AFTER THE NICU

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Developmentally Supportive Care

Neurobehavioral Organization

NIDCAP

(Newborn Individualized Developmental Care & Assessment Program)

- Systematic observation of behaviors correlated with environmental stressors
- Each infant is a recipient & active participant in care
- Subsystems are layered and intertwine with one another and with the environment at large







- □ Autonomic: RR, color, tremors, visceral signs
- Motor: tone, movement, posture
- **D** State/organizational: state ranges & transitions
- Interactional/attentional: ability to maintain active alert & accept/process input from environment with appropriate responses
- Regulatory: requires a stable balance within each subsystem & ability to return to homeostasis

Synaction

- Dynamic supportive relationship between subsystems providing foundation for developmental learning
- Caregiving and interactions should look like a dance with infant leading
- Development progression is enabled through a continuous balancing act of exploration/approach behaviors & avoidance/defense behaviors

Stress/ Avoidance Cues



- Spit up/gag
- Burp/gas
- **Stretch/drown**
- Arching/thrusting
- Gape face
- **Grimace**
- **Finger splay**
- □ Airplane/salute
- Averting
- Hiccough
- Yawn
- □ Sneeze
- Whimpering/fussing
- **Gasping**





Self Regulatory Cues





- Leg brace
- Hand on face/mouth
- Suck search/suck
- Hand/foot clasp
- Grasping
- Fisting
- Drowsy/sleepy state















Exploration/Approach Cues

- Relaxed appearance
- Pink
- Regular slow breathing
- Quiet alert
- Smooth movements
- Smiling or cooing
- Sucking or grasping





WEIGHING



Terminology

Age Assessment



- Typical gestation = 40 weeks determined by:
 - Early U/S, LMP, or Ballard
- **Gestational age (GA)** = age from conception to DOB
- Chronological age (CA) = Birth date age
- Adjusted age (PCA) = Birth date age minus # weeks preterm
 - Used for everything except birthdays & immunizations
 - Used till 2 yrs CA

Weight Classifications

- ELBW <1000 g
 VLBW 1000-1499 g
 LBW 1500 2499 g
- AGA 10 90%ile
 SGA <10%ile
 LGA >90%ile



Complications

PRENATAL = before birth PERINATAL = during birth POSTNATAL = after birth



GER vs. GERD

GER is common in preemies

Clinical findings

- Nighttime cough, gagging, vomiting, wheezing,
- Recurrent infections (including OM), apnea, stridor
- Resistance to feeding, FTT
- Atypical head and neck posturing

IVH

- Most common < 32 weeks</p>
- 90% occur first 3 days (50% on first day)
- □ Grade I, II, and III caused by:
 - Capillary bleeding 2° loss of blood flow/regulation or rapid changes in blood flow/pressures
- Grade IV caused by:
 - Hemorrhagic venous infarctions from lower grade bleeds progressing or increased venous pressures

Grade I: bleeding near ventricle

Grade I IVH

- Small amount of capillary bleeding in subependymal area/germinal matrix = beneath the lining of the ventricle
- □ ~60% of <1000g preemies
- Outcomes of Grade 1 and 2 generally similar to population without bleeds
- ~95% resolve with Ø sequelae
 ~5% mortality



Grade II: Blood in ventricle

Grade II IVH

- Extension of subependymal bleed into ventricle without enlargement; typically fills less than 50% of ventricle
- ~10 % mortality
 ~15 % with sequelae



Grade III IVH

- Enlargement of ventricle as it fills with blood indicating a more extensive bleed with > 50% of ventricular area
- ~20 % mortality
 ~35 % neurological sequelae

Grade III: Enlarged ventricle



Grade IV IVH

- Continued enlargement of ventricles with extension into surrounding brain tissue with parenchymal hemorrhage
- ~50 % mortality~90 % sequelae

Associated w/ hydrocephalus

Grade IV: Enlarged ventricle with blood in brain tissue



PVL (Periventricular Leukomalacia)

- Most common ischemic brain injury in preemies also called encephalopathy of prematurity (cystic and non-cystic forms)
- Occurs prenatally up to 24-32 weeks
- As many as 75% of preemies have evidence on autopsy



PVL

- Caused by ischemia, hypotension, reperfusion damage, or infarct
- White matter damage with associated gray damage resulting in smaller volume
- Focal white matter necrosis (around ventricles) leads to diffuse gliosis and deficit of myelinization often leading to cognitive, behavioral, or motor problems
- Associated with neurodevelopmental, cognitive, visual deficits, and CP

HIE (Hypoxic Ischemic Encephalopathy)

