

# An Interdisciplinary Approach to Earlier Identification and Intervention of Hearing Loss in Medically Complex Infants



Kelly A. Baroch, Au.D., FAAA  
Pediatric Audiologist  
Inpatient and Perioperative Audiology  
Program Coordinator

# Let's Talk About...

- Medically Complex Infants/Toddlers
  - Trends in this growing population
- Earlier Identification and Intervention
  - Moving from booth to bedside – providing quality hearing healthcare for our most fragile patients
  - Late onset/progressive hearing loss
  - Improving care coordination for hospitalized infants and children
- Inpatient Program Development
  - Challenges and lessons learned



# Inpatient Audiology Team





# Inpatient Audiology

## Inpatients

- Med/Surg
- Transitional Care (Trach Unit)
- NICU
- GI
- Oncology
- BMT
- Neurosurg
- Complex Air
- PICU
- CICU
- LIB TCC

- **Over 850 annually**

**10-20 deaf/HoH patients  
admitted on floors daily**

## Perioperative Program

### Main Campus

- Procedure Center
- OR
- Radiology
- ECHO
- Cardiac Cath

### Liberty Campus

- LIB OR
- LIB Radiology
- LIB Proton Center

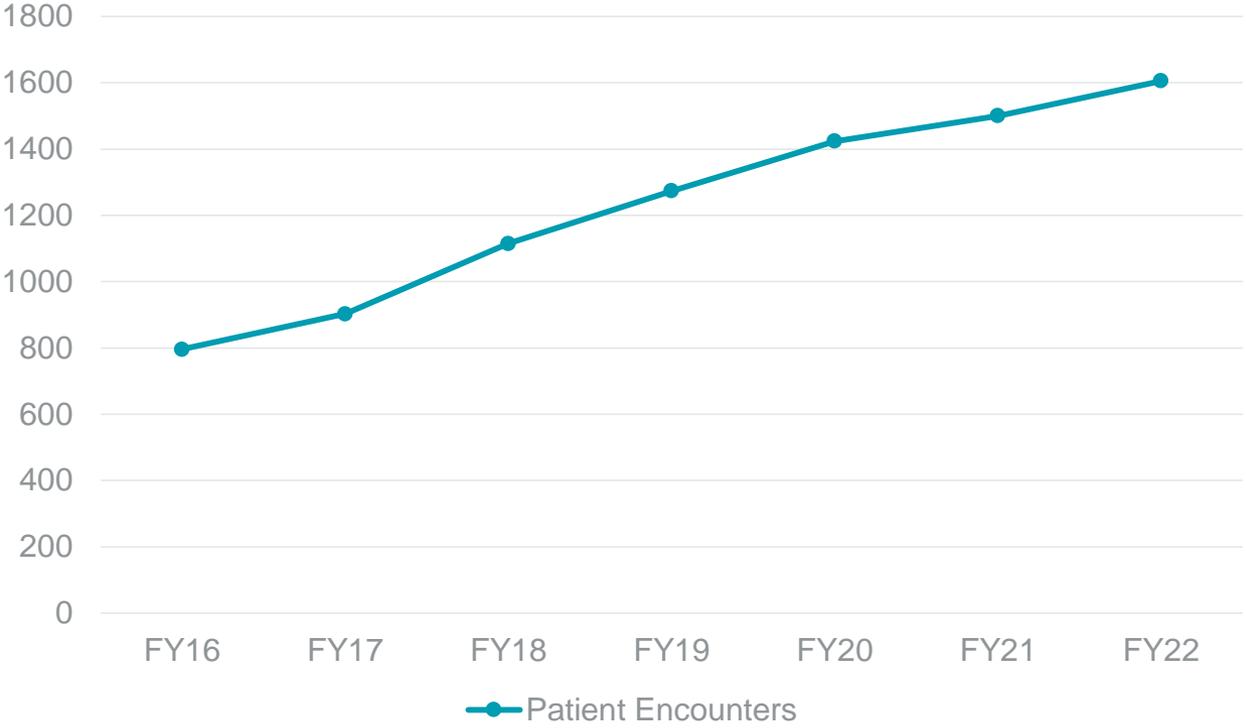
### Eastgate Campus – Coming Soon!

- EAS OR
- EAS Radiology

- **Over 750 annually**



# Inpatient Encounters by FY



# Viability

| Length of Pregnancy | Likelihood of Survival               |
|---------------------|--------------------------------------|
| 23 weeks            | 17%                                  |
| 24 weeks            | 39%                                  |
| 25 weeks            | 50%                                  |
| 26 weeks            | 80%                                  |
| 27 weeks            | 90%                                  |
| 28-31 weeks         | 90-95%                               |
| 32-33 weeks         | 95%                                  |
| 34+ weeks           | Almost as likely as a full-term baby |

March of Dimes 2013

As technology improves and we keep more infants alive, the length of stay in the NICU increases along with the risk of neurodevelopmental delays.

| Length of Pregnancy | Likelihood of Survival |
|---------------------|------------------------|
| 22 weeks            | 64%, 61%, 58%-70%      |
| 23 weeks            | 82%, 71%, 66% or above |

University of Iowa 2019

Journal of the American Medical Assc 2019



# Statistics

- 10-15% of infants in the US receive NICU care (March of Dimes)
- 1 out of every 10 babies in the US born prematurely
- Prematurity leading cause of long-term neurological disabilities in children
- 1 in every 33 babies has a congenital anomaly. Over 120,000 annually.

