

# HOLISTIC NEUROPROTECTION:

A SYSTEMATIC APPROACH



## DISCLOSURES

- Kathi Randall is the president/owner of Synapse Care Solutions, an education and consulting company to NICU's.

## OBJECTIVES

01

List the three stages of brain development

02

Give an example of how your NICU can alter the environment, a policy, or the culture of care to optimize neurodevelopment of babies in the NICU

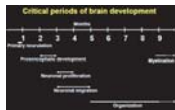
03

Discuss the four domains of holistic neuroprotective care.

## WHY DO WE NEED NEURO-PROTECTIVE CARE?

## NEONATAL BRAIN INJURY

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



## NEONATAL BRAIN INJURY – IS NOT "STATIC LESION" –

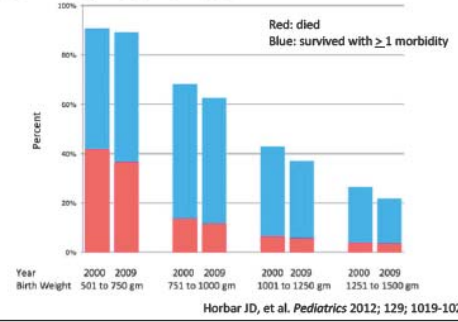
*some cells are lost, some are upregulated, some have cellular DYSmaturity*



## PERINATAL-NEONATAL BRAIN INJURY

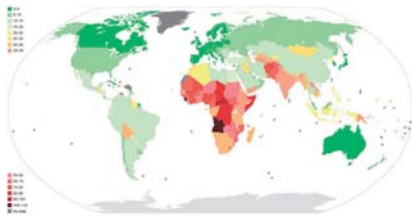
- The incidence of neurological disabilities related to perinatal brain injury has not decreased in decades
  - CP, Cognitive impairment, Epilepsy
  - Term and preterm infants are both affected

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



## INFECTIONS

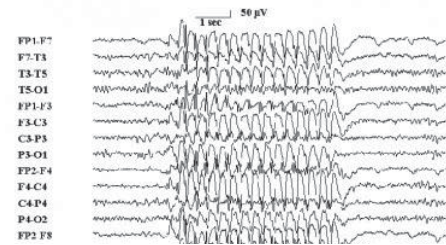
- After prematurity, infections are the 2<sup>nd</sup> leading cause of death around the world



BY ALTES - OWN WORK, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=3942842>

## INFECTIOUS

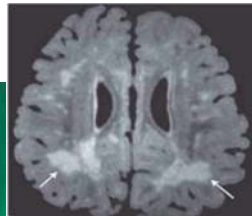
- Higher risk for seizures



10

## INFECTIOUS

- Zika & other viruses (like CMV) directly attack the brain



## CONGENITAL

- Premature birth and low birthweight cause about 1 in 4 neonatal deaths (25 percent).
- Birth defects cause about 1 in 5 neonatal deaths (20 percent).

12

## BIRTH DEFECTS ARE 2<sup>ND</sup> LEADING CAUSE OF DEATH IN THE US

- #1 – Heart Defects
- #2 – Lung Defects
- #3 – Genetic & Metabolic Syndromes
- #4 – Brain Malformations

[HTTP://WWW.MARCHOFDIMIES.ORG/COMPLICATIONS/NEONATAL-DEATH.ASPX](http://www.marchofdimies.org/complications/neonatal-death.aspx)

13

## CONGENITAL HEART DISEASE

- While it is true that the majority of children with CHD today will survive, up to half of surviving children will have impaired neurodevelopmental outcome across a wide spectrum of domains



International Journal of Pediatrics  
Volume 2010 (2010), Article ID 359590,  
<http://dx.doi.org/10.1155/2010/359590>

## WHY IS THE BRAIN SO VULNERABLE??

FETAL LIFE & BEYOND

## PHASES OF BRAIN DEVELOPMENT

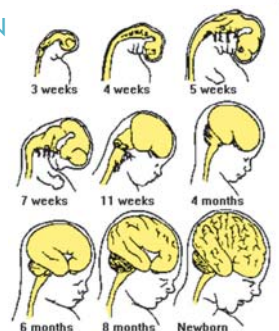
- Embryonic (0-8weeks)
- Fetal (8-40weeks)
- Neonatal (40weeks +)