- □ 1-4/1000 births in US
- Lack of oxygen and/or decreased blood flow to brain causing asphyxia
- Severe forms treated with hypothermia
- <u>Early</u> signs and classifications
 - Mild Usually resolve in 24 hours
 - Moderate Generally lethargic and low tone; can have seizures within first 24 hours; often with expected full recovery in 2 weeks
 - Severe Seizures can be delayed and severe increasing 24-48 hours after onset; EEG shows burst suppression; may be unresponsive to stim; decreased tone; absent reflexes; physiologic instability

HIE Outcomes

- Cognitive, motor, visual or auditory impairments
- **CP** associated with only 14.5% of HIE
- Severe 80% of survivors develop serious complications while only 10% are healthy
- Moderate 30-50% of survivors have serious complications
- Mild tend to be free from serious complications
- Red flags
 - Neuro motor findings (to be addressed later)
 - Total absence of movement or response
 - Cortical thumbs

Hydrocephalus

 CSF flow blocked or slowed causing ventricular enlargement with impingement on surrounding brain
 Treated by shunt or meds or monitored



Congenital Malformations

Neural tube defects

- Neural tube fails to develop in the first 4 weeks
- Anencephaly, encephaloceles, myelomeningoceles etc.

Segmentation defects

- Failure of development after neural tube closure
- Holoprosencephaly, septo-optic dysplasia etc.
- Cerebellar malformations
 - Dandy Walker cyst
 - Absence of symptoms in newborn period common
Congenital Malformations

Migration and cortical organization defects

- Defects in cell proliferation, migration, organization, and myelination
- Microcephaly, schizencepahly, lissencephaliy, macrogyria or microgyria, agenesis of corpus collosum
- Often undiagnosed in newborn period because symptoms are vague such as SGA, seizures, microcephaly, abnormal cry
- Migration defects can lead to seizures, cognitive impairment, sensory-motor dysfunction, and visual/auditory dysfunction

CP Prognosis for Walking

Hemiplegia

- 70% by 2
- 90% by 4

Mixed CP

- 80% will walk
- **50% by 4**
- Generally speaking if sitting by 2, children will walk. If sitting by 3, 50% will be community ambulators

Neonatal Abstinence Syndrome

Withdrawal from exposure prenatally

- SX present 24-72 hours of age: tremors, seizures, fevers, sweating, sleep problems, excoriation, irritability, GI disturbances, difficulty eating, excessive sucking
- Common opioids: heroin, codeine, Vicodin, oxycodone, morphine, fentanyl, subutex, methadone
- **27/1000 NICU admissions** (NEJM 2015)

NAS Treatment

Non pharmacological measures

- Massage
- Breast feeding and Kangaroo care
- Rooming in
- Comfort measures (swaddling, dark quiet room, cuddlers)
- Formula changes for ease of digestion
- Medications may include methadone, morphine, phenobarb

ROP

- Stages 1 to (least severe) 5 (most severe)
- Abnormal blood vessel development occurs and the fragile vessels can lead causing scarring and eventual retinal detachment
- Outcomes: blindness, myopia (near sighted), strabismus, amblyopia, or glaucoma
- Risk factors: <1200 grams, < 31 weeks, medical complications, respiratory problems requiring increased oxygen
- Treatment may include laser or vitrectomy

Plexus Injuries

Erb's

- 1-2/1000 births
- C5-6 injury
- 70-80% resolve within 1 year
- Paralysis and sensory damage

Klumpke's

- .2-2.5/1000 births
- C8 and T1 injury
- 90-100% recover
- Can be associated with Horner's syndrome

Brachycephaly







Plagiocephaly

20-30% of infants in US affected

Scored lower on BSID III with largest differences in language and cognition









- REM is critical from 28 wk 3 or 4 mo. for entire sensory system development
- REM deprivation leads to visual cortex problems, auditory problems, decreased plasticity, & smaller brain size
- Non REM deprivation leads to decreased learning capacity, decreased sensory memory consolidation, & loss of plasticity

Visual System

28-30 weeks – nearly continuous sleep (80-90% REM)

□ Term – 70% sleep (50% REM)

Atypical onset and intensity of sensory experiences may interfere with the development/function of developing systems (early visual experiences may lead to accelerated development with associated decline in auditory responsiveness)

Liu 2007

Visual System

- Last sense to develop
- Eyelids fused till ~24 wk; thin & poor light filter
- ~32 wk iris sphincter reacts & pathway from eye to brain in place but no response to color
- ~2-3 mo. respond to color (red first). Prefer faces, contrast, dimension
- Just because baby CAN see doesn't mean we should stimulate...Before birth at term – no visual stim or light is required