CDC 2019

# Infant Program – NICU/CICU Growth

- National Trends
  - Neonatal Abstinence Syndrome
    - 1 baby diagnosed with neonatal abstinence syndrome every 19 minutes in the US (CDC 2019)
    - Number of babies with neonatal abstinence syndrome rose 82% in the US from 2010 to 2017 (Hirai et al JAMA 2021)
  - Myelomeningocele
    - Up 30%
    - UNC Chapel Hill finds connection with low carb diets
  - Gastroschisis continues to increase (CDC 2018)
    - Has more than doubled in recent years
    - Possible link with opioid use
  - Cardiac defects
    - Journal of American Heart Association 2019 predicts increase due to global warming
    - The rise in temperatures stemming from climate change may increase the number of US infants born with congenital heart defects between 2025 and 2035. The greatest percentage increases in the number of congenital heart defects are predicted in the Midwest, followed by the Northeast and the South.

US NICU admissions increased by 38% from 2008 to 2018 (Scientific Reports 2021)

# Infant Program – NICU/CICU Growth

- Regionally
  - Perinatal Institute and Cradle Cincinnati working to improve infant mortality rates in Hamilton County
  - Rate of prematurity and birth defects some of the highest in the country
  - Rank in the bottom 30 counties nationally
  - 56% of deaths in first year of life due to prematurity
  - 23% due to birth defects



[Cradlecincinnati.org/data](http://Cradlecincinnati.org/data)

# Infant Program – NICU/CICU Growth

- CCHMC
  - Increased bed space (42/62/75/100)
  - Fetal Care Program
    - 550-600 patient evaluations
    - 100-130 fetal surgeries
    - 200-250 NICU(65%)/CICU(45%) admissions
      - 46% regional/national market
      - ALOS NICU: 55-60 days ALOS CICU: 30 days
    - Fetal Care Center Special Delivery Unit
      - 175 deliveries this year
      - 225 next year with 6 total beds
      - 5-10% annual growth
  - ECMO Program
    - 2016 numbers doubled from 25 to 50 cases annually
    - Have averaged 50-55 cases annually consistently
  - Neonatal Dialysis Program (Center for Acute Care Nephrology)
    - First in the US Cardio-Renal Pediatric Dialysis Emergency Machine



# The Challenges of Early Identification and Intervention of Hearing Loss



# Our History

- JCIH 2000
  - Infants referred from UNHS begin audiologic and medical evaluations before 3 months of age or **3 months after discharge for NICU infants** (Dalzell et al, 2000).
- JCIH 2019
  - Infants with congenital aural atresia in one or both ears or with visible pinna/ear canal deformity such as stenosis or severe malformation **should not be screened in either ear but should be referred for diagnostic audiologic evaluation immediately upon discharge. The diagnostic audiologic evaluation can also be accomplished while the infant is in the NICU or other inpatient hospital unit.**
  - For some infants in the NICU (e.g., infants on ventilators), it may not be feasible or practical to complete a hearing screening prior to one month of age due to the high likelihood of middle ear effusion, noise interference, and electrical interference from equipment. **Alternative arrangements should be made for completing the hearing screening on these infants at a time when they are medically stable**

# The Changing Faces of the NICU



# The Changing Faces of the NICU

- Delayed diagnosis and intervention
  - Negatively impacts parent-infant bonding
  - Negatively impacts language development
  
  - Negatively impacts how the infant reacts to medical care!!!

- CCHMC NICU 2002-2003
  - Miss rate 30%
  - LTF rate of 42%
  - Average age of diagnosis 7 months AA
  - Average age of device fitting 10 months AA

# 1-3-6 Timeline: “Screening” Limited Diagnostic

- ABR by 1 month adjusted age
  - Medical instability
  - “Technology focused and crisis driven” D. Vittner
  - Distrust of medical team

- ❖ In-house audiologist
  - ❖ Developmental Team
  - ❖ Medical Rounds
  - ❖ Team member vs. consultant
  - ❖ Diagnostic value



# Testing Early: Collaboration with Medical Team

- Knowledge
  - Do your homework
    - Know the medical history
    - Risk factors
    - Read care plans
    - Ask what calms/stresses infant and know how to manage – Developmental care!!!!
- Take every teaching opportunity
  - Nursing orientation
  - Residents/APNs/Attendings
- “Team member” vs “tech”/consultant
  - What does the audiologist bring to the table?
  - Team player – help out where you can
  - Leave patient the way you found them
  - Silo vs big picture
- Why do we care?
  - Gatekeeper to the patient
  - Earlier access for testing
  - Assistance with choosing ideal test time
  - Advocates in reinforcing message - reducing LTF

## 1-3-6: Diagnosis

“If the newborn doesn’t pass the initial screening, explore the possibility of using audiologists already in the facility to do a definitive ABR before the baby leaves the hospital.”

