Hearing Impairment in Infant & Children-Assessment, Screening and Early Diagnosis

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Hearing Impairment in Children

• Often a silent disability
• Recognition delayed often till 1-2 years
• Children with
  - normal hearing and no other developmental problems
  - Essential components of language are developed by 3-4 years
Need to screen newborn babies for hearing

AAP

Significant hearing loss is one of the most common major abnormalities present at birth and if undetected will impede speech, language and cognitive development.
Failure of Early identification

Early auditory deprivation

Interferes with development of neural structures necessary for hearing

Significant hearing loss: Interferes with development of Phonological & speech perception

Required for language learning

Poor academic performance
Advantages of Early identification

- Infants who receive early amplification and comprehensive rehabilitation
  - Improved speech & language skills
  - School achievement
  - Self Esteem
  - Psychological adaptation

- When compared to those who do not receive amplification until 2-3 yrs of age
JCIH : Joint committee on Infant Hearing 1990

• Goal
  – Identify & initiate treatment by 6 month

• Screening all: May not be Cost Effective

• Screening only high risk neonates
  – Misses 50% with severe to profound hearing loss
Conclusions

1. All infants admitted in NICU be screened prior to discharge
2. Universal screening for all infants within 1st 3 months of life
3. Preferred model for screening: OAE, followed by ABR; if OAE fail
What Tests to use for Screening

“Test Battery Approach”

– Single test is insufficient for complete information

- To detect type of hearing loss
- Percentage of hearing loss
- Appropriate remedial procedures
Anatomy of the ear and sound transmission
Tests Available

- Behavioral Observation Audiometry (BOA)
- Otoacoustic emissions (OAE)
- Impedance Audiometry (Tympanometry)
- Pure tone audiometry (PTA)
- ABR or BERA (Brain Stem Evoked Audiometry)
- ASSR (Auditory Steady State Response)
BOA (Behavioral Observation Audiometry)

- Reasonable test to screen
- Does not specify accurate degree of hearing loss or site of lesion
- Requires skilled personnel, time consuming
- Highly subjective test
- Co-operation of the child
- Most difficult in developmentally slow infants
- Intervention and rehabilitation may be delayed
BOA

• **Informal**
  - Sound is presented behind the baby at ear level at 3 feet distance.
  - Child is engaged in activity
  - Response is observed.

• **Formal**
  - Two room situation
  - Specific intensity, Masking Noise, speech stimulus
  - Variable intensity
## Auditory Behavior Index for Infants: Stimulus & Level of Response

<table>
<thead>
<tr>
<th>Age</th>
<th>Warbled Pure Tones</th>
<th>Expected Response</th>
<th>Startle to Speech</th>
</tr>
</thead>
<tbody>
<tr>
<td>06 wk</td>
<td>78 dB</td>
<td>Eye-widening, eye-blink, Awakening, Startle</td>
<td>65 dB</td>
</tr>
<tr>
<td>6 wk-4Mo</td>
<td>70 dB</td>
<td>Eye-widening, eye-blink, CRMM</td>
<td>65 dB</td>
</tr>
<tr>
<td>7-9 Mo</td>
<td>30-40 dB</td>
<td>Localization of sounds</td>
<td>65 dB</td>
</tr>
<tr>
<td>9-13 Mo</td>
<td>25-35 dB</td>
<td>Localization of sounds</td>
<td>65 dB</td>
</tr>
</tbody>
</table>
ELECTROPHYSIOLOGY
Electrophysiology is the study of electrical phenomena associated with a physiological process such as hearing.
What are Otoacoustic Emissions?

• **OTO** = EAR
• **ACOUSTIC** = SOUND
• **EMISSION** = COMING OUT
Mechanism for OAEs
Important facts about OAEs:

- The presence of evoked OAEs is a powerful indicator of normal cochlear function.
- 90-98% of normally hearing ears produce OAEs.
- Robust OAE-Newborn (2-days).
- Infants – reduced.
- Achieved Adult value - 2 Yrs.
- Detects cochlear dysfunction.
OAE

- Objective measurement
- Non-invasive
- Sensitive
- Very less time consuming (1-2 min)
- Conducted at Bed-site/Nursery
- TOAE – Choice for hearing screening
- DPOAE - Highly diagnostic test
Transient Evoked

Evoked using a transient signal (click or gated tone pip) & the responses collected after stimulation sequence
Distortion product

Evoked with 2 pure tones of different frequency & the response recorded simultaneously with the stimulation sequence
Clinical Applications

*When OHC are structurally damaged or non-functional OAEs cannot be evoked

*OAEs are absent in the presence of conductive and/or significant sensorineural hearing loss (>~30dB HL)
Impedance audiometry

- Highly diagnostic test
- For Middle ear pathology
- Depicts the movement of the Tympanic Membrane
- Type of Curve”A” : Normal – suggestive of normal structure & function
- Type of Curve”B” : Flat Curve – suggestive of SOM/Blue Ear
- Type of Curve”C” : Negative peak-suggestive of onset of Otitis Media or resolving OM
Impedance audiometry
Pure Tone audiometry