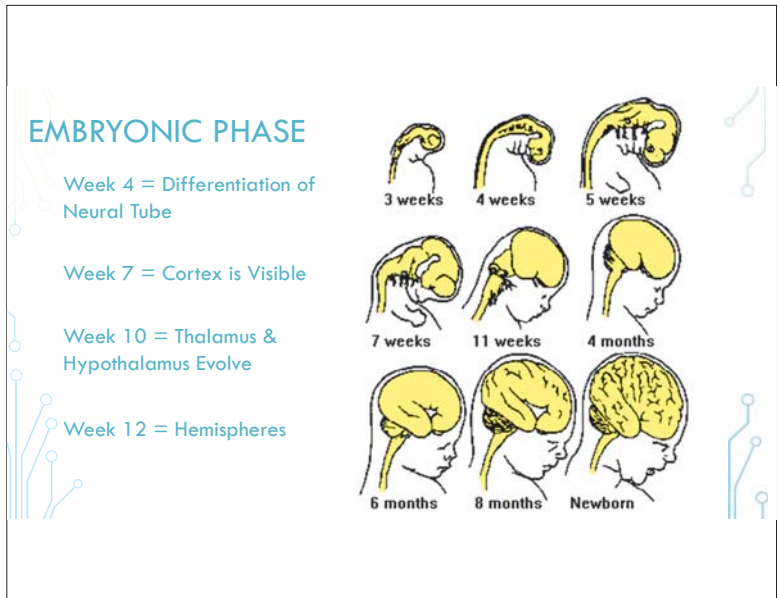
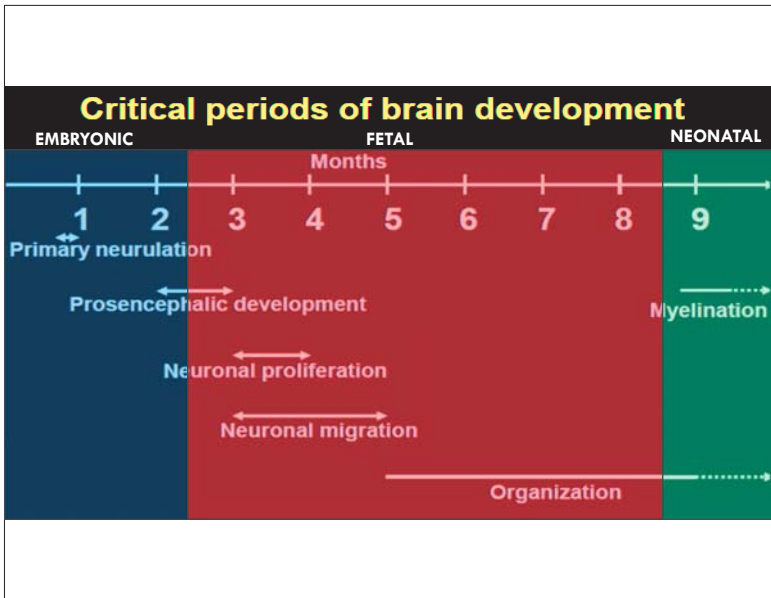
## NEURO-DEVELOPMENT



## THE BRAIN IS A DYNAMIC ORGAN

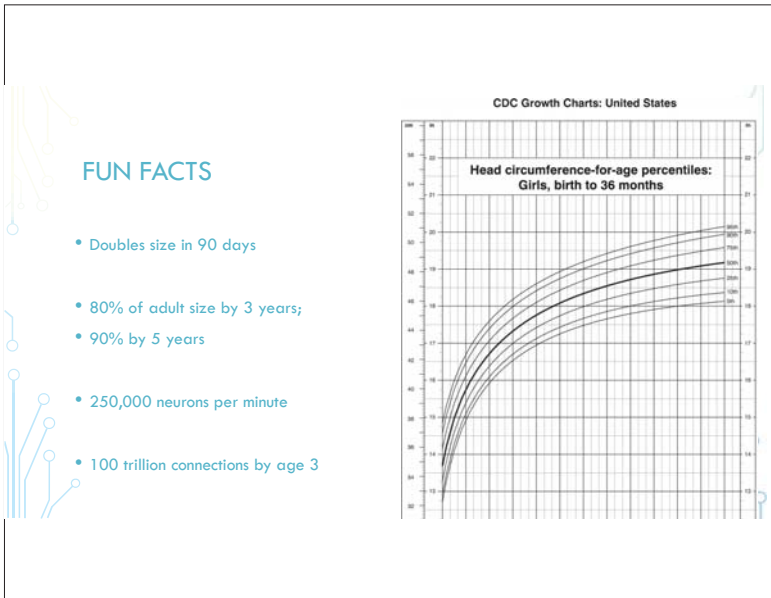
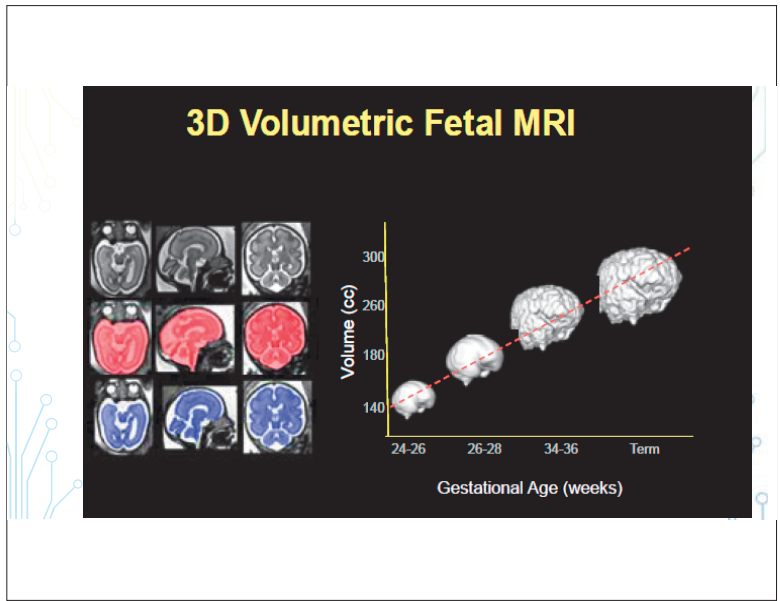
- Changing dramatically in **structure and function** in the first 5 years of life
- - Rapid growth
- - Folding to increase surface area
- - Grey matter to white matter
- - Synaptic Changes