Communicating the Need For Follow-up to Improve Outcomes of Newborn Hearing Screening, Workgroup, July 2001

# Diagnostic ABR – Critical Questions

| Training of ABR Audiologists  | Equipment   | Protocols  | Culture   |
|---|---|--|---|
| Achieving best sleep state”!!!<br>(developmentally supportive touch, positioning) | Measures of background noise and estimate of strength of response                           | Where can you reduce wasted time? (ex. suprathreshold runs at each frequency)                            | Audiologists, in general, do not like change  |
| Bone conduction ABR!!!  | Improvements in averaging techniques and noise rejection                                    | Are your protocols defeating your technology (ex. required minimum sweeps vs residual noise coefficient) | Do you have the right people/numbers on your inpatient team?? These need to be your most experienced ABR audiologists |
| Ongoing ABR audits and case study review  | Consider advancements (Chirp stimuli, ASSR)   | What information do you need, minimally, to answer the question?   | Do you choose equipment based on what provides the best outcome for the population or what is “comfortable”?          |
| Utilize manufacturer trainers and experts at pediatric facilities                 | Steep learning curve when changing to different equipment, different signal processing etc. | Prioritization of frequencies to quickly identify or r/o SNHL AND middle ear pathology                   |   |

# Care Plans

## Jacelyn's Sensory Care Plan

- I rely on my sense of touch to know when you want to interact with me. Please approach my bed slowly and gently. Place your hands firmly beside me on my mattress so I feel your presence. Then touch me gently on my leg up to my head and face where I am most helped by your touch.
- Please help me by giving me lots of positive sensory input (I love it when you touch me).
- When you hold me, please sit or stand so that your face is softly illuminated on my face.
- Holding me when you talk and sing helps me hear your voice while I lie in bed.
- Please give me time to use my senses before you come next. Give me a tactile cue (like a tickle) before my touch.
- Please try to keep my daily routine consistent so I can learn to anticipate what will happen next.
- Many different caregivers can be helpful. Please use my primary nursing team and caregivers who are familiar and comfortable with me.

Thanks for helping me!!

### Important Information about My Hearing Device Bone Conduction Device (BCD)

**ONLY TO BE WORN WITH DIRECT SUPERVISION OF AN ADULT.  
BATTERY IS TOXIC IF INGESTED.  
PLEASE INSURE BATTERY DOOR IS CLOSED COMPLETELY.**

I cannot hear well when I do not wear my device. Please follow my sensory care plan to know how to communicate with me.

#### How it works

- The BCD helps me be aware of what is happening in my environment.
- Sound vibrations are sent to my inner ears.
- **TURN ON** - Close the battery door completely
- **TURN OFF** - Open the battery door

#### When should I wear it?

- When I am awake, alert, and under active adult supervision. **The battery is toxic!**
- Please watch my cues while I am wearing my hearing device. If I seem to be getting overstimulated, please take it off.
- Take my hearing device off when I am tired, so I can get good comfortable sleep.
- My hearing device is electronic, so please keep it dry and in my clear bag.
- **PLEASE STORE MY DEVICE SAFELY WHEN NOT IN USE**

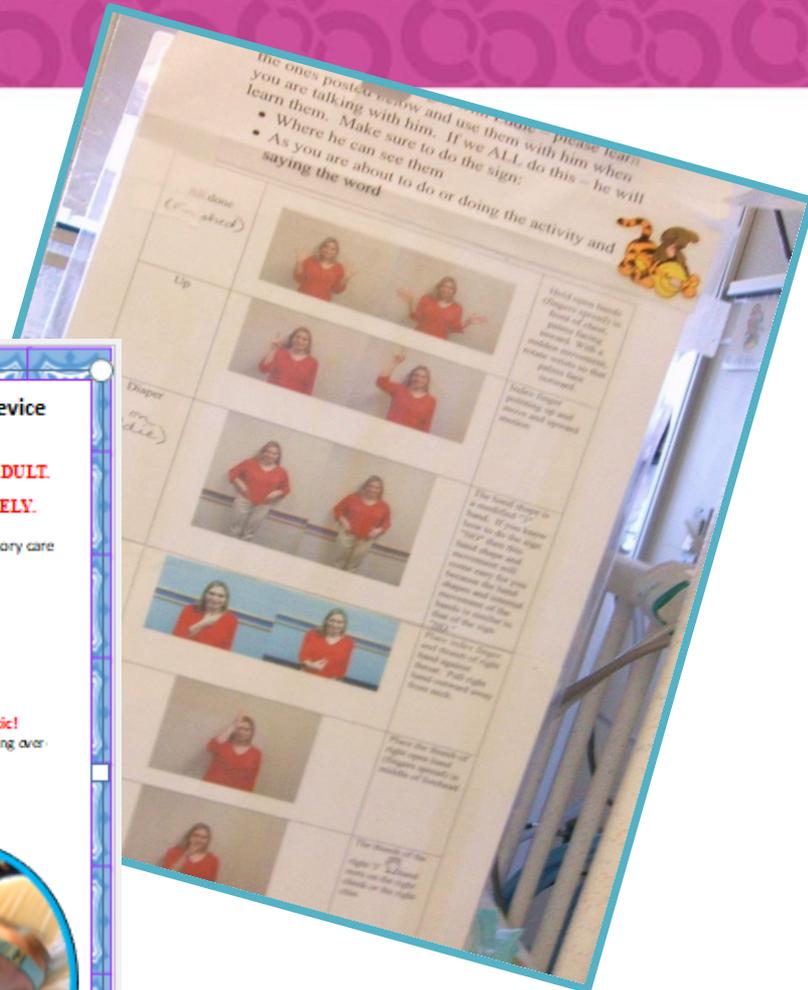
#### How to put it on

- My headband should be snug around my head with the BCD on my forehead or on the side of my head.
- You can adjust the placement where the BCD sits on my head.

#### Check the battery

- Close the battery door completely
- Cup your hand over the BCD (oscillator) on the headband.
- You should be able to feel a slight vibration and hear it "whistle" if the battery is good.