- Measurement of pure tone on individual frequency in dB.
- Sound is presented through headphones.
- Child is conditioned to respond to sound by pitting the pebble down.
- Audiogram is plotted.
- Type & Percentage of the hearing loss is measured.
Pure Tone audiometry
Auditory Brainstem Response (ABR)
The Auditory System

Combined Wave From All Sites
Stimulus is a Click Event

ECochG
ABR
SSEP
Time (ms)
Combined Wave From All Sites
Stimulus is a Click Event

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Generators of the ABR

- Medial geniculate body
- Inferior colliculus
- Lateral lemniscus
- Superior & accessory olive area
- Dorsal cochlear nucleus
- Ventral cochlear nucleus
- Auditory cortex
- VIIIth nerve

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ABR

• ABR is a test of the VIII Nerve integrity
• Hearing test - to estimate hearing thresholds especially in hearing impaired
• Uses acoustic stimuli (click)
• Measures the response at different points along the auditory nerve using an Evoked Potential Machine (Averager)
• Electrodes placed at appropriate points on the scalp.
• The test is performed under sedation
• Age – no bar
• Time – 20 min
• Results are reported on the basis of intensity level at which peak :V: is detected
• Latencies of peak 1,3,5
• Latencies vary depending upon the age
ABR Equipment

Monitor

Head-box (incl. electrodes and leads)

Amplifier

Signal Processing Unit

Printer

CPS and speech processor for stimulation
DISCREPANCIES IN ABR RESULTS...

Depending on-

• Placement of Electrodes and type of transducers
• Artifacts due to electrical interference
• Parameters used for testing (type of stimulus, no of sweeps, artifact rejection rate, electrode montage etc)
• Clinical skills and experience of the tester (ability to identify the waves correctly)
Advanced Physiological Test

Response is sinusoidal wave – No need to identify peaks.

Software automatically detects response

And also generates an AUDIOGRAM !!!
Multi-frequency ASSR

- Earlier testing at each frequency done one at a time.
- Time consuming
- New systems capable of measurement of responses
  - From both ears
  - At 4 different frequencies SIMULTANEOUSLY!! : - )
ASSR - Stimulus and Response

**Stimulus Waveform**
- 1000 Hz with
- 100 Hz Amplitude
- Modulation

**Effective Frequencies**
- 900 Hz
- 1000 Hz
- 1100 Hz

**Evoked Response**
- same frequency as the modulation frequency

- **t(ms)**
  - 30
  - 20
  - 10

**Stimulus Waveform**
- 1000 Hz with
- 100 Hz Amplitude

**Modulation**
- ASSR - Stimulus and Response
- CF (CF-MF) (CF+MF)
- Frequency
- **t(ms)**
  - 10
  - 20
  - 30

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Audiogram Generation

ASSR Response Audiogram:
Name: ASSR (DEMO0015-2002BB01)
Date: Nov. 11, 2002

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Print | OK

HL Correction:
- None - SPL
- General Table
- General Regression

Name: ASSR, Easy (DEMO0015-2002BB01)
Date: Nov. 11, 2002
Right 500 Hz  0 dB SPL No Response  File: EABD0A.1
Right 1000 Hz  0 dB SPL Response  File: EABD0A.1
Right 2000 Hz  0 dB SPL No Response  File: EABD0A.1
Right 4000 Hz  0 dB SPL No Response  File: EABD0A.1
Left  500 Hz  0 dB SPL No Response  File: EABD0A.1
ASSR Threshold vs Behavioural Threshold

Hearing Threshold (dBHL)

Frequency (Hz)

-10 0 10 20 30 40 50 60 70 80 90 100 110

125 250 500 1000 2000 4000

- Behavioural thresholds
- ASSR estimated thresholds

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ASSR Test Equipment

Figure 1: The principal components of the ERA System when in use.

1. PC running ERA System software under Microsoft Windows.
2. Serial cable. The ERA System Unit is connected to the PC via the serial port. This avoids the need for plug-in cards, and enables the use of most PC compatible computers.
3. ERA System Unit. This generates the stimulus and analyses the subject's response.
4. Fibre-optic cable. This ensures that the subject is isolated from main's power voltages.
5. EEG amplifier. This battery powered unit captures and amplifies subject EEG response.
6. Tubephones.
• EABR is analogous to the ABR response, but is evoked using electrical stimulation to auditory nerve
• Assess the central processing
Our Experiences and Achievements in this field....

*Clinic Equipped with latest state-of-the-art high quality diagnostic Instruments

*Diagnosed more than 2500 children and infants for advanced audiological tests

*Running WHO project for hearing screening for RML Hospital

*Running OAE screening in high-risk babies in Sir Ganga Ram Hospital

*Selected for Cochlear Implant rehabilitation by SGRH, RML, R&R Hospital, AIIMS

*Extended rehabilitation services to areas like – Assam, Agra, Kanpur, Panipat, Chandigarh, Haryana,
Result of Early Diagnosis

Miraculous change from a silent world to lively & musical world !!!