### PROLIFERATION

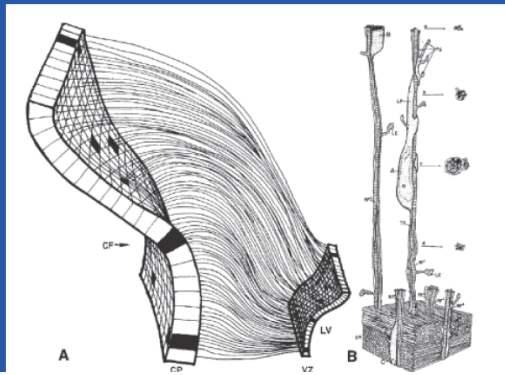
- Occurs between 8-16 weeks gestation
- Toxins can significantly alter number of neurons
  - Chemicals and environmental substances can reduce the number of neurons



### MIGRATION

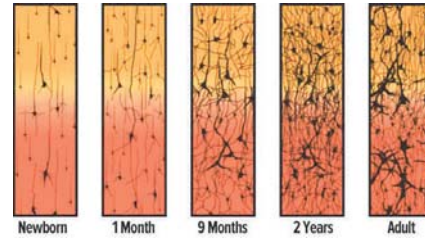
- Peaks between 3 and 5 months gestation
- Complete by 6 months gestation
- Migration is critical for development of the cerebral cortex and deeper structures, (6 layers)
  - Basal ganglia
  - Hypothalamus/thalamus
  - Brainstem
  - Cerebellum
  - Spinal Cord

## Second Trimester Neuronal migration along radial glia



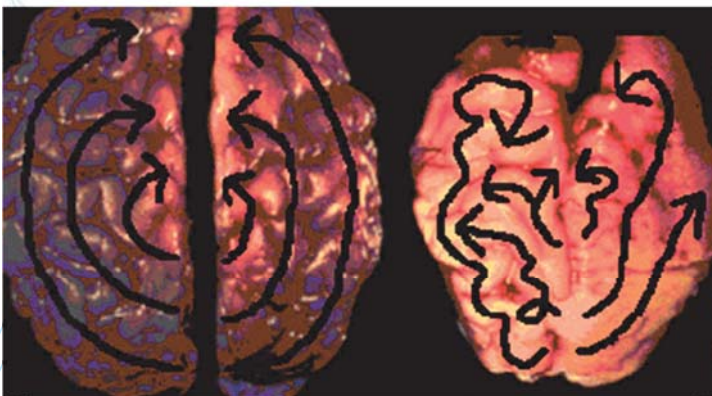
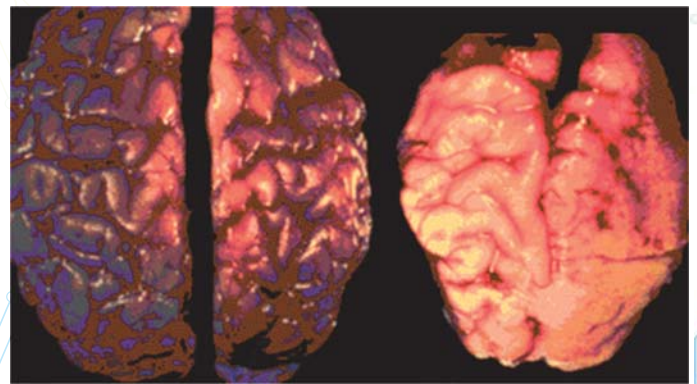
## ORGANIZATION

- Peaks 5 months (20 weeks) gestation and continues for several years after birth

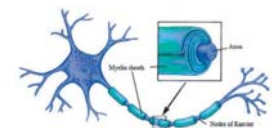


## NEURONAL ORGANIZATION

- Basis for brain function, allow to function as integrated whole
- Complex circuitry
- Cell differentiation, death, synaptic development, neurotransmitters
- Stabilization of cell connections



