Audiology in the NICU

EHDI Conference 2010
Chicago, IL

Brandt Culpepper, Ph.D. - Northside Hospital Atlanta, GA
Healthy People 2010: Objective 28.11

Increase the proportion of newborns who:

- Are screened for hearing loss by age 1 month
- Have audiologic evaluation by age 3 months
- Are enrolled in the appropriate intervention services by age 6 months.

“The 1-3-6 EHDI Plan”
National EHDI Goals

- Developed in collaboration with state EHDI programs, federal and national agencies, CDC developed EHDI program objectives and performance indicators

- Goals
  - Program Objectives
    - Performance Indicators
National EHDI Goals

- **Goal 1:**
  - All newborns will be screened for hearing loss before 1 month of age, preferably before hospital discharge.

- **Goal 2:**
  - All infants who screen positive will have a diagnostic audiologic evaluation before 3 months of age.
    
    *(Fit with amplification when appropriate within 4 weeks of identification)*

- **Goal 3:**
  - All infants identified with hearing loss will receive appropriate early intervention services before 6 months of age (medical, audiologic, and early intervention)

*The 1-3-6 EHDI Plan*
Prevalence of PCHL

- 1 / 1000 children born deaf (severe to profound bilateral SNHL)
- 2-4 / 1000 children with permanent childhood hearing loss 30 dB HL or greater
- 95% of children with substantial bilateral hearing loss are born to hearing parents
- Up to 60% of congenital hearing loss is genetic
Well Baby vs. Special Care Nursery (SCN) at Northside Hospital

- About 10-12% of all newborns will be special care babies (16,000-18,000 annual births)
- About 1/100 from SCN will have PCHL

http://www.iurc.montp.inserm.fr/cric/audition/english/start2.htm
Definition of Targeted Hearing Loss

Expanded from congenital bilateral and unilateral sensory or permanent conductive HL to include neural hearing loss (auditory neuropathy/dyssynchrony) in infants admitted to the NICU > 5 days.

JCIH 2007
Hearing Screening Protocols

- Separate protocols are therefore recommended for NICU and well baby nurseries.

- NICU babies >5 days are to have AABR included as part of their screen so that neural HL will not be missed.
Communication

- Information at all stages of the EHDI process is to be communicated to the family in a culturally sensitive and understandable format.

- Hearing screen information, audiology diagnostic and habilitation information should be transmitted to the medical home and the state EHDI coordinator.
JCIH 2007 Abbreviations

- JCIH
- EHDI
- ABR
- CMV
- ECMO
- AAP
- MCHB
- HRSA
- NI DCD
- CDC
- UNHS
- OAE
- IFSP
- OME
- FM
- DSHPSHWA
- GPRA
- OMB
Communication

- Auditory Brainstem Response
  - ABR
  - BAER
  - BSER
  - BSERA
  - EAP
  - BEAP
  - BERA
  - AABR
  - ABAER
  - SABR

- Otoacoustic Emissions
  - OAE
  - EOAE
  - SFOAE
  - TEOAE
  - DPOAE
  - COAE
  - TOAE
COMMUNICATION? Acronyms (cont.)

- Related to Behavioral Assessment
  - BOA
  - VRA
  - VROCA
  - TROCA
  - COR
  - CPA
  - DA
  - OPP
  - SRT
  - SDT
  - SAT
  - MTS
  - MRL
  - NBN
  - WT
  - SF
  - WRS
  - AC
  - BC
## COMMUNICATION?

### Acronyms

#### Professional Programs
- EHDI
- UNHS
- NHS
- HRSA
- MCHB
- NIDCD
- NIH
- CDC
- NCBDDD
- AAO-HNS

#### Intervention
- ASHA
- AAA
- JCIH
- AAP
- CED
- PINES
- SLP
- ASDC
- AGBell
- AVI
- HA
- ALD
- DSL
- AGC
- ALD
- DSP
- BTE
- ITE
- ASL
- TC
## NICU Acronyms

- AGA
- SGA
- LGA
- IUGR
- IV
- RDS
- PDA
- ABDs
- GA
- PO
- CPAP
- NC
- NBN
- WBN
- NI CU
- NEC
- IVH
- ROP
- NG tube
- APGAR
- PROM
- LBW
- VLBW
- ELBW
Screening: NICU

- 10-15% of the newborn population
  - Level I: basic care, well-infant nurseries
  - Level II: specialty care by a neonatologist for infants at moderate risk of serious complications
  - Level III: a unit that provides both specialty and subspecialty care including the provision of life support (mechanical ventilation)
Major indicators in NICU

