction
- ADD/ADHD
- Autism
- Learning disability
- Schizophrenia
- Attachment disorders

Behavior and Development

- Not something to address after medical factors have resolved
- Instead, something we should be addressing in tandem
Exploring the Early Development of the Premature Infant

- Development in the NICU is not static
  - Acquisition of medical factors and brain injury
  - Brain development
  - Neurobehavioral changes

- Understanding early development can:
  - Allow a better understanding of factors that can be helpful or harmful in the NICU environment
  - Can equip the clinician with strategies to optimize development in the NICU
    - Environmental
    - Therapeutic
    - General positive experiences

Progression of Tolerance of Handling

- Potential physiological compromise with any handling
- Motor stress signs
- Short periods of handling with some compromise to states of arousal
- Increasing periods of alertness and tolerance of handling
- Coping with environmental stressors and still available to interact with caregivers and meet needs (feeding)

Assessment and Interventions in the NICU

- Tailored to the infant
  - Gestational age
  - Medical status
  - Energy expense
  - Other interactions
### During the NICU: Critical Period of Development

- **Neurobehavioral changes**
- **Brain development**
  - Evolution of brain injury
  - Brain maturation

### Neurobehavioral Changes in the NICU

- **Behavior**
  - Self regulation
  - Orientation
  - Excitability
  - Arousal
- **Motor patterns**
  - Tone
  - Quality of movement
  - Posture
  - Reflex development
- **Feeding performance**

### Patterns of Development From 34 PMA to Term

- **Rapid changes in final 6 weeks of extra-uterine life**
- **Changes in motoric function**
  - Increasing hypertonia ($p<.001$)
  - Decreasing hypotonia ($p=.001$)
  - Declining quality of movement ($p=.006$)
- **Changes in behavior**
  - Increasing arousal ($p<.001$)
  - Increasing excitability ($p<.001$)
  - Decreasing lethargy ($p<.001$)
Complement Understanding of Early Developmental Progression

• Tonal changes
• Behavior changes
• Tolerance of handling

• Patterns of altered development
  – Quality of movement decreases

Brain Development of the Premature Infant in the NICU

• Not static during the NICU hospitalization

• Evolution of brain injury
• Brain maturation
• Myelination

Evolution of Brain Injury

• Change from fetal to own circulation

• Most commonly in the first week of life
  – Stress
Brain Injury in the NICU

- Common forms of brain injury:
  - White matter disease
    - Periventricular leukomalacia
    - Focal white matter injury
  - Intraventricular hemorrhage
    - Grade I
    - Grade II
    - Grade III
    - Grade IV
  - Cerebellar Injury
    - Focal injury
    - Cerebellar hemorrhage

Changes To the Brain During the NICU Stay

- Cortical folding
- Increased brain volume
- Myelination

Cortical folding

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Brain Development During NICU Hospitalization

- In our cohort:
- By term equivalent (compared to full term, healthy infants):
  - Decreased brain volumes
  - Poor cortical folding

**Term Control**

**Preterm**

Decreased transverse diameter

Why Does Development and Brain Development Lag Behind?

- Brain injury
  - Detected on MRI/CUS
- Medical factors that interrupt development
- Lack of positive experiences
  - Parenting
  - Holding
  - Feeding
  - Touch
  - Interaction
- NICU environment
- Stress

Perinatal Exposures

- Medical factors are associated with poor early neurobehavior:
  - Gestational age at birth
  - Length of stay
  - Brain injury
  - Use of sedatives
  - Caffeine use
  - Length of intubation
  - Postnatal steroids
  - PDA
  - IUGR
Parent Separation
- Lack of a consistent caretaker
- Often times long periods of parental absence
- Parent stress, anxiety and depression
- Lack of parental confidence
- Focus on numbers and medical status
- Poor rates of holding and comfort

Parent Visitation in the NICU
- Average hours of visitation per week (weeks 1-2)
  - 26.20 ± 29.40 hours per week
- Average hours of visitation per week (weeks 3-4)
  - 21.26 ± 24.60 hours per week
- Average hours of visitation per week (weeks 5-discharge)
  - 20.15 ± 20.81 hours per week
- Average hours of visitation per week

Cuddle Holding
- Average number of days per week held (weeks 1-2)
  - 1.60 ±1.67 days held per week
- Average number of days per week held (weeks 3-4)
  - 2.12 ± 1.75 days held per week
- Average number of days per week held (weeks 5-term)
  - 2.93 ± 1.68 days held per week
- Average number of days per week

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Skin to Skin Holding

• Average number of days per week held skin to skin (weeks 1-2)
  – .94 ± 1.27 days held skin to skin per week

• Average number of days per week held skin to skin (weeks 3-4)
  – 1.10 ± 1.38 days held skin to skin per week

• Average number of days per week held skin to skin (weeks 5-term)

Holding

• Can be limited by medical interventions
• Parent presence
• Parent confidence
• Confidence of health care professionals