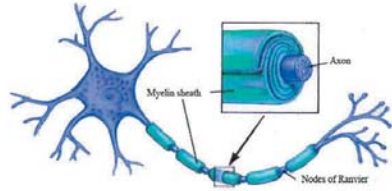
## MYELINATION



- Myelin, a fatty covering, insulates the circuitry; prevents leakage of current and enables rapid, efficient transmission of nerve impulses
- Enhances intercellular communication

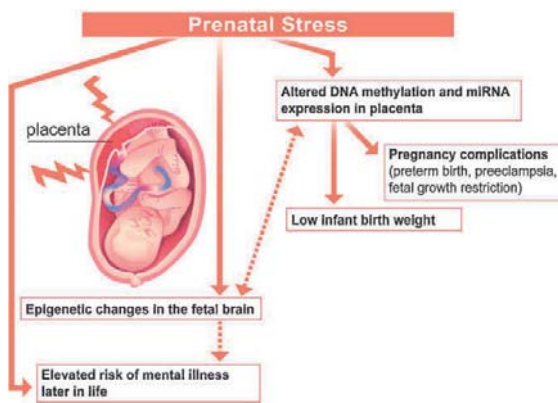
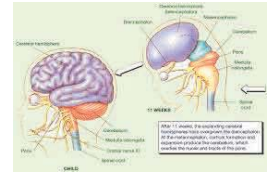
## MYELINATION

- Starts at 16 weeks; takes off at 24 weeks; mature at 2 years
- **Predictable progression**
  - - central to peripheral
  - - caudal to rostral
  - - dorsal to ventral
  - - sensory to motor

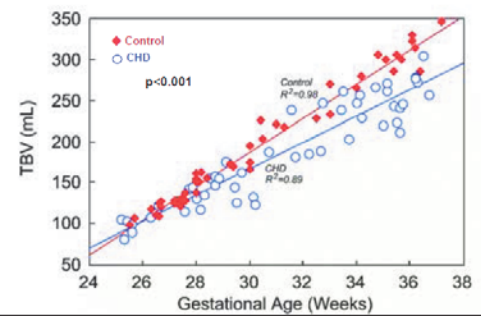


## THREATS TO BRAIN DEVELOPMENT: EMBRYONIC & FETAL

- Toxic Exposures (Drugs, Alcohol, Chemicals)
- Maternal Stressors:
  - Poverty
  - Malnutrition
- Congenital Developmental Disruptions
  - Of CNS
  - Of Cardiac

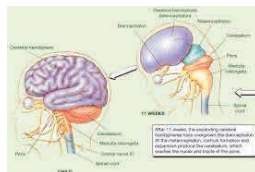


## Third trimester Total Brain Volumes in CHD and Control Fetuses

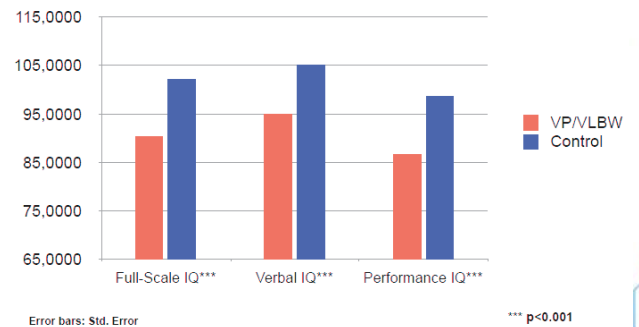


## THREATS TO BRAIN DEVELOPMENT: NEONATAL

- Prematurity
- Toxic Exposures (Drugs, Alcohol, Chemicals)
- Stress & Distress
- Malnutrition



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



Graphic Credit: Dr. Dieter Wolke, UK

## Psychiatric diagnosis: Childhood/ Adolescence

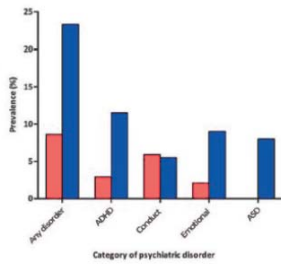
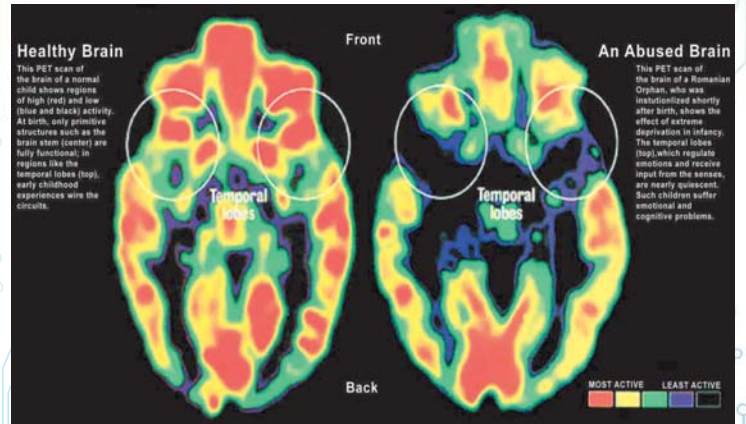
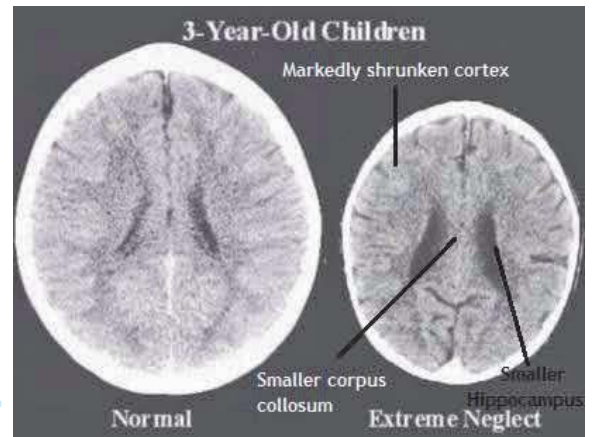
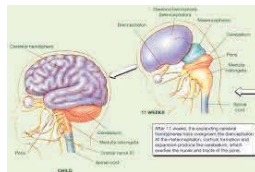