- Gestational Age
  - Term = 40 weeks
- Birthweight
- APGAR
Recommended Age Terminology

- **Gestational age (GA)**
  - Time from the first day of the last menstrual period to the date of birth, expressed as complete weeks

- **Chronological age**
  - Time elapsed after birth

- **Postmenstrual age**
  - Time in number of weeks after the day of menstruation

- **Corrected age**
  - Calculated by subtracting the number of weeks born before 40 weeks gestation from the chronological age. (for children up to 3 years)
Birth Weight Terminology

- AGA: Average for gestational age
- LGA: Large for gestational age
- SGA: Small for gestational age
- IUGR: Intrauterine growth restricted
Birth Weight

- Extremely low birth weight (ELBW)  
  - <1000 grams  
    - 2.2 pounds
- Very low birth weight (VLBW)  
  - <1500 grams  
    - 3.3 pounds
- Low birth weight
  - <2500 grams
    - 5.5 pounds
Prevalence of Prematurity

- ~12.5% of births in the US are preterm
  

- Since 1981, the number of preterm babies born has increased by 36%

  March of Dimes
  http://www.marchofdimes.com/peristats/
Preemies

- at increased risk for:
  - newborn health complications
  - Chronic disabilities
    - Developmental delay
    - Cerebral palsy
    - lung and gastrointestinal problems
    - vision and hearing loss
    - death

March of Dimes
http://www.marchofdimes.com/peristats/
Prematurity

- Extremely preterm: ≤27 +6 weeks GA
- Very premature: 28 to 31+6 weeks GA
- Premature: 32 to 36+6 weeks GA
- Full Term: 37 to 42 weeks GA
Distribution of prematurity

- 71.2% 34 - 36 weeks
- 13% 32 - 33 weeks
- 10% 28 - 31 weeks
- 6% < 28 weeks

March of Dimes
http://www.marchofdimes.com/peristats/
Survival Rate

- About 80% of GA > 26 weeks survive to one year
- About 90% at 27 weeks
- About 25% develop serious lasting disabilities
- Up to half may have milder problems, such as learning and behavioral problems

March of Dimes
http://www.marchofdimes.com/peristats/
Common Problems in the NICU

- Related to breathing:
  - Respiratory Distress Syndrome
  - Apnea (breathing stops)
  - Bronchopulmonary dysplasia (lungs not formed appropriately - chronic lung problems)
Respiratory Assistance

- ECMO
- Oscillator
- Mechanical ventilation
- CPAP (Continuous positive airway pressure)
- High Flow Nasal Cannula
- Nasal Cannula
Common Problems in the NICU

- Intraventricular Hemorrhage (IVH)  
  - (bleeding in the brain)
- Patent Ductus Arteriosus (PDA) (heart)
- Necrotizing enterocolitis (NEC) (intestines)
- Retinopathy of prematurity (ROP) (Vision)
- Anemia (blood)
- Hyperbilirubinemia (blood)
- Infections
Northside Hospital - Atlanta

- Acute Care Facility
- 16,000-18,000 babies annually
- 125 bed level III NICU (~1900 annually)

Staffing
- 4 full time audiology technicians
- 1 full time audiologist
- 1 full time position OPEN

Visit www.northside.com - ‘careers’ to apply
Northside Hospital Hearing Screening Protocol

- **Well Baby Nursery**
  - TEOAE
    - Wait 20 hours for vaginal delivery
    - Rescreen refers prior to discharge if time permits (1 OAE, 1 AABR)

- **NICU**
  - TEOAE for all babies
  - AABR when in NICU >5 days
NICU Addition to JCIH

- Diagnostic Evaluations prior to hospital discharge for babies:
  - $\leq 27$ weeks gestational age
  - $\leq 1000$ grams birth weight
  - biliruben $\geq 20$ or exchange transfusion
  - syndrome with associated hearing loss
  - Cooling, ECMO, PPHN
  - Audiologist/neonatologist discretion
When to screen

- When baby is medically stable
  - Out of isolette
  - Breathing room air
  - GA 34 weeks or greater
  - Acuity level 4 or less (scale of 1-7)
Implications for Audiology

- All NICU babies on monitors
  - Oxygen saturation
  - Cardiac function
  - Respiratory rates
  - Temperature
- Many need additional assistance
  - Respiratory
  - Nutritional
Challenges to Screenings in the NICU

- **Electrical Noise (AABR)**
  - Monitors, leads to babies

- **Baby Noise (OAE and AABR)**
  - Stridor, grunting, congestion
  - Breathing, sucking
  - Myogenic artifact

- **Environmental Noise (OAE)**
  - Monitors, people, phones
Screening Challenges cont.

