List the four pillars of a Neuro-NICU practice

Describe at least two neuro-protective interventions that can be delivered in any NICU
BRAIN INJURY... A REALITY OF ICU CARE

- High incidence of brain injury in intensive care setting - Regardless of age
  - Neonatal ICU
  - Paediatric ICU
  - Adult ICU
  - Cardiac surgery
  - Neurosurgery

NEONATAL BRAIN INJURY

- There are a number of causes and diagnoses
- Outcomes depend on location, timing, extent of injury, interventions

PERINATAL-NEONATAL BRAIN INJURY

- The incidence of neurological disabilities related to perinatal brain injury has not decreased in decades
  - CP, Cognitive impairment, Epilepsy
  - Term and preterm infants are affected

PERINATAL-NEONATAL BRAIN INJURY

- Leading cause of death and disability in children
  - Not just short term but long term effects

**NEONATAL BRAIN INJURY**

- Pre-term infants
  - Up to 50% of very low birth weight babies have neurological injury (IVH, PVL)
  - Survival continues to increase, especially for the smallest premature infant
  - At risk for the most severe injury

**WHAT WE STILL DON’T KNOW**

- On the basis of our follow-up data we feel that the size of the hemorrhage on ultrasound is by no means the only guideline to outcome. There may well be other factors influencing the result which we cannot yet diagnose by ultrasound.
  - M. I. Levene
  - Letter to the Editor, Lancet, 1981

**VON: Mortality and major morbidity among survivors. 2000 vs. 2009**

**IQ SCORES AT 26 YEARS (N=359)**

Graphic Credit: Dr. Dieter Wroka, UK
Neither structural brain alterations nor the medical complications common in the NICU population fully explain the variation in long-term neurobehavioral development.

- Milgrom, Pediatric Research, 2010

Perinatal brain injury is multi-factorial and is occurring at a micro level that we do not yet even understand fully.

- In the past - Cardiovascular and hypoxia-ischemia were the sole culprit; Gr III/IV IVH; PVL

Extremely preterm children were 6 times more likely to have ASD than classmates (OR 6.3, 95% CI 2.1 to 18.3).


Graphic Credit: Dr. Dieter Wolke, UK
**Neonatal Brain Injury**

- Term asphyxiated infants
  - Poor neurological outcomes

**Asphyxia & HIE**

- Hypoxic-Ischemia Encephalopathy
  - 1-4/1,000 live births
  - Perinatal brain injury
    - Ante-partum/Prenatal (30%),
    - Intrapartum (60%) and
    - post-partum (10%)
  - CP and mental deficiencies are common sequelae

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**Early Developmental Outcomes After Newborn Encephalopathy**

*Dixon et al; Pediatrics 2002;109:26 –33*

- Overall, 39% of patients had a poor outcome (defined by death, CP, or a significant degree of developmental delay, compared to 2.7% of control subjects.
- Overall 10% of patients had CP
- Severe NE – 52% poor outcome
- Moderate NE – 25% poor outcome
- Patients with a history of seizures were 3 times more likely to develop cerebral palsy than patients without. (p 0.04; 16%-6%)

**You will not incur a more focused period of risk for ischemic stroke than the week you are born.**

- Adult risk
  - All adult
    - <150/100,000/yr
    - <1:35000/week
  - High risk (HTN, DM, smoke)
    - <500/100,000/yr
    - <1:10000/week
  - Elderly
    - <1500/100,000/yr
    - <1:3500/week

- Perinatal risk
  - NAIS
    - >1:2500-4000 live births
    - 90% occur within 1st week
  - PPIS
    - APPIS – same again
    - PVI – same again*
  - CSVT
    - >0.6/100,000/yr

Highest adult: <1:3000/week
Overall Perinatal: >1:1500/week
**Neonatal Seizures**