Figure 1. Prevalence of psychiatric disorders at 11 y of age in a whole population-based cohort of 219 EPT (<26 wk) children (blue columns) and 152 term-born classmates (red columns) in the UK EPICure Study.



## THREATS TO BRAIN DEVELOPMENT: CHILDHOOD

- Prematurity Complications
- Poverty, Neglect, Malnutrition
- Maternal Depression & Mental Illness



SO... WHAT CAN WE DO???

## NEURO-NICU'S ARE POPPING UP ALL OVER THE GLOBE... HIGHLY TECHNICAL!!



- UCSF NeuroIntensive Care Nursery –2007
- Phoenix Children's NeuroNICU – 2009
- Johns Hopkins
- St. Louis Children's Hospital
- Vanderbilt Medical Center
- Children's National Medical Center, Washington D.C.
- Lucile Packard at Stanford University
- Boston Children's - Pediatric Neuro ICU

## DEFINITION OF HOLISTIC NURSING CARE

- "all nursing practice that has healing the whole person as its goal."
- Holistic care is a philosophy; it's a method to ensure care for all parts of a patient.
- Holistic nurses are those that recognize and treat each individual differently.



## NEURO-PROTECTION

- Initially the term applied to treatments and cares to prevent injury and cell death
- Now, it encompasses all interventions that promote normal development and prevent disabilities
- Interventions applied across 5 common pathways



## PREVENTION OF INJURY



## CONTAINMENT OF INJURY



## INCREASE CELLULAR TOLERANCE



## SALVAGE INJURED CELLS





## GROW & NUTURE NEW CELLS



## TODAY'S FOCUS

PREVENTION



NOURISH



## HOLISTIC NEUROPROTECTIVE CARE



©2010-2013 Koninklijke Philips N.V. All Rights Reserved

## HOLISTIC NEUROPROTECTIVE CARE

- *PHYSICAL*
- *ENVIRONMENTAL*
- *EMOTIONAL*
- *SOCIAL (FAMILY)*



©2010-2013 Koninklijke Philips N.V. All Rights Reserved

## HOLISTIC NEUROPROTECTIVE CARE

- *PHYSICAL:*
  - Head to Toe Vulnerability
  - Optimizing nutrition
  - Protecting skin
  - Positioning and handling
- *ENVIRONMENTAL*
  - Safeguarding sleep
  - Healing Environment
    - Smell, sound, touch, temperature, light



©2010-2013 Koninklijke Philips N.V. All Rights Reserved

## HOSLISTIC NEURO-PROTECTIVE CARE

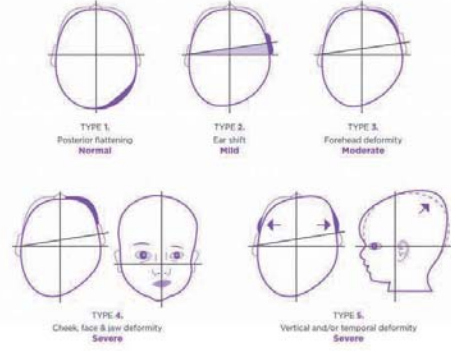
# HEAD 2 TOE

## HEAD, NECK & SENSORY



The Photo by Unknown Author is licensed under CC BY

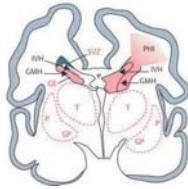
## DEFORMATIONAL PLAGIOCEPHALY



Copyright Technology in Motion Ltd 06/2015

## PREVENT BRAIN INJURY IN VLBWI THROUGH PBP

1. Antenatal betamethasone
2. Optimize peripartum management and delivery at a center with a NICU
3. Direct management by Neonatologists/NNPs
4. Minimize pain and stress
  1. Avoid early LP
  2. Developmental Care
5. Optimal Positioning (Mid-line)
6. Treat hypotension (Keep MAP > 30 not GA)
7. Limit postnatal indomethacin use
8. Optimize respiratory support
9. Limit sodium bicarbonate use
10. Use post-natal dexamethasone judiciously (>42 days & too early)



Carteaux et al. Evaluation and development of potentially better practices for the prevention of brain hemorrhage and ischemic brain injury in very low birth weight infants. Pediatrics. 2003;111(4 Pt 2):e489-96.

