AMPLIFICATION AND STRATEGIES FOR OPTIMIZING COMMUNICATION FOR HARD-OF-HEARING CHILDREN

Meghan Wisneski, AuD, CCC-A
Lisa Yamaguchi AuD, CCC-A
Disclosure

- We have the following relevant financial relationship to disclose:
  - We are Seattle Children’s Hospital Employees

- We have no relevant nonfinancial relationship(s) to disclose.
Objectives

1. Describe and define “hard-of-hearing” in terms of audiologic classifications.
2. Describe appropriate hearing device options for hard-of-hearing kids.
3. Describe how we verify and validate performance with or without hearing aids.
4. Describe effective communication strategies in various environments.
How does the ear work?

- **Outer Ear** – opening of the ear canal up to the tympanic membrane
- **Middle Ear** – includes the 3 ossicles (middle ear bones)
- **Inner Ear** – includes the cochlea
- **Auditory nerve**

(Washington State DOH)
Types of Hearing Loss

- **CONDUCTIVE HEARING LOSS** means there are problems with the outer or middle parts of the ear. Most times, there is something in the outer or middle ear that blocks the sounds from passing through the structures. Medicine or surgery can sometimes help this type of hearing loss.

- **SENSORINEURAL HEARING LOSS** means there is a problem with the cochlea (inner ear) or the auditory nerve. This type of hearing loss is permanent. It is not usually fixed by medicine or surgery.

- **MIXED HEARING LOSS** means there is a problem in both the outer or middle ear and the cochlea.
Classifications of hard-of-hearing

- Mild to Severe Hearing Loss
- Unilateral hearing loss (UHL)
- Conductive hearing loss (CHL)
Example: Mild to Moderate Sensorineural (SNHL)
Example: Mild to Severe SNHL
Example: Mild to Moderately-Severe, Asymmetric Mixed Hearing Loss (MHL)
Difficulties of Mild to Severe Hearing Loss

- Difficulty accessing all speech frequencies
  - Can lead to speech and/or language delay

- Difficulty understanding speech in noise
  - Can lead to academic or attention issues

- Executive functioning or auditory memory issues (higher level functioning issues)
Classifications of hard-of-hearing

- Mild to Severe Hearing Loss
- Unilateral hearing loss (UHL)
- Conductive hearing loss (CHL)
Example: Mild to moderately-severe MHL in right ear
Example: Unilateral profound SNHL
Example: Moderate to Severe CHL
“But my child has one good hearing ear” – The Importance of Binaural listening

- Localization
- Listening in Noise
- Stimulation of binaural pathways
Effects of unilateral hearing loss on school performance

- Children with unilateral hearing loss have greater difficulty...
  - Localizing where sounds come from
  - Understanding speech in a noisy classroom
  - Maintaining attention
- More likely to be rated by teachers as having behavior problems
- Difficulty with school work, particularly language based subjects such as reading, writing, and spelling.

“Children with aidable unilateral hearing loss should be considered candidates for amplification in the impaired ear due to evidence for potential developmental and academic delays. Children with unilateral hearing loss are at greater risk than children with normal hearing for speech and language delays and academic difficulties.”


**Options will be based on your child’s age, anatomy, degree of hearing loss, and listening needs.**
Classifications of hard-of-hearing

- Mild to Severe Hearing Loss
- Unilateral hearing loss (UHL)
- Conductive hearing loss (CHL)
Why does CHL need its own section?

- CHL can often be fluctuating, which adds its own challenges for management.

- CHL can also have physical barriers to hearing aid fittings that SNHL does not have (ex. otorrhea).

- Even though sound detection may return to normal, “functional” hearing may remain impaired.
Evidence for Duration of Deficits

- Several types of deficits have been measured in early childhood (~0-30 months) related to recurrent OM, including binaural masking level differences, language comprehension/production, and speech in noise testing (Zumach 2010, Zumach 2009, Moore 1991). **These deficits seem to resolve by school age.**

- However, children in these studies were otherwise typically developing, and did not include children with syndromes associated with chronic eustachian tube dysfunction.
Example: Cleft Palate with fluctuating hearing loss
Example (cont.)
Hearing Device Options

- **Amplification:**
  - **Conventional hearing aids**
  - Bone conduction devices
  - CROS systems

- **Assistive Technology:**
  - Streaming devices
  - FM systems
Conventional Hearing Aids

