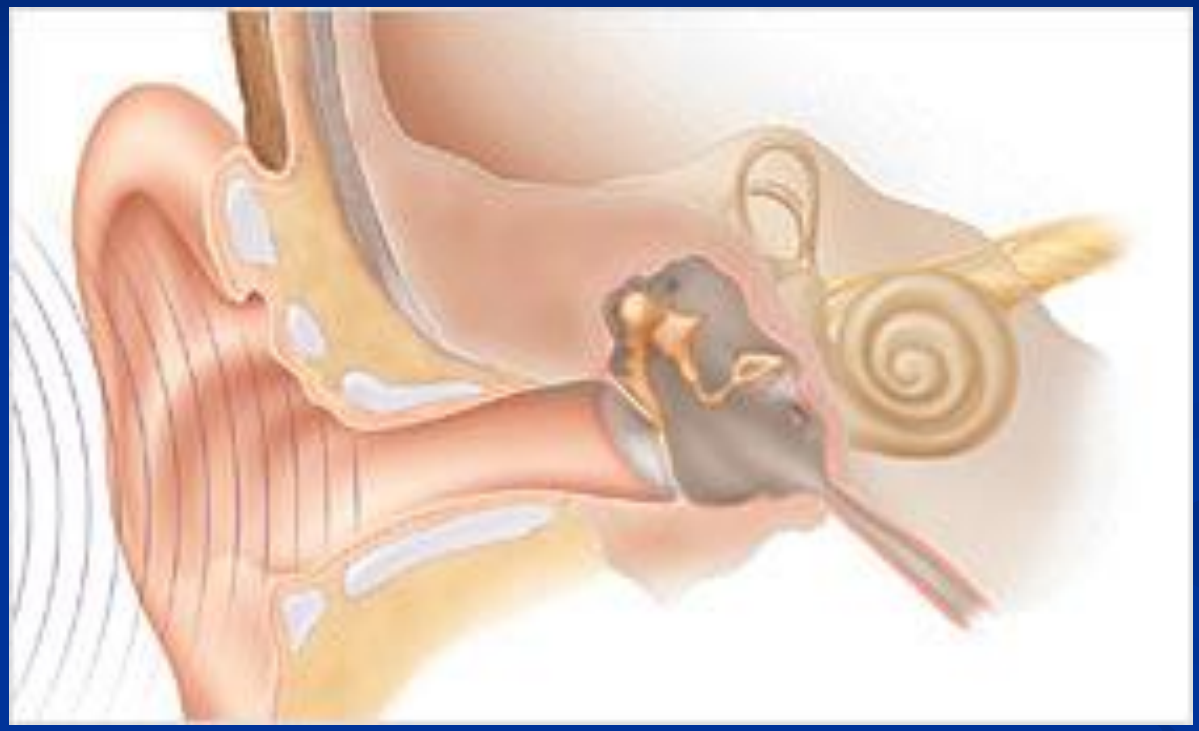
# Basic Diagnostic Evaluation: Audiology

Steve Bowditch, MS, CCC-A
Audiologist
Dept. of Otolaryngology
Johns Hopkins Hospital

# Parts of the Ear: Basic Anatomy

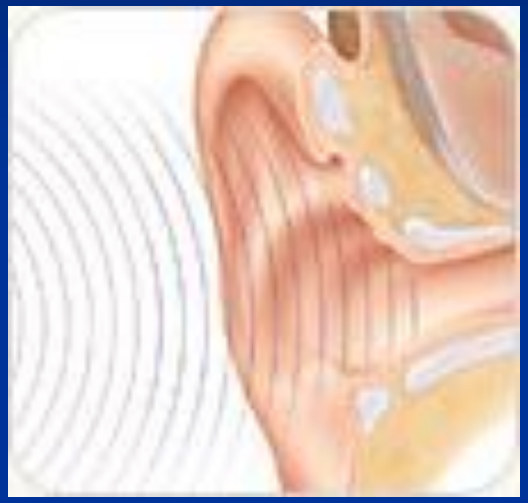


Outer Ear

Middle Ear

Inner Ear

# Outer Ear



- Funnels Sound into the Head
- Wax Glands
- Don’t use Q-Tips!