## USE MIDLINE HEAD POSITION



## Building Better Baby Brains - The 4B Project

*NICU Nurse Driven IVH Prevention Initiative*  
 Allyssa VanArsdale, RN, BSN and Frances Upton, RN, ADN  
 East Tennessee Children's Hospital (ETCH) Knoxville, TN

### IVH Prevention Guidelines for the Bedside Caregiver

1. Admit local low traffic and blood pressure alignment which avoids jugular vein compression impeding venous drainage.
  2. Reposition age and blood pressure alignment which avoids jugular vein compression impeding venous drainage.
  3. Main alignment which avoids jugular vein compression impeding venous drainage.
- Impact**  
 •Increased the staff nurses' and respiratory therapists' knowledge of IVH prevention and its basic cause.
- Comparison of the current Vermont Oxford Network data for all VLBW infants treated at ETCH demonstrated the following:
- Prior to implementation (2015)- 21.3% IVH
  - Post implementation (2016)- 10.9% IVH
  - This is a 48.8% decrease in all grades of IVH.
- ...two weeks gestation and monitored for the occurrence of IVH. Gestational ages of this group ranged from twenty-three weeks and three days to thirty-two weeks gestation and monitored for the occurrence of IVH.

## HEAD, NECK & SENSORY



The Photo by Unknown Author is licensed under CC BY

## THE SENSORY SYSTEM DEVELOPMENT

- Tactile
  - 8-12 weeks
- Vestibular
  - 10-14 weeks
- Gustatory
  - 12-16 weeks
- Olfactory
  - 14 weeks
- Auditory
  - 19-25 weeks
- Visual
  - 5<sup>th</sup> month through 1<sup>st</sup> year of life



## THE "PREEMIE FLIP"



## OLFACTORY SYSTEM



## AUDITORY

- Sound vs Noise
- Maternal Voice
- Music Therapy



## NOISE IN THE NICU

- Chronic Stress Exposure
  - Can causes physiologic instability
- Areas of Research:
  - Linked to attention disorders
  - Linked to increased ototoxicity of some meds
- Alarm Fatigue (staff)



## PROTECT SLEEP!!

- REM Sleep Deprivation, results in:
  - Disordered sensory system development in infants
  - Disordered or disrupted learning and memory creation
  - Loss of cortical plasticity into adulthood
  - Smaller adult brain size



## CHEST, ABDOMEN & HEMODYNAMICS

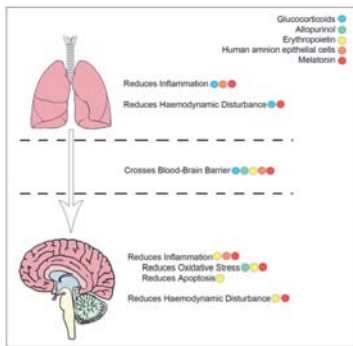
Ventilation & Nutrition

## VENTILATOR INDUCED BRAIN INJURY

- Cerebral inflammation and cerebral haemodynamic instability are also two of the critical pathways involved in preterm brain injury
- Mechanical ventilation is a risk factor for cerebral inflammation and brain injury in preterm neonates.
- The risk increases proportionally with the intensity of treatment.

• *Ventilation-induced Brain Injury in Preterm Neonates: A Review of Potential Therapies Neonatology 2016;110:155-162 DOI: 10.1159/000444918*

## VENTILATOR INDUCED BRAIN INJURY



## DRAWING BLOOD FROM UAC'S



Umbilical artery catheter blood sampling volume and velocity: impact on cerebral blood volume and oxygenation in very-low-birthweight infants. Roll C, Hüning B, Künicke A, Krug J, Horsch S. Acta Paediatr. 2006 Jun;95(1):68-73.