- How it works: microphone picks up sound, sound is processed in the hearing aid, and sound is delivered to the ear via earmold or slim tip.
- Requires a patent ear canal and pinna.
- For any age
- Preferred option for bilateral permanent hearing loss
Conventional Hearing Aids

- Amplification option for unilateral hearing loss patients
- Must have normal anatomy and some degree “usable hearing”
- Younger children will usually use earmolds
Conventional Hearing Aids

- Conductive hearing loss
  - Not recommended for acute cases of otitis media (i.e. hearing loss expected to improve in a matter of weeks) due to risk of over-amplification
  - Fittings may be complicated by otorrhea or pain
  - Important to keep earmold very clean
  - Important to have an otolaryngologist involved in care when making these recommendations
Hearing Device Options

- Amplification:
  - Conventional hearing aids
  - **Bone conduction devices**
  - CROS systems

- Assistive Technology:
  - Streaming devices
  - FM systems
Traditional Bone Conduction Hearing Aids

- Good option for children with abnormal anatomy or single-sided deafness
- Placed on a sweatband or hard headband
- The oscillator and the microphone are on opposite sides
- For any age
- Good option to overcome fluctuations in hearing related to middle ear dysfunction
Auditory Osseointegrated or Soft Band Processors

- Good option for children with abnormal anatomy or single-sided deafness
- Placed on a softband or metal headband around the head, or may be surgically implanted
- Microphone and oscillator are on the same side
- For any age
Hearing Device Options

- Amplification:
  - Conventional hearing aids
  - Bone conduction devices
  - **CROS systems**

- Assistive Technology:
  - Streaming devices
  - FM systems
CROS Hearing Devices

- Contralateral routing of the signal
- The microphone is on the poorer hearing ear and the signal is wirelessly transmitted to the good ear.
- Requires a pinna and ear canal
- For patients older than 5 years of age
- Ideally worn without earmolds to avoid occluding the better ear
Example: Unilateral profound SNHL
Example: Mild to moderately-severe MHL in right ear
Hearing Device Options

- **Amplification:**
  - Conventional hearing aids
  - Bone conduction devices
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- **Assistive Technology:**
  - FM systems
  - Streaming devices
FM Systems

- Increase the signal-to-noise ratio (SNR).
- The FM system consists of a transmitter, microphone, and receiver.
- The person speaking will wear the transmitter and the child wears the receiver.
- Can be used with a hearing aid or alone.
- Can also be in the form of desktop speaker.
Streaming Devices

• Used for connectivity between hearing aids and audio devices
• Bluetooth enabled, or can be used with audio cable
• Some manufacturers have remote microphone options
• Allows user to listen to audio input wirelessly
AAA Practice Guidelines (2013) recommend the following when monitoring children with hearing loss:

- Electroacoustic verification
- Aided audiogram
- Outcome measures
- Recommendations for assistive technology
Ensuring Audibility

- The Speech Intelligibility Index (SII) is a standardized method of calculating the audibility of a speech signal that can be applied to hearing-aid verification results.
- The SII is an acoustic measure, not a behavioral prediction.
- This means that the SII represents the audibility of speech, and is not a prediction of speech recognition scores.
Example of Electroacoustic Verification and Aided SII
Electroacoustic Verification - which method to use?

- Ching et al (2010): Prescriptive fitting Methods - DSL v4.1 vs. NAL-NL1
  - Laboratory results vs. real world measures
  - Real world measures demonstrate:
    - Preference for soft speech and speech from behind with DSL v4.1
    - More positive feedback about loudness comfort with NAL
    - Significant association between reported preference for NAL-NL1 and lesser degrees of hearing loss
Verification (cont.)