# Middle Ear

- Ear Drum, Malleus, Incus, Stapes and Stapedius Muscle
- Transforms sound waves into mechanical energy
- Site of ear infections, perforations and certain growths

# Inner Ear

- Cochlea (balance and hearing sections), 8th Nerve
- Transforms mechanical energy into electrical stimulation of nerve
- Most common site of hearing loss

# Types of Hearing Loss

| Type of Loss | Site of Lesion |
| --- | --- |
| Conductive | Outer and Middle Ear |
| Sensorineural | Inner Ear |
| Other | 8th Nerve or Auditory Cortex |

# Test Types

- **Objective:** Tests which measure a physical characteristic of the ear, requiring no active participation from the patient.

- **Subjective:** Tests which measure an aspect of hearing requiring active participation from the patient.

# Basic Audiological Test Battery

- Otoscopy
- Tympanogram
- Acoustic Reflex
- Audiogram
- Speech Testing
- Otoacoustic Emissions (OAE)
- Auditory Brainstem Response (ABR, BAER, AEP)

# “Special” Audiological Test Battery

- Electrocochleography (ECochG)
- Central Auditory Testing (CAPD)
- Tinnitus Testing
- Other Evoked Potentials (MMN, P300)

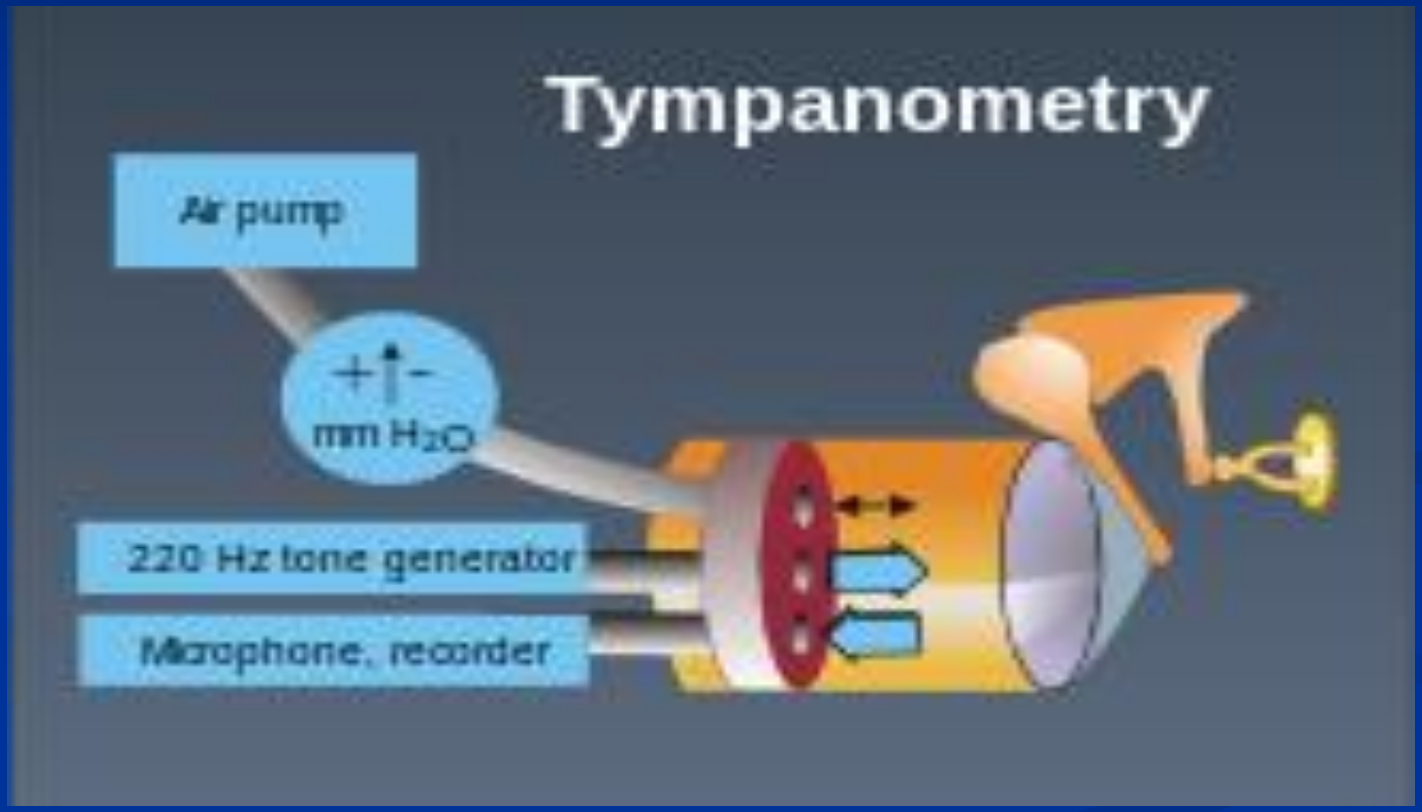
# Otoscopy

- Part of Ear:  Outer
- Type of HL: Conductive
- Type of Test: Objective

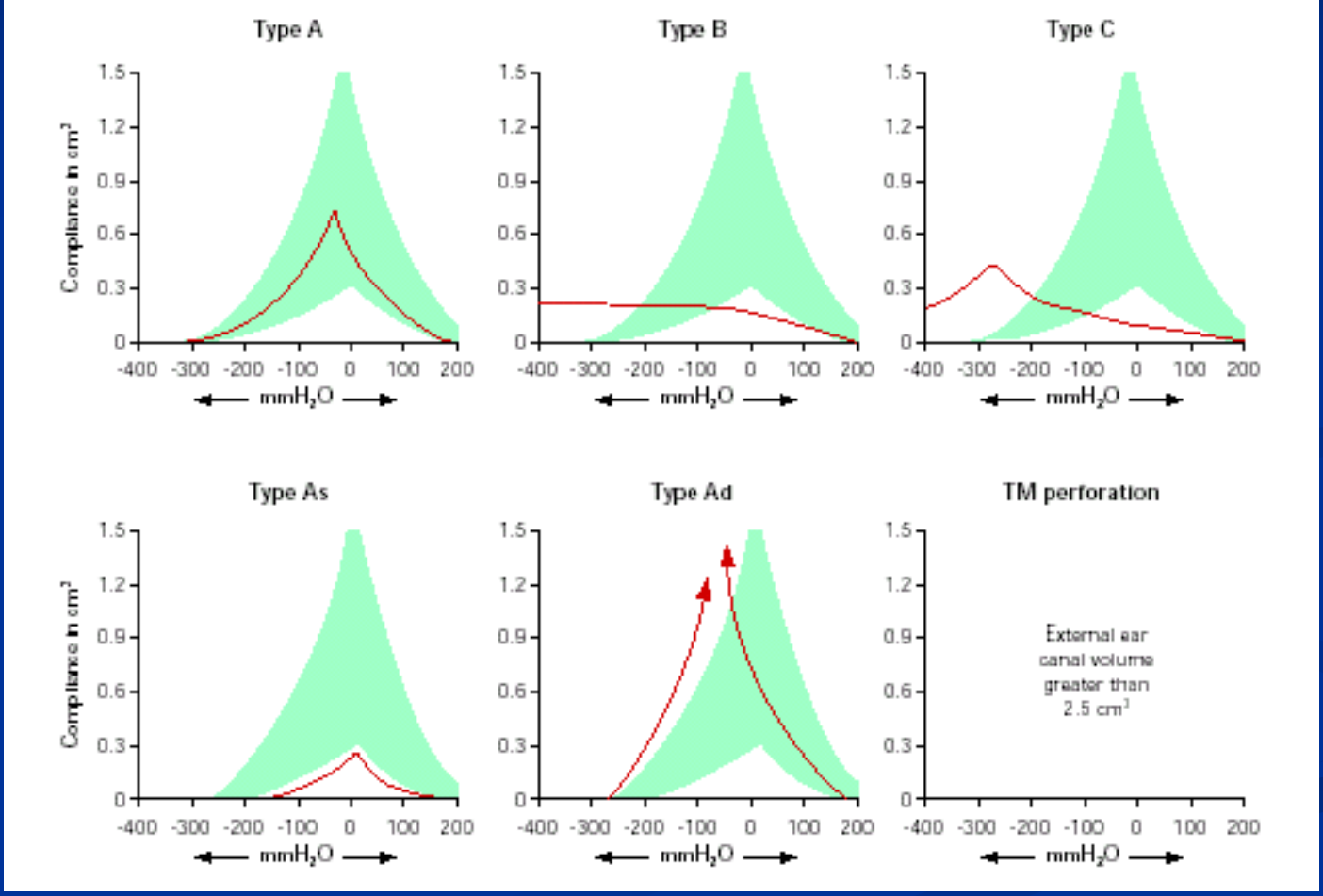
# Tympanogram

- Part of Ear:  Middle
- Type of HL: Conductive
- Type of Test: Objective
- Description: Measures the movement of the eardrum.

# Tympanogram schematic



# Tympanogram cont'd



# Acoustic Reflex

- Part of Ear:  Middle/Inner/lower Brainstem
- Type of HL: Conductive/Sensorineural
- Type of Test: Objective
- Description: Measures the contraction of the stapedius muscle in response to loud sounds via movement of the eardrum.