- Finding each baby’s nurse
- Co-bedded newborns
- “Lining up” to provide baby all that’s needed before discharge
- **Space**
  - For instrumentation
  - For electrodes
  - For electrical outlets
Deciding to co-bed multiples is one of the few decisions families get to make for their infants in the NICU.
Screening Challenges

- **Documentation – Paper and pen**
  - Hospital
    - Medical Record: Nurse’s chart & Doctor’s chart
    - Dept. Tracking system
  - Parents
    - Admit packet – state brochure
    - Results letters
  - State
    - All babies who do not pass – Children 1st
    - All confirmed hearing loss
Electronic Documentation

- Wireless laptops
- Direct charting into the medical record
  - NBN – Dec 15, 2009
  - SCN – Mar 8, 2010
  - Diagnostics – Apr 1, 2010
- Parent letters generated automatically
- Children 1st forms generated automatically
- Pediatrician letters automatically generated
Diagnostic Protocol

- ABR
  - AC Clicks
  - 500 Hz and 4000 Hz

- OAE

- Tympanometry (1000 Hz)

If hearing loss is indicated:
  - BC clicks, additional tone bursts
Challenges to Diagnostics

- When baby is ‘quiet’
- On a ‘good day’
- Out of isolette
- Acuity a 4 or below (7 point scale)
- Breathing room air (preferably)
- When 3 months chronologically regardless of GA (coordinated with neonatology)
Diagnostic Challenges

- **Noise**
  - Electric
  - Baby / myogenic
  - Acoustic

- **Baby state**
  - Reflux, helping out, touch defensive
Communication

- Information at all stages of the EHDI process is to be communicated to the family in a culturally sensitive and understandable format.

- Hearing screen information, audiology diagnostic and habilitation information should be transmitted to the medical home and the state EHDI coordinator.
Communication with Parents

- GA law – educate parents about newborn hearing screening
- Report results to follow up pediatrician (medical home post-discharge)
Communication Challenges

- Parents often not present during screening / diagnostics
- Results communicated to nurse, nurse practitioner, NPP, and/or neonatologist
- Direct contact to parents of all infants if they do not pass or if Dx results are not normal
NSH Program Stats

1-1-07 to 12-31-07

- Total Infants: 18,016
  - Transferred: 125
  - Deceased: 100

- Eligible to Screen: 17,791
  - Infants Screened: 17,661 (99.3%)
  - Infants Not Screened: 130 (0.7%)
    - Inconclusive: 2
    - Refused: 1
    - Missed: 127
NSH Program Stats

1-1-07 to 12-31-2007

- Total Screened 17,661
  - Passed 17,064 (96.6%)
  - Referred 597 (3.4%)

Missed 127

Needing OP follow up: 724
Returned for follow up: 535 (74%)
NSH Program Stats
1-1-07 to 12-31-2007

- **Recommended for Evaluation** 218
  - Normal Hearing 131 (60.2%)
  - Not Evaluated 1 (0.3%)
  - Eval in Process 15 (6.9%)
  - Confirmed Hearing Loss 71 (32.6%)
    - Sensorineural 25 (35.2%)
    - Mixed 1 (1.4%)
    - Permanent Cond. 4 (5.6%)
    - Transient Cond. 41 (57.7%)
**NSH Program Stats**

*1-1-07 to 12-31-2007*

- *3.99 Infants per 1000 with hearing loss of any type*

- *1.69 infants per 1000 with permanent childhood hearing loss*

*follow up not yet completed for 2007*
Confirmed Hearing Loss

- **Conductive - Transient**
  - Not our primary target, but we don’t ignore
  - Allow several weeks to clear w/o intervention
  - Repeat screening, refer for medical follow-up
  - Persistent conductive losses are referred for ENT consult
  - Increased emphasis on monitoring communication development

- **Conductive - Permanent**
  - Considered a target to ID through program
  - Referral for ENT consult
  - Consideration for amplification
Confirmed Hearing Loss

- **Sensorineural**
  - ENT consult
  - *Genetics referral
  - Early Intervention program w/ experience with hearing loss
  - Amplification (HA, CI, ALD, etc.)
  - Speech/Language evaluation
  - *Vision evaluation
  - GA State DOH, Babies Can’t Wait, Children’s First; GA PINES, etc.
  - Ongoing audiologic testing
Confirmed Hearing Loss