PubMed PMID: [16373299](https://pubmed.ncbi.nlm.nih.gov/16373299/)

## NEONATAL NUTRITION

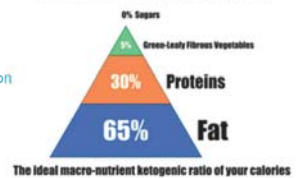
- Growth is Brain
- Optimal Nutrition is Neuroprotective
  - Protein
  - Essential Fatty Acids
  - Mother's Milk
  - Infusion causes fat loss
- The Phenomenon Extra Uterine Growth Restriction is common (up to 35%)



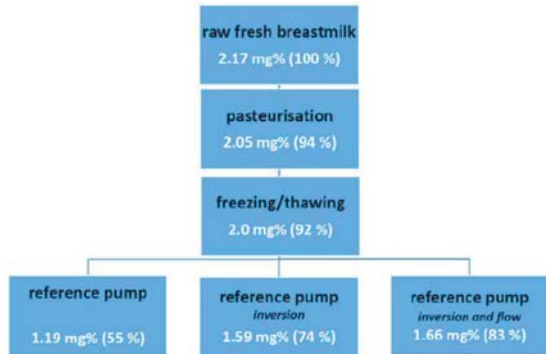
## NUTRITION

- Mother's milk --- primarily fat
- Infusion & storage can modify composition

### Keto Food Pyramid



This Pyramid is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License. [CC BY-NC-SA](https://creativecommons.org/licenses/by-nc-sa/4.0/)



## Early Nutrition in Preterm Infants

- Increased protein and energy during 1<sup>st</sup> week of life improved 18 month neurodevelopmental scores
- ↑ 10kcal/kg/day = ↑ 4.6 MDI points
- ↑ 1g protein/kg/day = ↑ 8.2 MDI points
- Increased lipid intake in first 14 days is associated with improved DQ at 1 year of age

de Troil et al. Early lipid supply and neurological development at one year in VLBW preterm infants. Early Hum Dev 2012.

Stephens et al. First week protein and energy intakes are associated with 18 month developmental outcomes in extremely low birth weight infants. Pediatrics 2009.



## Metabolic Risk in Preterm Infants?

- Reduced insulin sensitivity
- Increased risk to develop type II diabetes
- Elevated blood pressure and resting heart rate
- Increased low-density lipoprotein
- Higher truncal fat



## Small for Gestational Age Term Infants

- Rapid growth in weight and length in the first months after birth
- Most catch up to peers by 6-12 months
- Poorer neurodevelopmental outcomes than AGA term infants
- More prone to later metabolic disease



## MUSCULO-SKELETAL SYSTEM

### Optimal Position

- Midline
- Flexed
- Contained



[http://www.nurturedbydesign.com/en/thezakymedical-staff\\_development.php](http://www.nurturedbydesign.com/en/thezakymedical-staff_development.php)

## INFANT POSITIONING ASSESSMENT TOOL (IPAT)

Max Score = 12

Indicator	0	1	2
Shoulders			
Hands			
Hips			
Knees, ankles, feet			
Head			
Neck			

Coaglin, Lehman, & Gibbins (2010) Reliability and Effectiveness of an Infant Positioning Assessment Tool to Standardize Developmentally Supportive Positioning Practices in the Neonatal Intensive Care Unit, Newborn and Infant Nursing Reviews, Volume 10, Issue 2, Pages 104-106, June 2010

## HOLISTIC NEUROPROTECTIVE CARE

- **PHYSICAL:**
  - Optimizing nutrition
  - Protecting skin
  - Positioning and handling
- **ENVIRONMENTAL**
  - Safeguarding sleep
  - Healing Environment
    - Smell, sound, touch, temperature, light
- **EMOTIONAL:**
  - Minimizing stress and pain



©2010-2013 Koninklijke Philips N.V. All Rights Reserved

## PAIN AND STRESS IN THE NICU

- Mounting evidence that repeated stress has profound and long-lasting effects on the CNS
  - Especially during the critical early periods of infant development
- Stressors can be:
  - Physical
  - Psychological
  - Social



554

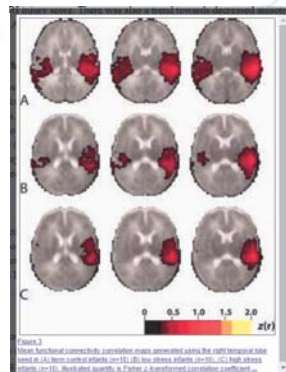
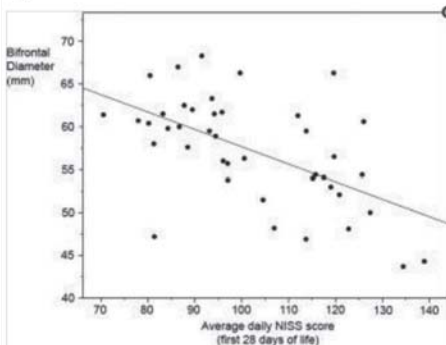
CA. Newham et al. / Early Human Development 85 (2009) 549-555

### Appendix A

NICU Infant Stressor Record Sheet (~28 weeks)

INSTRUCTIONS: Enter the time that the procedure was performed (eg: 9:15 am)		Name:
		Date:
Acute Items	Chronic Items	
<b>extremely stressful (score 5)</b>	<b>extremely stressful (score 5)</b>	
Multiple attempts inserting IV, IA, UAC/UVIC		
Intubation		
Insertion percutaneous chest drain		
Eye examination		
<b>very stressful (score 4)</b>	<b>very stressful (score 4)</b>	
Sectioning of ETT tube	having systemic infection	
Sectioning of nose and mouth	HFOJet vent without sedation	
Removing infant from incubator/bed (unwrapped)		
Insertion of IV, IA, UAC/UVIC		
Insertion of percutaneous long line		
7am-8am	8am-11am	11am-1pm
1pm-3pm		