Auditory System

Prefer human voice



- Sounds in utero include: low frequency sounds (maternal tissue absorbs high frequencies)
 - Blood "whooshing"
 - Intestines gurgling
 - Voice tones
- ~50% of infants have hearing loss with prolonged exposure to high db noise in utero

Can react to loud noises in utero by 9 weeks





Pain response is well differentiated by 2nd trimester

Vestibular System



Highly sensitive in preemie

Fetus SHOULD be floating in a "hot tub" with smooth modulated movements

Awake or asleep...fetus moves 50+ times/hour

Smell and Taste

Developed by 28 weeks

Highly developed...some studies show amniotic fluid tastes different based on mom's diet

Implications????

- Purell
- Alcohol & cleaning agents



Environment

INTRA UTERINE

- Dark
- Warm
- Tight
- Quiet/muffled
- Fluid
- All needs met
- Circadian rhythms



EXTRA UTERINE

- Light/visual stim
- Sound
- Artificial rhythms
- Needs Ø met by placenta/mom
 - HR, RR, oxygen, waste, digestion, temp

Brain



CNS

Brain weight

- 20 wks weighs 10% of term brain
- 34 wks weighs 65% of term brain
- 20 <u>billion</u> neurons at birth (brain size ↑ due to axon & dendrite growth & arborization)

Development

- 0-20 wks Structural development (genetically controlled)
 - 1 trillion cortical neurons originate in germinal matrix
 - During prime, germinal matrix releases 100,000 neurons/day
- 20 wks 3 yrs Neuronal & cell realignment/organization
- 3 years adolescence Pathway development & pruning



Embryonic Development



Developmental Progression & Susceptibility to Teratogens & Fetal Loss

(Modified from Keith Moore, The Developing Human: Clinically Oriented Embryology, 3rd Ed., W.B. Saunders Co.: Philadelphia, PA, 1983.)



CNS



Sensory system complete at 24 wk but no modulation till 34-35 wk

- Myelinization begins in utero & continues for years
 - Myelinated vs. unmyelinated nerve tissue is like paved vs. gravel roads

Why is all this so important???

- Animal studies show premature activation of cortical pathways leads to:
 - Inhibition of differentiation
 - Alterations in pruning
 - Interference with prefrontal & cross modal development
- Preemies with NO damage have alterations in cell organization due to altered:
 - Neurogenesis
 - Migration
 - Myelinization
 - Cell death/pruning
 - Synaptogenesis
- This affects neuro-motor skills, visual-motor integration, IQ/academic performance, language, executive function, behavior (ADHD etc.)

Brain differences

Term baby at birth

Typical preemie at 40 weeks AA





Motor

Preterm





Term

Preemie Posture

- W arms
- Frog legs
- Gravity dependent
- Loosely fisted
- • midline
- Poor modulation
- Head molding
- Increased extension
- (Ψ physiological flexion)



Outcomes



Report Card

Viability

- Gestation age at which survival is 50%
- 23-25 weeks in developed countries
- 2017 MOD report card for Ohio
 - Preterm rate 10.4% (Very high comparatively)

Survival

- <23 weeks 17% chance</p>
- 24 weeks 39% chance
- 25 weeks 50%
- >32 weeks majority survive

March of Dimes

Report Card

- Morbidity (boys at higher risk than girls)
- 1/10 premature babies will develop lung disease, CP, blindness, or deafness
- In those born < 26 weeks</p>
 - 22% will have severe disability
 - 24% will have moderate disability
 - 34% will have mild disability (low cognitive scores, require glasses)
 - 20% will have no problems

Report Card

- In an average week in Ohio...
 - 2,678 babies are born
 - 276 are born preterm
 - 194 are born late preterm
 - 46 are born very preterm

General Information

- Lack of normal developmental input in gestation OR inappropriate timing of input leads to abnormal brain development
- **a** As birth weight & gestational age \downarrow disabilities \uparrow
- As co-morbidities ↑ disabilities ↑
- Cognitive outcomes are moderated by environmental factors such as socioeconomic status, parent educational background, 2 parent family, neighborhood, schooling, social and racial background

General Information

- Increasing prevalence of low severity dysfunctions (ie learning disabilities, borderline to low average IQ, ADHD, visual motor integration, executive dysfunction, behavioral prob)
- Preemies are especially prevalent to social domain impairments as the shift in concerns goes to subtle impairments due to alterations in circuitry
 - Preemies have 3x > chance of developing psychiatric diagnoses such as anxiety, ADHD, and ASD
 - Preemies tend to internalize behaviors, have dysregulation, be shy and unassertive, withdrawn, and demonstrate decreased social competence/adaptations.
 - Social impairments are seen in "non injured" preemies

When Assessing...