Please call Audiology with any questions contact:  
Evan Murphy, AuD  
Mobile: 513-543-0206 Office: 513-513-4148



## Jacelyn's Sensory Care Plan

- I rely on my sense of touch to know when you want to interact with me. Please approach my bed slowly and gently. Place your hands firmly beside me on my mattress so I feel your presence. Then touch me gently on my legs and work your way up to my head and face where I am most sensitive. This will help me from being startled.
- Please help me by giving me lots of positive touch. This gives me good sensory input (I love it when you stroke my hair!!)
- When you hold me, please sit or stand near an overhead can light so that your face is softly illuminated. This may help me focus on your face.
- Holding me when you talk and sing to me lets me feel the vibration from your voice while I listen.
- Please give me time to use my sense of touch to know what is coming next. Give me a tactile cue for activities whenever you can. For example, before my trach care, please touch my neck gently on both sides of my trach. When we're done, please hold me!
- Please try to keep my daily routine as consistent as possible. This will help me learn to anticipate what is happening next.
- Many different caregivers can be overwhelming for me. Please use my primary nursing team whenever possible, so I have caregivers who are familiar and know me.

Thanks for helping me!!

*Jacelyn*

# Hearing Devices

- Work with the medical team to determine when infant is medically stable for fitting
- Device fitting may need to be avoided during certain treatments near the head including mandibular distraction or newly placed ventriculoperitoneal shunt.
- If a parent is not interested in a hearing device, the sensory care plan is followed and speech pathologists continue to provide education regarding early language acquisition and communication options.
- Completely different counseling and mindset from outpatient fitting



# Hearing Devices

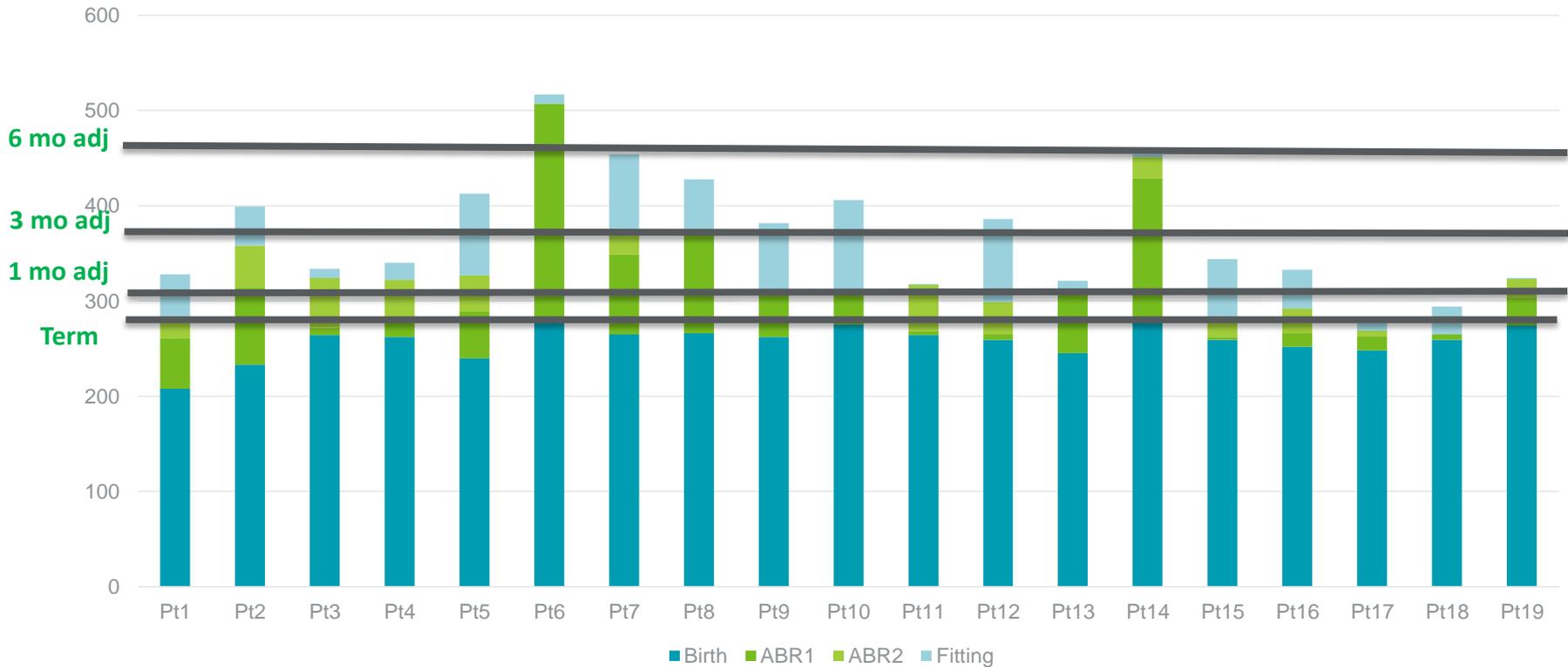
- Loaner bone conduction devices are utilized and can be fit shortly after diagnosis
  - 10 bone conduction devices/softbands
  - 10 pairs of BTE hearing aids
- Parents and medical team are educated regarding device care and recommended use
- Utilized at specific times during communication and with adult supervision
- Communication opportunities for hearing device use include: during parent holding, talking, or singing with the infant, during longer periods of medical care and developmental therapies including: occupational, physical, speech and music therapy
- Parents and staff taught to monitor the infant's cues for discomfort or overstimulation and remove the device when warranted
- When the infant is not wearing a hearing device, recommendations within the Sensory Care Plan should be maintained

# Hearing Devices

- Frequent audiologic follow up and monitoring is completed with the infant, family, nursing staff and therapists who manage the device.
- Unfortunately, there are no validated outcome measurements currently available that are appropriate for infants who are admitted to the hospital.
- To determine perceived benefit, our inpatient audiologists have developed a set of questions appropriate for parents and caregiving team.
- Data regarding the infant's responses to medical care and parent bonding is collected, discussed, and documented.