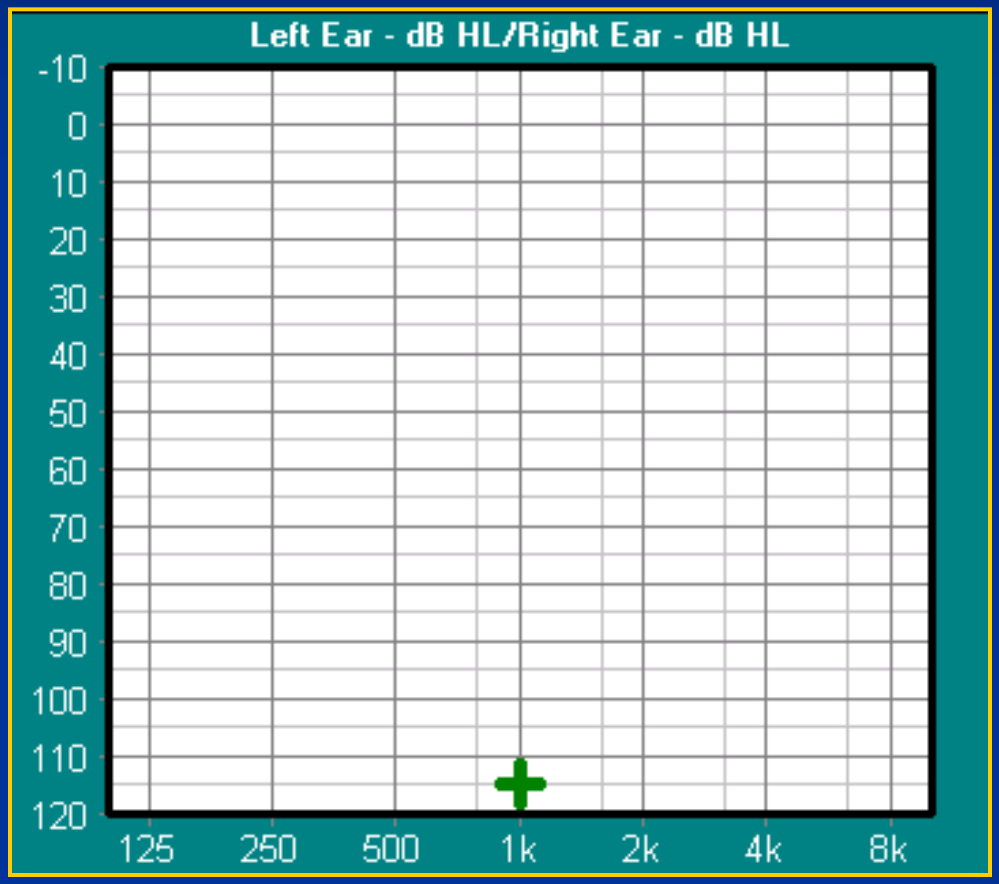
# Acoustic Reflex cont'd

- In response to loud sounds, the stapedius muscle contracts, pulling back on the middle ear bones and subsequently the eardrum.
- Measured as a reduction of middle ear compliance.

# Audiogram

- Part of Ear:  Outer/Middle/Inner
- Type of HL: Conductive and Sensorineural