- Look at organization and the threshold of disorganization
- Look at infant's ability to modulate and regulate state control at rest and with intervention
- Look at strategies of self regulation

General Red Flags

- Inability to orient to and follow visual or auditory stimuli
- History of PVL, asphyxia, IVH 3-4, seizures, or other significant brain changes
- □ Infants with multiple comorbidities such as BPD, NEC, IVH...
- Birth weight <1500 grams or SGA/IUGR</p>
- □ GA < 30 weeks
- History of feeding problems
- Genetic or congenital anomalies

Movement Red Flags

- Postural or movement asymmetry
- Small movement ranges or en bloc movements
- Jerky or tremoring that is constant or occurs without movement
- Weak movement or postural control
- Suddenly occurring/brisk movements
- Cramped synchrony (synchronized, stereotypical, and monotonous spontaneous movements rather than elegant writhing movement)

Cramped Synchrony



Cramped Synchrony
Atypical Newborn Movements/Paucity



Common Deficits

Neuromotor - (5-10% severe) risk \uparrow with \uparrow co-morbidities

- **Cognition/IQ** (IQ \downarrow 1.5 points/week for < 33 weekers)
- **Processing speed** (decreases with increasing skill complexity)
- Visual/perceptual skills (visual sensory, visual memory, visual motor skills, spatial processing and organization, acuity, contrast sensitivity, strabismus, stereopsis, and convergence)

Language (receptive, expressive, and semantic)

Executive function

- I. Attention/joint attention
- Impulse control and self regulation
- **3**. Initiating activity
- 4. Working memory/learning
- **5**. Mental flexibility and utilization of feedback
- 6. Planning and organization
- 7. Selection of efficient problem solving strategies
- **8**. Monitoring performance

Late Preterm

- 34-36 weeks gestation
- Not on radar for follow up clinics or EI
- 35% increase in brain size and 5 fold increase in white matter volume occurs during this time making them higher risk
- Studies show decreased reading and math scores
- Do better than preterm infants but not as well as term peers

Differences

Preemie at 40 weeks vs term at 40 weeks

- 1. Less flexed posture
- 2. Less UE traction and LE recoil
- 3. Increased visual and auditory orientation and alerting
- 4. Decreased pull to sit and head control
- 5. Decreased ventral suspension with LE extension

Assessments

Focus on

- Motor milestones
- Neuro exam
- Reflexes and postural reactions
- Change in neuro status over time
- History of neuro damage

Assessments

- Test of Infant Motor Performance (>34 weeks 4 mo.)
- Neurological Assessment of Preterm and Full Term Newborn Infants (Dubowitz and Dubowitz 1981)
- Neonatal Neurobehavioral Evaluation (Lee 1988)
- Neurobehavioral Assessment for Preterm Infants (32-42 weeks) (Korner 1991)
- Naturalistic Observations of Newborn Behavior (Als)
- Assessment of Preterm Behavior (>30-32 weeks) (Als)
- Neonatal Behavioral Assessment Scale (36-44 weeks) Nugent)
- Infant Behavioral Assessment (Hudlund & Tatarka)
- Movement Assessment of Infants (<12 mo)</p>
- TIME (birth-42 mo)
- AIMS (Alberta Infant Motor Scale) (birth-18 months)

Supports

NICU follow up clinics

- Lowest birth weight
- Those with documented risk of disability such as BPD, PVL, brain insult/HIE
 - TCH follows infants <28 weeks GA, <1500 g, grade III-IV IVH or PVL, seizures, HIE/cooling)
- Serial exams vital
- TCH uses BINS and recommended Bayley at 18 months for highest risk
- Screen, refer, provide anticipatory guidance, and education

Why so early?

- Repetition essential
- Sensory receptors are activated by movement
- Active movement and participation essential for coordination, accuracy, and learning to respond to environmental demands
- External factors can change the developing brain and alter prognosis

Contingency

- Contingent caregiving leads to improved outcomes, bonding, self-regulatory skills
- Teach parents to read cues/signs and how to respond
- Encourage contingent interactions with play and caregiving
- Empowers parents

Resources

- Pathways.org
- ehd.org
- Marchofdimes.org
- CDC.gov
- Nicuniversity.org
- Pediastaff.com
- Prematurity.org

THE END