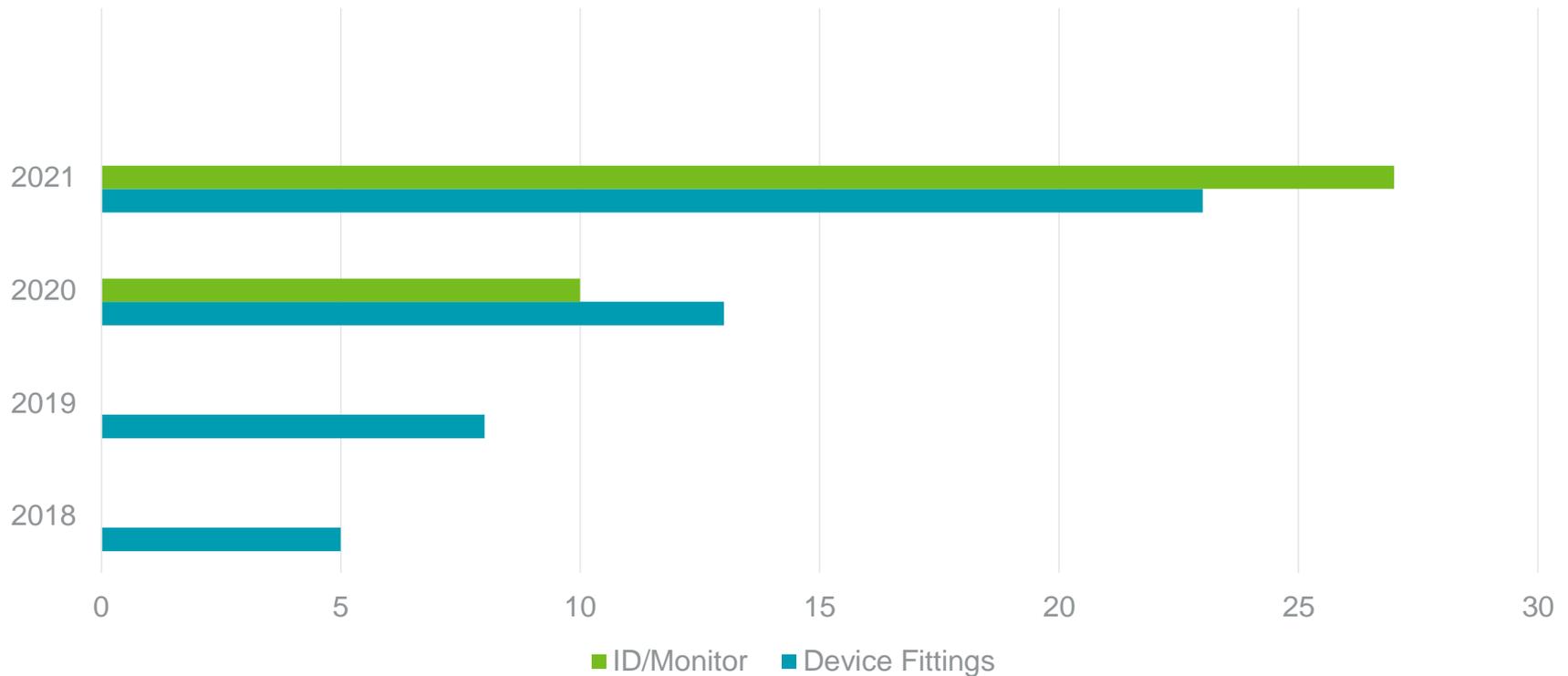
# Timing of Diagnosis and Intervention

Inpatient Infant 1-3-6



# Inpatient Hearing Aid Fitting

Inpatient Hearing Aids



# What does your child respond to...

## Without a device

- Someone talking at the bedside (average speech level)
- Very loud sounds



## With a device

- Music/ mobile
- Monitors
- Click of the door
- Soft speech
- Speech further away from the bed
- Alert
- Eye contact
  
- Calmed with painful care

# Parent – Infant Attachment

## *Positive Responses with the Hearing Device*

- *“My child is more engaged, gets excited and has more eye contact with me.”*
- *“My child would get the biggest smile on his face when he heard our voices.”*
- *“My child has more interest in Music Therapy with me and loves it.”*
- *“During suctioning and trach care- She is calm when I talk to her, where she typically becomes upset and arches her back”*
- *“He was more engaged and interested when I was talking to him, instead of just going to sleep.”*
- *“She is more engaged, gets excited and has more eye contact.”*

# Monitoring

- Increased risk for late onset/progressive hearing loss
  - CMV
  - ECMO
- Prevalence of late onset/progressive hearing loss is greater than originally thought
  - 3.5 to 7 years of age (Yoshinago-Itano 2013)



