Assessment of Peripheral and Central Auditory Function

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Grand Rounds Presentation
February 11, 2004
Auditory Function

- Complex auditory pathway
- Peripheral Auditory Assessment
  - Basic armament of the otolaryngologist
- Central Auditory Assessment
  - Relatively new interest
  - Multidisciplinary
Ossicular Amplification
Anatomy
Tonotopic organization
Anatomy
Peripheral Auditory Assessment

- Pure Tone Audiometry
- Speech Audiometry
- Acoustic Immittance
- Auditory Brainstem Responses
- Electrocochleography
- Otoacoustic Emissions
Pure Tone Audiometry

- Most common
- Pure tones (sinusoids) are tonotopically maintained by the cochlea.
- Air conduction testing
  - Octave frequencies
  - Interoctave frequencies
- Bone conduction testing
Pure tone audiometry
Decibel Scale

- **Audiologic units**
  - dB SPL: sound pressure level
  - dB HL: hearing level
  - dB SL: sensation level

- **Audiometric 0**

- dB = $10 \log 10$
Frequency Sensitivity

- Human hearing spectrum from 20-20,000Hz.
- Differentially sensitive
  - 125Hz: 45dB
  - 1000Hz: 6.5dB
  - 10,000Hz: 20dB
Audiogram Levels

- **Normal**
  - 0 - 20 dB

- **Mild**
  - 20 - 40 dB

- **Moderate**
  - 40 - 60 dB

- **Severe**
  - > 60 dB
Audiogram - Speech Banana
Crossover

- Audiometric results are only valid when the results are actually of the test ear.
- Interaural attenuation reflects crossover.
- Air conduction from 40-80dB
- Bone conduction even at 0dB
Masking

- The audiometric technique used to eliminate responses by the non-test ear.

- An appropriate noise is presented to the non-test ear while the test ear is being tested.

- Masking level must exceed the non-test ear threshold, but not create crossover.
Speech Audiometry

- Determines how well a person hears and understands speech.
- Spondee words
- SRT
- SRT should be in close correlation with PTA.
Speech Audiometry

- Word recognition scoring %
- 20-50 Phonetically balanced words
- Conductive hearing loss
  - Excellent WRS
- Sensorineural hearing loss
  - Poor WRS
- Rollover
Rollover

- Code intensity of neural discharges usually occurs by 3 mechanisms:
  - Pure monotonic
    - - - - - - - - - - - - - - -
  - Monotonic at low intensity
    - - - - - - - - - - - - - - -
  - Monotonic with reversal at increasing frequency
    - - - - - - - - - - - - - - -
# Auditory behavior index for infants

<table>
<thead>
<tr>
<th>Age</th>
<th>Noisemakers (Approx. SPL)</th>
<th>Warbled Pure Tones (Re: dB HL)</th>
<th>Speech (Re: dB HL)</th>
<th>Expected Response</th>
<th>Startle to Speech (Re: dB HL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–6 wk</td>
<td>50–70 dB</td>
<td>78 dB</td>
<td>40–60 dB</td>
<td>Eye-widening, eye-blink, stirring or arousal from sleep, startle</td>
<td>65 dB</td>
</tr>
<tr>
<td>6 wk–4 mo</td>
<td>50–60 dB</td>
<td>70 dB</td>
<td>47 dB</td>
<td>Eye-widening, eye-shift, eye-blinking, quieting; beginning rudimentary head turn by 4 mo</td>
<td>65 dB</td>
</tr>
<tr>
<td>4–7 mo</td>
<td>40–50 dB</td>
<td>51 dB</td>
<td>21 dB</td>
<td>Head-turn on lateral plane toward sound; listening attitude</td>
<td>65 dB</td>
</tr>
<tr>
<td>7–9 mo</td>
<td>30–40 dB</td>
<td>45 dB</td>
<td>15 dB</td>
<td>Direct localization of sounds to side, indirectly below ear level</td>
<td>65 dB</td>
</tr>
<tr>
<td>9–13 mo</td>
<td>25–35 dB</td>
<td>38 dB</td>
<td>8 dB</td>
<td>Direct localization of sounds to side, directly below, ear level, indirectly above ear level</td>
<td>65 dB</td>
</tr>
<tr>
<td>13–16 mo</td>
<td>25–30 dB</td>
<td>32 dB</td>
<td>5 dB</td>
<td>Direct localization of sound on side, above and below</td>
<td>65 dB</td>
</tr>
<tr>
<td>16–21 mo</td>
<td>25 dB</td>
<td>25 dB</td>
<td>5 dB</td>
<td>Direct localization of sound on side, above and below</td>
<td>65 dB</td>
</tr>
<tr>
<td>21–24 mo</td>
<td>25 dB</td>
<td>26 dB</td>
<td>3 dB</td>
<td>Direct localization of sound on side, above and below</td>
<td>65 dB</td>
</tr>
</tbody>
</table>
Acoustic Immittance

- Impedance: resistance to acoustic flow
- Admittance: ease of acoustic flow
- Tested by:
  - Tympanometry
  - Acoustic Stapedial Reflex
Stiffness vs. Mass
Acoustic Stapedial Reflex

- Lowest intensity required to elicit a stapedial muscle contraction.