- **Auditory Neuropathy**
  - ENT consult
  - *Genetics referral
  - Early Intervention program w/ experience with hearing loss
  - Amplification (HA, CI, ALD, etc.)
  - Speech/Language evaluation
  - *Vision evaluation
  - GA State DOH, Babies Can’t Wait, Children’s First; GA PINES, etc.
  - Ongoing audiologic testing
## Incidence of Hearing Loss and Permanent Childhood Hearing Loss

<table>
<thead>
<tr>
<th></th>
<th>Total NSH Population</th>
<th>NBN</th>
<th>SCN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants per 1000 with HL</td>
<td>3.99</td>
<td>1.49</td>
<td>29.3</td>
</tr>
<tr>
<td>Infants per 1000 with PCHL</td>
<td>1.69</td>
<td>0.87</td>
<td>9.98</td>
</tr>
</tbody>
</table>
NSH Program Stats
1-1-07 to 12-31-07

- Outpatient Screening
  - Referred babies
    - 74% returning to NSH for OP rescreen to date

- Not screened as IP
  - 79% returned to NSH for OP rescreen
Case Studies

- Comparison of 2 babies
  - Newborn Nursery
  - Special Care Nursery
  - Full Term
  - 25 wk GA
## Comparison: WBN vs. SCN

<table>
<thead>
<tr>
<th>Zachary</th>
<th>Zoe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Born at 39 weeks GA</td>
<td>Born triplet C at 25 wk GA</td>
</tr>
<tr>
<td>Birth weight 4860 gms (10 lbs. 11 oz.)</td>
<td>Birth weight 726 grams (1 lb 7 oz.)</td>
</tr>
<tr>
<td>APGARs 9 and 9</td>
<td>APGARs 5 and 8</td>
</tr>
<tr>
<td>C-section</td>
<td>C-section</td>
</tr>
<tr>
<td>Mild jaundice</td>
<td>Multiple complications and risk factors for hearing loss</td>
</tr>
<tr>
<td>Discharged at day 4 of life</td>
<td>Discharged at 1 year, 3 months</td>
</tr>
</tbody>
</table>
Comparison WBN vs. SCN

### Zachary
- IP Screening on day 3
- IP Rescreen on day 4
- OP Screening on day 11
- Diagnostic Evaluation on day 22 (week 3)

### Zoe
- Day 3 - intubated, bilious pneumonia, phototherapy
- Day 4 - intubated, photoTx
- Day 11 - intubated, phototherapy, small PDA, minimal grade 1 IVH
- Day 22 - intubated, paralytics, diuretics, antibiotics, cardiac meds
- Day 51 - weaned to CPAP
Comparison: WBN vs. SCN

<table>
<thead>
<tr>
<th>Zack</th>
<th>Zoe</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENT week 5</td>
<td>No IP screen – Dx eval</td>
</tr>
<tr>
<td></td>
<td>Concerns raised by OT/PT Developmental Team</td>
</tr>
<tr>
<td></td>
<td>Still on NC, acuity 5</td>
</tr>
<tr>
<td></td>
<td>Dx Eval on week 22</td>
</tr>
<tr>
<td></td>
<td>Chronological age (5 months), week 7</td>
</tr>
<tr>
<td></td>
<td>Corrected Age</td>
</tr>
<tr>
<td></td>
<td>ENT as IP 23 weeks</td>
</tr>
<tr>
<td></td>
<td>Parents to ENT 24 weeks</td>
</tr>
</tbody>
</table>
## Comparison: WBN vs. SCN

### Zack
- GA PINES week 4
- ENT ‘visualized fluid’ week 5
- Tubes week 7
- Repeat ABR – severe to profound SNHL
- Hearing aids week 12
- CI workup 8 months
- CI bilateral 10 months

### Zoe
- GA PINES week 37 (still an IP)
- Repeat ABR – sedated 41 weeks
- Hearing Aids – week 45
- Discharge from hospital 63 weeks 1 day

---

GA PINES = Georgia Parent Infant Network for Educational Services
## Implications for 1-3-6 EHDI Goals

<table>
<thead>
<tr>
<th>Well Babies</th>
<th>SCN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Should be able to meet outlined goals</td>
<td>Many preterm and/or medically fragile babies are ‘not ready’ for audiologic services until after their chronological age has passed the EHDI goals</td>
</tr>
</tbody>
</table>