# Monitoring

Combo with any sedation opportunity

OR

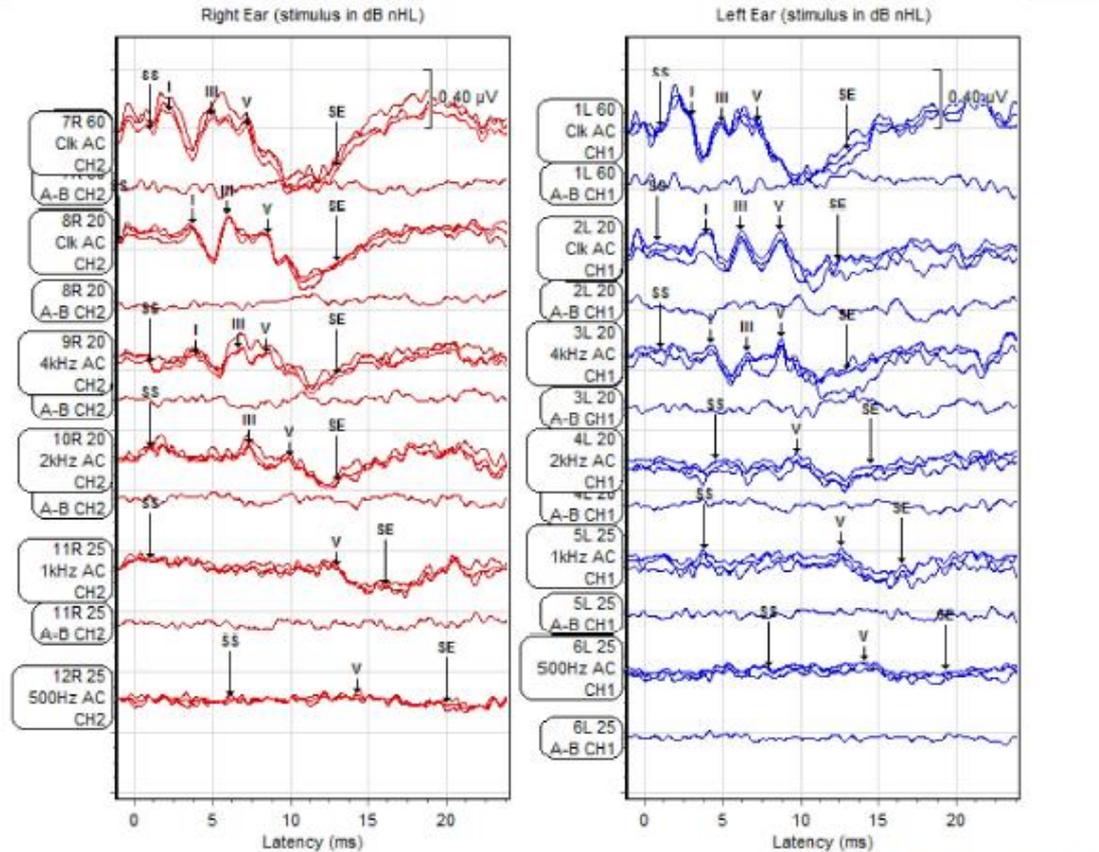
Radiology

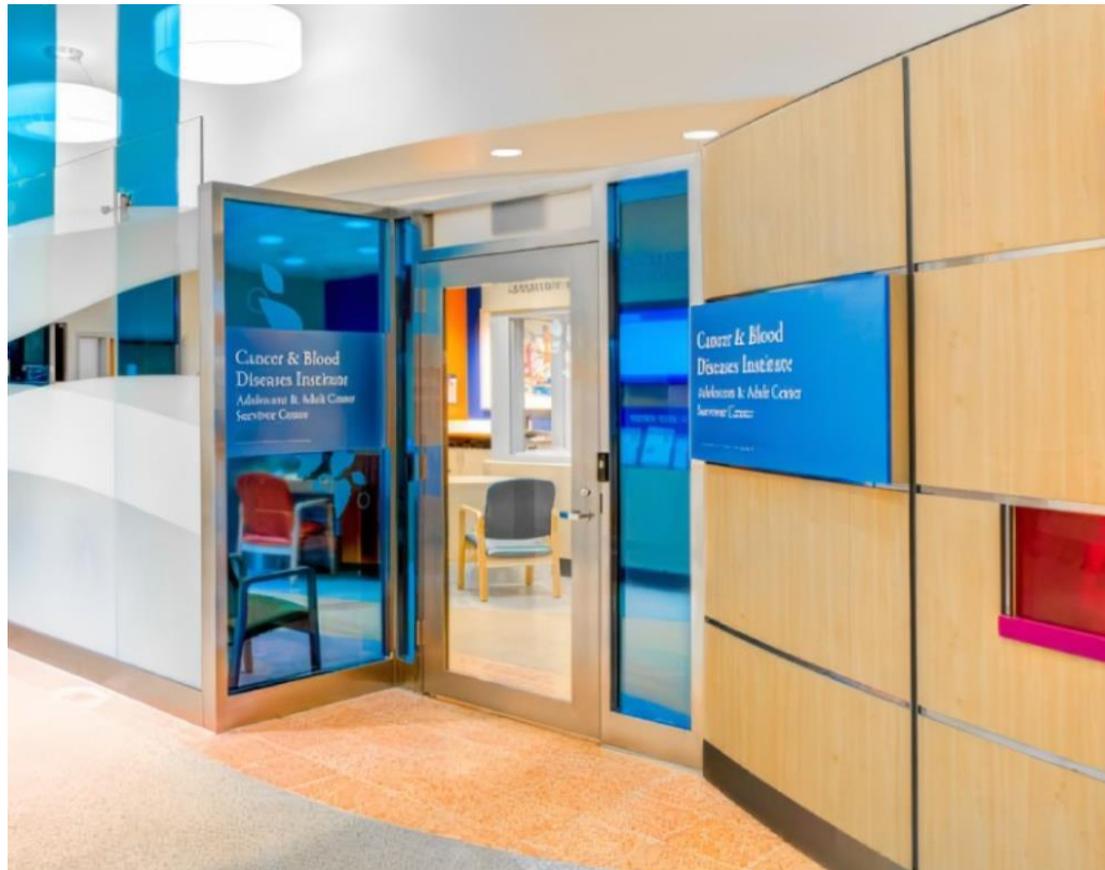
ECHO lab

Cardiac Cath Lab

Procedure Center

Bedside testing during re-admissions





# Ototoxicity Program - Oncology/BMT Growth

- National Trends
  - Incidence of pediatric cancer up 27% since 1975
  - Incidence varies by age with 15-19 years and 0-4 years being the fastest growing
  - Brain and central nervous system cancers
    - Highest incidence in children age 1-4 years
    - Neuroblastoma accounts for 50% of solid tumor cases in children  
Usually present at birth
  - Hepatoblastoma
    - Diagnosed less than 3 years of age
    - Prematurity is a risk factor with 1 in 5 born before 30-32 weeks GA

National Cancer Institute (SEER Program)



# The Need for High Frequency Tone Bursts

- Although often underappreciated, even hearing loss restricted to high frequency ranges (4,000-8,000 Hz) can have a significant impact on language development, verbal abilities, and reasoning skills in young children. This is of particular concern with patients treated in early childhood for embryonal malignancies because the ototoxic effects are concurrent with the developmental period in which the process of acquiring speech and language skills is so critical.

Gurney and Bass 2012

# SIOP Boston Grading Scale

## **PEDIATRIC GRADING** SIOP Boston Ototoxicity Scale

| Grade | Parameters   |
|-------|--|
| 0     | $\leq 20$ dB HL at all frequencies   |
| 1     | $> 20$ dB HL (i.e., 25 dB HL or greater) SNHL above 4 kHz (i.e., 6 or 8 kHz) |
| 2     | $> 20$ dB HL SNHL at 4 kHz and above   |
| 3     | $> 20$ dB HL SNHL at 2 kHz or 3 kHz and above                                |
| 4     | $> 40$ dB HL (i.e., 45 dB HL or more) SNHL at 2 kHz and above                |

**^ Based on sensorineural hearing loss (SNHL) in dB HL; bone conduction or air conduction with normal tympanogram**

# Protocols

- Hearing evaluation prior to every round of chemo with -platin or other ototoxic drugs
- Hearing evaluation within 1 month post treatment
- Hearing evaluation every 4-6 months until 2 years off treatment then annually

# Just the Beginning

- Other special population protocols
  - Meningitis
  - Non-accidental trauma
  - Temporal bone fractures

# Care Coordination

- My Chart Bedside
- EPIC tracking
- Audiology Care Coordinator
  - Helps track infants birth to 3