<b>moderately stressful (score 3)</b>					<b>moderately stressful (score 3)</b>
Nappy changes					nursed in radiant warmer
Position changes					local infection
Removal of IV					HFOJet vent with sedation
Receiving nasal CPAP					Hudson Prong CPAP
Insertion of Hudson Prong					fasting for surgery
Insertion of nasogastric tube					recovering from surgery
Cavage feed					percutaneous chest drain
Removing infant from incubator/bed (wrapped)					conventional ventilation w/o sedation
Cardiac echocardiogram					
Ultrasound					
CT/MRI					
X-ray					
Being weighed					
<b>a little stressful (score 2)</b>					<b>a little stressful (score 2)</b>
Mouth care					nursed in incubator
Eye toilet					IV fluids
IV Flushing (to ensure IV patency)					IV/IA/UAC/UVIC in situ
Sampling eg. blood gases					conventional ventilation with sedation



## MATERNAL HOLDING + PAINFUL EXPERIENCES

Breastfeeding, when compared to placebo or no intervention control, effectively reduces behavioral pain response associated with common puncture procedures in infants

- ✓ Heart rate
- ✓ Cry duration
- ✓ Behavioural facial response



Shah et al. Breastfeeding or Breast Milk for Procedural Pain in Neonates. *Cochrane Database*, 2012.

## HOLISTIC NEUROPROTECTIVE CARE

- **PHYSICAL:**
  - Optimizing nutrition
  - Protecting skin
  - Positioning and handling
- **ENVIRONMENTAL**
  - Safeguarding sleep
  - Healing Environment
    - Smell, sound, touch, temperature, light
- **EMOTIONAL:**
  - Minimizing stress and pain
- **SOCIAL:**
  - Partnering with families



©2010-2013 Koninklijke Philips N.V. All Rights Reserved

## KANGAROO CARE IMPROVES BRAIN OUTCOMES AND MORE

Kangaroo mother care is associated with:

- Reduction in mortality (RR 0.68 95% CI 0.48-0.96)
- Reduction in nosocomial infection (RR 0.42 95% CI 0.24-0.73)
- Increased weight, length and head circumference gain
- Improved Bayley MDI ( $p=0.03$ ) and PDI ( $p=0.06$ ) at 1 year



Conde-Agudelo A, et al. Cochrane Database of Systematic Reviews (2011)  
Ohgi S, et al. J Perinatol (2002)

## EARLY & UNINTERRUPTED SKIN TO SKIN

- Even in the C-Section Room



Source: <http://evidencbasedbirth.com/the-evidence-for-skin-to-skin-care-after-a-caesarean/>

## PARENTAL PROVIDED MASSAGE



## CREATE BONDS THAT WILL LAST A LIFE-TIME



## MATERNAL MENTAL HEALTH

- Depression is a common mental health diagnosis
- Treating mothers can result in better outcomes for babies
  - Improved toddler attachment
  - Improved toddler temperament
  - Improved maternal parenting efficacy



Developmental cascade effects of interpersonal psychotherapy for depressed mothers: Longitudinal associations with toddler attachment, temperament, and maternal parenting efficacy  
Elizabeth D. Handley<sup>1</sup>, Louisa C. Mohr-Petras<sup>1</sup>, Fred A. Rogosch<sup>1</sup>, Dante Cicchetti<sup>1,2</sup> ...  
DOI: <https://doi.org/10.1017/S0954579417000219>  
Published online: 12 April 2017

## 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 between Baby and Family



## FINAL THOUGHTS

- 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.

## MORE TRAINING AND RESOURCES

1. Local trainings occurring nationwide
2. NANN – Providence, RI – Preconference on NeuroNICU (October)
3. The 10<sup>th</sup> International Conference on Brain Monitoring and Neuroprotection in the Newborn in Killarney, Ireland (October)
4. The ONE Conference -- NeuroNICU Nursing – San Diego, CA – Feb 2018
5. Stanford University offers a NeuroNICU Training course annually – August 2018

## ONLINE TRAININGS & RESOURCES

- VON = NICQ = Virtual Video Visits of NeuroNICU's
- Online aEEG Education –
  - [www.aEEGCoach.com](http://www.aEEGCoach.com)
- FREE...NeuroNICU Webinar Series & 2018 Conference Information
  - [www.synapsecare.com](http://www.synapsecare.com)





[WWW.SYNAPSECARE.COM](http://WWW.SYNAPSECARE.COM)

97

# THE *One* CONFERENCE

Neuro NICU Nurse Training

**February 4-6, 2018**

#onenurse2018

[www.synapsecare.com](http://www.synapsecare.com)