- Birth is the most common time of life to have seizures
- 0.7-2.7/1000 live births at term
- Estimated 50-100/1000 live births in preterm
- 20% mortality, 40-60% morbidity, 20% epilepsy
- In the setting of HIE with seizures – associated death or cerebral palsy 50-90%

**4 Pillars of Neuro-NICU Care**

- Assessment
- Imaging
- Monitoring
- Protection

**The Neuro-Conscious NICU**

- Neuro-Assessment
  - Identification of Risk
  - Clinical/Hands On
  - Metabolic
  - Follow Up Care
**Clinical Assess**
Influenced by sedatives, age, experience

**Bedside Assessment Tools**
Finnegan, Sarnat

**NEUROLOGICAL EVALUATIONS**

**SPECIALIZED STUDIES FOR NEURO-ASSESSMENT**

- CSF examination
- Newborn Screen
**Specialized Studies for Neuro-Assessment**

- Brain Stem Auditory Evoked Responses
  - Hearing Screening
- Visual Evoked Potentials

**The Neuro-Conscious NICU**

- Neuro-Assessment
  - Identification of Risk
  - Clinical/Hands On
  - Metabolic
  - Follow Up Care
- Neuro-Imaging
  - MRI
  - MRS
  - Ultrasound

**Serial Head Ultrasound**

**CT, MRI, MRS, f-MRI, PET**
What monitoring devices are used for sick neonates in the NICU?

- Temp
- Blood Pressure
- End Tidal CO2
- SaO2
- Respiratory

**WHAT ABOUT THE BRAIN?**

**EEG**
- MRI
- MRS
- Ultrasound

**NIRS**
- aEEG
- NIRS
- Hearing

**Neuro-Assessment**
- Identification of Risk
- Clinical/Hands On
- Metabolic
- Follow Up Care

**Neuro-Monitoring**
- EEG
- aEEG
- NIRS
- Hearing

**Neuro-Imaging**

![Image: jordaneuro.com](image)

![Image: international league against epilepsy](image)
aEEG
Using pattern recognition and classification.

With aEEG you can appreciate:
- Overall brain activity (background)
- Sleep-wake patterns
- Potential seizure activity
- Symmetry between cerebral hemispheres

Who will benefit from monitoring with aEEG?

- **Term Infants**
  - HIE
  - Induced Hypothermia
  - Seizures
  - Meningitis
  - Stroke
  - Cerebral Vascular Malformations
  - ECMO
  - Neonatal Abstinence
  - Metabolic Disease
  - CHD
  - Post op
  - Post arrest

- **Preterm infants**
  - Maturation
  - Developmental Interventions
  - Evolution of Sleep
  - Sepsis/Meningitis
  - Seizures
  - IVH
  - Post cardiac arrest

Add example of raw EEG
Add example of aEEG

- Continuous Normal Voltage
- Discontinuous Normal Voltage
- Burst Suppression
- Continuous Low Voltage
- Inactive/Flat/Isoelectric
THE NEURO-CONSCIOUS NICU

- **Neuro-Assessment**
  - Identification of Risk
  - Clinical/Hands On
  - Metabolic
  - Follow Up Care

- **Neuro-Monitoring**
  - EEG
  - aEEG
  - NIRS
  - Hearing

- **Neuro-Imaging**
  - MRI
  - MRS
  - Ultrasound

- **Neuro-Protection**
  - Developmental Care
  - Cooling
  - Medications
  - Adjunctive

WHAT IS NEURO-PROTECTION??

- Initially used to characterize substances or strategies capable of preventing cell death
- Now, encompasses all interventions that promote normal development and prevent disabilities
- And are used in a diverse range of populations


WHAT IS NEURO-PROTECTION??