- 3 primary acoustic reflex characteristics
  - Presence or absence of the reflex
  - Reflex threshold
  - Reflex Decay
Acoustic Reflex Decay

- Measures the ability of the stapedius muscle to maintain sustained contraction.
- Lower frequency tone/noise for 10 seconds
Acoustic Reflex in Cochlear Disorders

- Primarily determined by the degree of hearing loss.
- Less than 50dB: normal
- Between 50-80dB: proportionally elevated
- Greater than 50dB: absent
Acoustic Reflex
Tone vs. Noise

- Broadband Noise usually has 20-25dB lower thresholds than the reflex thresholds for tones.
- Physiologically not possible to have behavioral thresholds higher than acoustic reflex thresholds for tones. (malingersers)
Facial Paralysis

- Absent or abnormal stapedial reflex when the recording probe is ipsilateral to the side of the lesion.

- Can also be helpful in locating lesions proximal or distal to the stapedial muscle.
Eighth nerve lesions

- Absent reflexes when stimuli is presented to the affected ear.
- Reflexes in eighth nerve lesions are not dependent on the degree of hearing loss.
- Rapid reflex decay
Auditory Brainstem Responses

- Impulses that are generated by the auditory neural pathway that can be recorded on the scalp.
- Not a direct measure of hearing.
- Detected as early as 25wks gestation.
- Not affected by sleep, sedation, or attention.
Click or Transient Evoked ABR

- Most widely used
- Moderate intensity levels with resultant firing of a wide range of neural frequency units.
- Repeatable Wave V to within 10dB of behavioral responses.
- Limited by frequency specificity
Tone Burst ABR

- More accurate results than click-evoked ABR
- Increased latency periods than click-evoked.
Bone Conduction ABR

- As reliable and repeatable as air conduction ABR.
- Particularly useful in structural abnormalities
  - Canal Atresia or stenosis
Primary goal is a clear and reliable Wave I

- Wave I: distal 8th nerve
- Wave II: proximal 8th nerve
- Wave III: cochlear nuclei
- Wave IV: SOC
- Wave V: Lateral Lemniscus
ABR
ABR

Infant vs Adult

- Less waveform morphology
- Increased absolute and interwave latencies
- Should correct by 18-24 months of age.
Electrocochleography

EcoG

- Measures stimulus related potentials of the most peripheral portions of the auditory system.

- 3 major components:
  - Cochlear microphonic
  - Summating potential
  - Action potential
EcoG
Electrode placement

- Noninvasive
  - Ear canal
    - >50%
  - Tympanic membrane
    - >40%

- Invasive
  - Transtympanic
    - >30%
EcoG
Meniere’s disease
Otoacoustic Emissions

- Low energy sounds produced by the cochlear outer hair cells.
- Cochlear amplification.
- Spontaneous emissions
  - Not present in greater than 25dB hearing loss.
- Evoked Emissions
  - Transient evoked
  - Distorted Product
TEOAE

- Transient stimuli, clicks, evoke emissions from a large portion of the cochlea.
- Generally present when hearing thresholds are below 35dB.

Advantages
- Reliable separate normal from abnormal at 20-30dB
- Fast

Disadvantages
- Poor at higher frequencies
DPOAE

- DP are additional tones that are created when two tones are presented. f1 and f2
- DP occurs at 2(f1-f2) by a nonlinear process.
- Generally present when hearing thresholds are below 50dB.
- Advantage is higher frequency (6000Hz)
OAE

Right Ear

Response Waveform

Reproducibility = 86%

Left ear

Response Waveform

Reproducibility = 40%
OAE and middle ear pathology

- Transmission properties of the middle ear directly influence the OAE characteristics.
  - Otitis media
  - Newborns
  - Tympanic membrane perforations
Central Auditory Processing

- No accepted definition of CAP.
- Task Force on CAP consensus and development
  - Sound localization
  - Auditory discrimination
  - Auditory pattern recognition
  - Temporal aspects of audition
  - Auditory performance decrements with competing and degraded acoustic signals.
CAPD Categories

- Decoding
- Tolerance Fading Memory
- Integration
- Organization
Buffalo Model

- Takes into account the classification of CAPD as well as speech and language evaluation and academic characteristics.

- CAP battery
  - Staggered Spondaic Word (SSW) test
  - Phonemic Synthesis (PS) test
  - Speech-in-Noise (SN) test
  - Masking Level Difference (MLD) test
Decoding Category

- Most common (50%)
- Breakdown of auditory processing at the phonemic level.
- Difficulty reading and speaking & Articulation Errors “r” & “l”
- Posterior temporal lobe
Decoding category

- Management strategies center on improving phonemic and metaphonemical skills.
  - Hooked on Phonics and Phonemic Synthesis Skills program
  - Clear and concise instructions
  - Outlining objectives
  - Written instructions
Tolerance-fading memory category

- Second most common (20%)
- Poor auditory memory and difficulty understanding speech in adverse conditions.
- Deficits in expressive language and writing.
- Impulsive responders, short attention spans.
- Auditory continuous performance test can screen for ADHD.
- Linked to Broca’s area of the inferior frontal lobe.
Tolerance-fading memory

- Management focuses on improving the signal to noise ratio and strengthening short term memory skills.
- FM system is beneficial.
- Noise desensitization.
- Earplugs and quiet study areas.
Integration category

- Difficulty integrating auditory information with visual and nonverbal aspects of speech.
- Deficits of the corpus callosum and angular gyrus.
- Dyslexics and poor reader

Management

- Improving signal to noise ratio
- Structured phonetically based reading exercises
Organizational category

- Least common category.
- Characterized by reversals and sequencing errors.
- Individuals are often disorganized at school and at home.

Management

- Improving sequencing skills and organizational habits.
- Consistent routines, checklists, calendars.
CAPD

- Multidisciplinary approach
  - Otologist
  - Speech Pathologist
  - Audiologist
  - Schools
Conclusion

- Peripheral Assessment
  - Measures of objective hearing
  - Measures of physiologic hearing
- Central Assessment
Bibliography

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