• In our cohort:
  – First hold ranged from day of life 1 to day of life 76
  – Average day of first hold: day of life 10

Through Length of Stay

• Holding increases
• Skin to Skin holding peaks in weeks 3-4
• Visitation decreases after first week
• On average, infants first held on day of life 10
Parent Visitation in the NICU

- Associated with neurobehavioral outcome at term:
  - Increased levels of parent visitation associated with
    - Better quality of movements ($p=0.014$)
    - Less hyper-excitability ($p=0.006$)
    - Less arousal ($p=0.013$)
    - More hypotonia ($p=0.002$)

Parent Holding

- Cuddle holding associated with neurobehavioral outcome at term:
  - Improved quality of movement ($p=0.003$)
  - Diminished stress signs ($p=0.004$)
  - Less hyper-excitability ($p=0.024$)

- Skin to skin holding associated with neurobehavioral outcome at term:
  - Less hypertonia ($p=0.017$)

Caregivers are Important to the Brain

- Caregiving is critical for the early establishment of relationships and bonding
- Parent-child relationships are a good predictor of outcome
- Early experiences, negative and positive, lie the foundation for responsivity later
  - Early learning and memory
  - Brain development
Other NICU Factors

- NICU environment
- Stress

Stress and Associations with Brain Development

- Infants in the NICU are exposed to a myriad of stressful exposures in the NICU
- 44 infants
- Bedside Log
  - Nurses recorded during each shift
  - Checked against the medical record

Neonatal Infant Stressor Scale (NISS)

- Bedside log delivered to infant bedside after enrollment in the study
- NISS
  - Easy to use single record sheet
  - 36 procedures and interventions
    - Ranging from diaper change to intubation
    - Stressful exposures documented by nurses on each shift
    - Measured from birth until term equivalent
    - Cumulative stress score
Associations Between Stress Exposure and Brain Injury
- Cerebellar hemorrhage and stress exposure (odds ratio, 1.155; 95% confidence interval, 1.055-1.265; \( p = 0.002 \))
- Total brain injury score and stress exposure (28 days: \( r = 0.362, p = 0.02 \); total average to discharge/term: \( r = 0.35, p = 0.023 \))
- Bifrontal and biparietal diameters were reduced with increasing

Associations Between Stress Exposure and Early Neurobehavior
- Abnormal movement pattern \( (r = -0.422, p = 0.04) \) more prevalent with increased stress in the first 14 days
- Non-optimal reflexes on the NNNS \( (r = 0.265, p = 0.09) \) was observed in infants with more stressful exposures, which also persisted after correction \( (r = 0.343, p = 0.04) \).

Single Patient Room in the NICU
- Many hospital renovations underway
- Converting the NICU barn (open bay) areas to single patient rooms
  - Private environment for family
  - Decrease stimuli
    - Decrease sounds
    - Individualized lighting
    - Individualized care

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Single Patient Room in the NICU

- Expected to increase parent experiences in the NICU
- Expected to be advantageous for the development of the infant

- Preliminary studies
  - Shorter length of stay
  - Decreased risk of infection
  - Positive staff and parent perceptions
  - Longer length of lactation for mothers

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Single Patient Room in the NICU

- Our cohort

- Effects on the mother and family:
  - More parent visitation in the single patient room
  - Parents report more feelings of stress in the single patient room

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Single Patient Room in the NICU

- Effects on the Infant During Hospitalization
  - More excitability at 34 weeks PMA (p=.005)
    - No other neurobehavioral effects detected
  - No difference in any medical factors during the NICU

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Single Patient Room in the NICU

- Effects on development at age 2
  - Infants hospitalized in the single patient room demonstrated poor language skills compared to their counterparts at age 2 (p=.001)
    - On average, they scored almost 9 BSID-III points lower
  
- Effects of isolation?
  - Urban NICU with poor parent visitation rates
  - Diminished language exposure?

Interventions in the NICU

- Hands on approach
- Hands off approach

- Find the balance
- More research is needed

Effects of Doing Too Much...

- Physiological compromise
  - Brain injury
- Medical compromise
- Poor learning experiences
- Energy expenditure
  - Unavailable for feeding
  - Unavailable for interaction with parents
Effects of Doing Too Little...
- Lack of positive learning experiences
- Contributing to the developmental disadvantage that premature infants have
- Increased likelihood of poor response to handling and treatment later

Finding a Balance...
- Minimizing stimuli that cannot be tolerated
- Reducing stress exposure
- Positive experiences to help lie networks within the brain
- Improving parenting within the NICU

Why are Interventions in the NICU Important?
- Already have a developmental disadvantage by term equivalent
- Sub-optimal parenting
- Negative environmental exposures
- Critical period of development
What are Ideal NICU Interventions?

• More research is needed

Please proceed to complete the test.
Questions?
Please contact jan@infantdriven.com.