- In Peds and NICU, neuro-protective interventions are becoming common and even “standard of care”
  - From Cooling babies with HIE to Near Drowning and a number of other diseases
- Overall these interventions fall in to 1 of 5 primary domains of Neuro-Protection

Prevention of Injury

Containment of Injury

Increase Cellular Tolerance

Salvage Injured Cells
**Interventions That Aim To:**
- Grow New Neurons (neurogenesis)
- EPO
- Stem Cell
- IGF-1
- Massage
- Kangaroo Care

**Neural Plasticity**
- Experience Dependent
- What fires together, will wire together

**Neural Pruning**
- Experience Expectant
- Use it, or lose it
**WHAT IS NEURO-PROTECTION??**

Interventions That Aim To:
- Nurture the neurons we have
- Minimize Stress and Pain
- Offer Positive Sensory Experiences
- Minimize Parent-Child Separation
- Protect Sleep
- Promote Strong Bonds with Family
WHERE ARE YOU NOW?
WHERE ARE YOU GOING

- Neuro-conscious care can be a
  - A QI project
  - A Program
  - A new unit design
  - Change in culture

THE NEURO-CONSCIOUS NICU TEAM

- **Nursing**
  - Identification of Risk
  - Triage patient, staffing, equipment
  - Clinical Assessment
  - Apply equipment

- **Neurology**
  - Mechanism of injury
  - Coordinate application and interpretation of EEG/aEEG
  - Manage seizure

- **Neonatology**
  - Stabilize infant
  - Attention to physiology and diagnosis
  - Advanced Life Support

- **Family & Follow Up**
  - Prognosis
  - Long-term continuity
  - Support

SCOPE OF NEURO-NICU PROJECT

- **Practice**
  - Who, What, When, How often
  - Bedside Hands-On Assessment Skills
  - Use of Tools: NIDCAP, Sarnat, Finnegan

- **Research**
  - Cares and Populations
  - Cooling & Protective Therapies
  - Monitoring
  - Outcomes & Follow Up
  - VON or Other Registry

- **Equipment**
  - What do we have?
  - Do we have what we need?
  - Training/Competency
  - Standardize Use

- **Training/Personnel**
  - Start Up/Ongoing
  - Multi-Disciplinary Team
  - Outreach

WHO WILL BE SERVED?

- Babies of all ages who are at-risk for neurological insult or with evidence of brain impairment or injury
**Across the Continuum of Care**

- From Admission to Discharge
  - In the NeuroNICU for 7-14 days

- From Discharge To Home
  - Referrals to Early Start, PHN, Home Health

- From Home To Follow-up Clinic And Other Specialty Visits

**Lessons For Us All**

- It’s time to translate research into bedside practice
- It’s time to expand our care and our expertise; above the clavicles
- It takes a team
- It takes vision
- It takes knowing your WHY
- It takes time
- Above all prevention, but don’t neglect the opportunities for promoting optimum brain growth
  - The simple stuff is the most important stuff
  - The importance of every day practices

**Why a Neuro-NICU?**

- Brain Injury is a reality of many infants in the NICU.
- The brain is the organ that has the greatest impact on long term quality of life and function.
- We have the opportunity to improve the quality of life of high-risk infants, and the quality of care provided through the expansion of new technologies, therapies, and practices.
- A systematic program will allow improved identification and treatment of brain injury and pathology
- Early and more aggressive treatment of neonatal brain pathology will not only result in better survival but better neuro-developmental outcomes
- Foster an early and strong relationship between family and Neurology team for long-term management and care
Theories of Neuroprotection:
- Degos V et al. Anesth Analg, 2008;106:1670-1680; G
- Gonzales and Ferriero Clin Perinatol . 2009; 36;

Outcomes:

In-Utero Exposures:
- Environmental Working Group 2004 - 10 Americans Study
- Melatonin - Under Investigation in the UK - MINT Trial
- Infections and Brain Injury - Kolan, J of Child Neuro, 2014; Yu, JAMA, 2013
- Pain, and Parents:
  - NICU Parents and PTSD - Shaw, Clements, Poehlmann, Pediatrics 2011

REFERENCES