- Medical Team
  - High Risk Clinic
  - Complex Care Pediatricians

## Inpatient Audiology

### How Can We Help During the Hospital Stay?

The Inpatient Audiology team is here to help during your child's hospital stay. We can do many hearing services at the bedside so your child doesn't have to leave the room.

#### • Hearing Tests

- Does your child need a hearing test or are you worried that your child's hearing has changed?
- We can often do bedside hearing tests or auditory brainstem response (ABR) tests during a nap or with a surgery.

#### • Hearing Aid Repairs

- Is your child having problems with their hearing aid?
- We can do small hearing aid repairs (biking changes etc.), provide batteries, take molds of the ear, and check the aid to see if it needs to go in for repair.

#### • Communication Plans

- Is your child having trouble hearing the doctors and nurses? We can help make a plan.

If we can help with any of these, please have your nurse or doctor contact the On-Call Audiologist in "Who's On Call".

You can also call us from your room at 69914 or 61193 (513-636-9914 or 513-636-1193 from outside the hospital).



🏠 Panels (No results found)

🏠 Other Medications (No results found)

🏠 Other Procedures ⤴

|   | Name                            | Type     | Pref List   | Px Code |
|---|---------------------------------|----------|-------------|---------|
| 🏠 | Audiology Brainstem Response... | AUDIO... | AUD REFE... | AUD4    |
| 🏠 | ABR with Sedation               | AUDIO... | AUD REFE... | AUD59   |

Epic Master Daily S  
In Basket New Msg  
My Messages  
Results  
Orders  
Patient Call  
Pt Call Back  
Pt Reminder (20)  
**Hospital ADT (3)**  
My Open Charts  
My Open Encoun  
Addendum Notific  
Staff Message (1)  
CC'd Charts  
Message Routing  
Review Reports  
Pt Reports

hyperspace - CCM ABBIOLOGY - Cincinnati Children's Production - KELLY BARUCH - All 20:14 Reminder - Hospital

Epic Master Daily Schedule Schedule IP Job Aids In Basket Chart Encounter Telephone Call My Reports Safety Report

Reports

Library

deaf Search Clear

Show templates Collapse all

Find IP Patients Generic Criteria + New report

Matching reports

★ Admitted Patients with Deaf/HoH FYI Flag or Hearing Issue Documented Run Edit

This reporting workbench will display all currently admitted patients that have the Deaf/Hard of Hearing FYI Flag or have a hearing issue documented in the Functional Screen.