- So what’s the difference?
  - DSL v4.1 prescribed more gain on average (up to 10 dB) than NAL-NL1
  - DSL v4.1 prescribed more low frequency gain than NAL-NL1
    - This explains why background noise can be more noticeable or bothersome for some kids

- Both methods have shortcomings- NAL-NL1 may not provide audibility for soft speech, but DSL v4.1 may not provide listening comfort in all situations
## Solution! DSL v5.0

<table>
<thead>
<tr>
<th>Change Description</th>
<th>Change amount and direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult/acquired versus pediatric/congenital target</td>
<td>7 dB reduction for moderate losses, 3 dB for severe losses.</td>
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<tr>
<td>Interpolation</td>
<td>Greater number of target values across frequencies when working with partial audiograms.</td>
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<tr>
<td>Compression threshold</td>
<td>Less gain and output for low-level inputs due to prescribed compression threshold. Inputs of 70 dB and above are not affected.</td>
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<tr>
<td>Output limiting</td>
<td>Narrowband output limiting targets largely unaffected. Output limiting for speech may cause target reductions of 5 to 10 dB if hearing loss is severe or test level is high.</td>
</tr>
<tr>
<td>Quiet versus noisy environments</td>
<td>Compression threshold raised by 10 dB and gain reduced at low-importance speech frequencies by about 5 dB.</td>
</tr>
<tr>
<td>Binaural fittings</td>
<td>Optional. Will reduce targets for speech by 5 dB. Output limiting targets are not affected.</td>
</tr>
<tr>
<td>Conductive or mixed hearing loss</td>
<td>Increases gain by up to 9 dB for mild losses, 5 dB for severe losses, depending on magnitude of air-bone gap.</td>
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Validation/Outcome Measures

- **Aided audiogram**
  - Should NOT be used for verification of hearing aid programming
  - However, with bone conduction devices may provide some information

- **Speech perception testing**
  - Best indicator of performance
  - Can be completed with single words, sentences, or in noise to determine many facets of child’s performance

- **Questionnaires**
  - For younger children, or to get at issues beyond audibility
  - Rely on parent report for younger children
  - Allows for screening older children for psycho-social issues related to hearing loss
Case Study 1

• Aided Testing:
  • CID W22 words
    • Right: 76%
    • Left: 76%
  • PBK words
    • Right: 92% words, 97% phonemes
    • Left: 88% words, 96% phonemes
  • BKB-SIN: 2.2 SNR loss

9 year old boy. Hearing loss first suspected at age 3, but not confirmed or aided until 6 years old.
Test set-up for bilateral hearing loss
Case Study 2

• Speech-in-Noise Testing:
  (Words- CNC test, Sentences- AzBio)

  • Quiet:
    • 99-100% words, phonemes, and sentences
  • Noise (+5 SNR) without FM system
    • 16% words and 44% phonemes
    • Sentences- 74% correct
  • Noise (+5 SNR) with FM system
    • 98-100% words, phonemes, sentences

11 year old girl. Congenital left-sided microtia and atresia.
Test set-up for unilateral hearing loss

Speech (toward poor ear)

Noise (toward better ear)
Case Study 3

27 month old boy. Hearing loss diagnosed at birth, aided by age 2 months.

• Aided Testing at age 27 months:
  • Ling 6 sound detection-
    • RIGHT: /a,i,u,m,s/ at 25 dB HL, /sh/ at 30 dB HL
    • LEFT: /a,i,u,m,s,sh/ at 25 dB HL
  • Questionnaire: MedEl LittlEars
    • Age 8 months- 15/35
    • Age 13 months- 23/35
    • Age 27 months- 31/35
Aural Habilitation

- The goal of aural habilitation (AH) therapy includes helping a child:
  - Make sense of sound
  - Develop language skills through listening
  - Improve their speech production

- Aural Habilitation vs. speech therapy
  - Both therapies are for children with speech and language delays or who are at risk for delays
  - A child without hearing loss may have speech errors that are developmental. They may benefit from speech therapy.
  - A child who has speech errors related to their hearing loss may benefit from AH.

Communication Strategies
Communication Strategies

- Strategies for home with younger children
  - Use clear speech
  - Even rate and do not dramatically slow down
  - Do not speak LOUDER- this distorts your speech
  - Create a language rich environment at home
  - Reduce background noise at home- think about the unnecessary white noise
  - Keep your hands away from your face

- Enjoy communicating with your child!

Communication Strategies

- Strategies for school
  - Explain to teachers the importance of facial cues and getting child’s attention first
  - Visual cues (use of white boards or overhead projector)
  - Environment modification
    - Preferential seating
    - Reduce background noise
    - Soften surfaces
  - Context- ex. written plan for school day
  - Have all school personnel aware of hearing loss if they interact with the child
Questions?

Thank you!
References

- Aural Habilitation Therapy. Seattle Children’s Hospital Patient and Family Education, 2013
- www.asha.org/SIG/09/