Additional reports Details

My Reports

Library

# Inpatient Audiology

## How Can We Help During the Hospital Stay?

The Inpatient Audiology team is here to help during your child's hospital stay. We can do many hearing services at the bedside so your child doesn't have to leave the room.

- **Hearing Tests**

- Does your child need a hearing test or are you worried that your child's hearing has changed?
- We can often do bedside hearing tests or auditory brainstem response (ABR) tests during a nap or with a surgery.

- **Hearing Aid Repairs**

- Is your child having problems with their hearing aid?
- We can do small hearing aid repairs (tubing changes etc.), provide batteries, take molds of the ear, and check the aid to see if it needs to go in for repair.

- **Communication Plans**

- Is your child having trouble hearing the doctors and nurses? We can help make a plan.

If we can help with any of these, please have your nurse or doctor contact the On-Call Audiologist in "Who's On Call".

You can also call us from your room at 69914 or 61193 (513-636-9914 or 513-636-1193 from outside the hospital).



# Care Coordination

- My Chart Bedside
- EPIC tracking
- Audiology Care Coordinator
  - Helps track infants birth to 3
- Medical Team
  - High Risk Clinic
  - Complex Care Pediatricians

## Inpatient Audiology

### How Can We Help During the Hospital Stay?

The Inpatient Audiology team is here to help during your child's hospital stay. We can do many hearing services at the bedside so your child doesn't have to leave the room.

- **Hearing Tests**
  - Does your child need a hearing test or are you worried that your child's hearing has changed?
  - We can often do bedside hearing tests or auditory brainstem response (ABR) tests during a nap or with a surgery.
- **Hearing Aid Repairs**
  - Is your child having problems with their hearing aid?
  - We can do small hearing aid repairs (biking changes etc.), provide batteries, take molds of the ear, and check the aid to see if it needs to go in for repair.
- **Communication Plans**
  - Is your child having trouble hearing the doctors and nurses? We can help make a plan.

If we can help with any of these, please have your nurse or doctor contact the On-Call Audiologist in "Who's On Call".

You can also call us from your room at 69914 or 61193 (513-636-9914 or 513-636-1193 from outside the hospital).



Epic  
 Master Daily S  
 In Basket New Msg  
**My Messages**  
 Results  
 Orders  
 Patient Call  
 Pt Call Back  
 Pt Reminder (20)  
**Hospital ADT (3)**  
 My Open Charts  
 My Open Encoun  
 Addendum Notific  
 Staff Message (1)  
 CC'd Charts  
 Message Routing  
 Review Reports  
 Pt Reports

Panels (No results found)

Other Medications (No results found)

Other Procedures

| Name                            | Type     | Pref List   | Px Code |
|---------------------------------|----------|-------------|---------|
| Audiology Brainstem Response... | AUDIO... | AUD REFE... | AUD4    |
| ABR with Sedation               | AUDIO... | AUD REFE... | AUD59   |

# Tips from the Trenches

## Building and Growing an Inpatient Audiology Program



# Building an Inpatient Audiology Program

- Interdisciplinary relationships are critical
- Educate, educate, educate
- Effective diagnostic protocols
- Equipment that is appropriate for the environment/population
- Choose a reasonable starting point
  - Sensory Care Plans
  - Parent Support
  - Device Fitting



## Elijah's Sensory Care Plan

- Please approach my bed slowly and gently. If I am awake, let me see you before you touch me. If I am asleep, please place your hands firmly beside me on my mattress so I sense your presence. Then touch me gently on my legs and work your way up to my head and face where I am most sensitive. This will help me from being startled.
- Please help me by giving me lots of positive touch. This gives me good sensory input.
- When you hold me, please sit or stand near an overhead can light so that your face is softly illuminated. This helps me focus on your face, and use my vision.
- Holding me when you talk and sing to me lets me feel the vibration from your voice while I listen.
- Please give me time to use my sense of touch to know what is coming next. Give me a tactile cue for activities whenever you can. For example, before a diaper change, please let me see the diaper, then touch it gently on the back of my hand. This will help me learn what is coming next.
- Please keep a snoedel with my parents' scent on it in my bed when they can't be here with me.
- Please try to keep my daily routine as consistent as possible (ex. I always have my baths at night). This will help me learn more about my day.
- Many different caregivers can be overwhelming for me. Please use my primary nursing team whenever possible, so I have caregivers who are familiar and know me.

Thanks for helping me!!

*Elijah*

# Building an Inpatient Audiology Program

- Small team of audiologists dedicated to the population
- Extensive ABR experience
- Strong medical knowledge
- Personal characteristics
  - Flexibility
  - “Thick skinned” 😊
  - Adrenaline “junkies” with a calm demeanor

# Building an Inpatient Audiology Program

- Need to be close to the action 😊
  - Offices in critical care area
- Dedicated inpatient schedule vs split schedule with ambulatory
- Plan on early mornings/late nights
- The OR never runs on time

# Building an Inpatient Audiology Program

- ♥ Emotionally and physically draining work
- ♥ You will lose patients
- ♥ Self-care is critical – compassion fatigue is real!!!
- ♥ Participate in “debriefings”
- ♥ Reflect and celebrate the small wins
  
- ♥ You will be inspired EVERY DAY!!!



[Kelly.Baroch@cchmc.org](mailto:Kelly.Baroch@cchmc.org)

513-659-2022