- Type of Test: Subjective
- Description: Plots hearing loss as a function of volume and frequency.

# The Audiogram



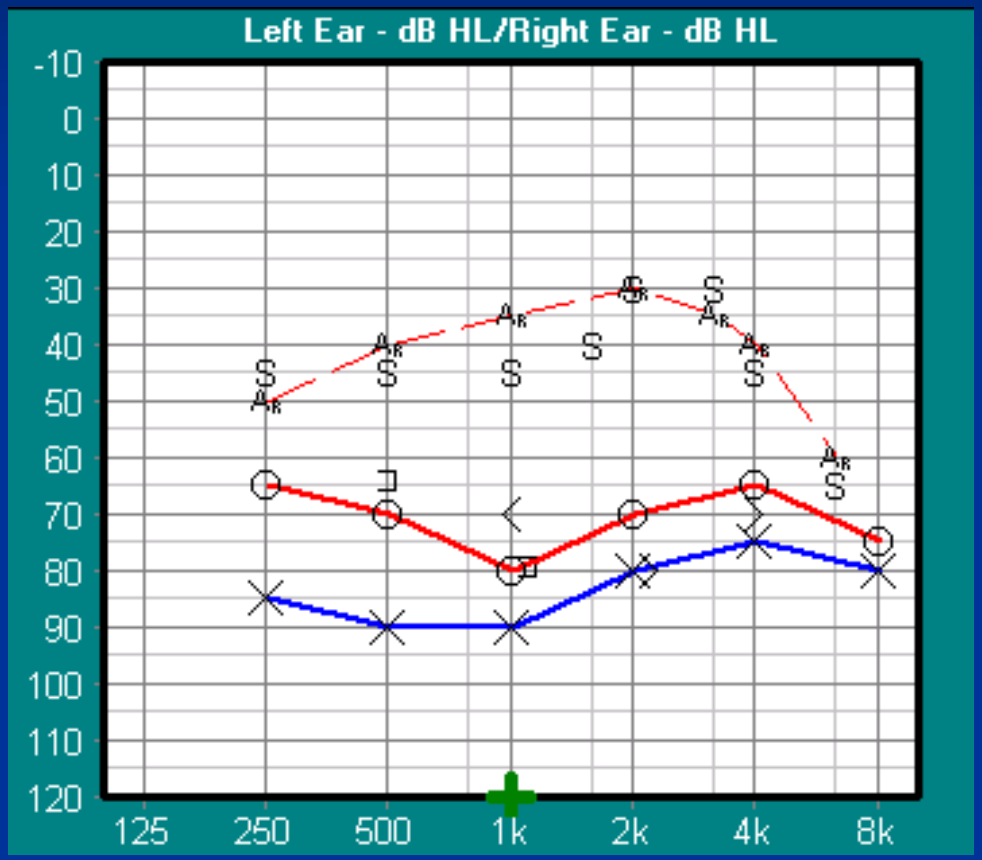

Frequency (in Hertz)

- Standard octaves 250, 500, 1000, 2000, 4000, 8000 Hz

Intensity (in Decibels)

- Test range from -10 to 120 dB HL

# Audiometric Symbols



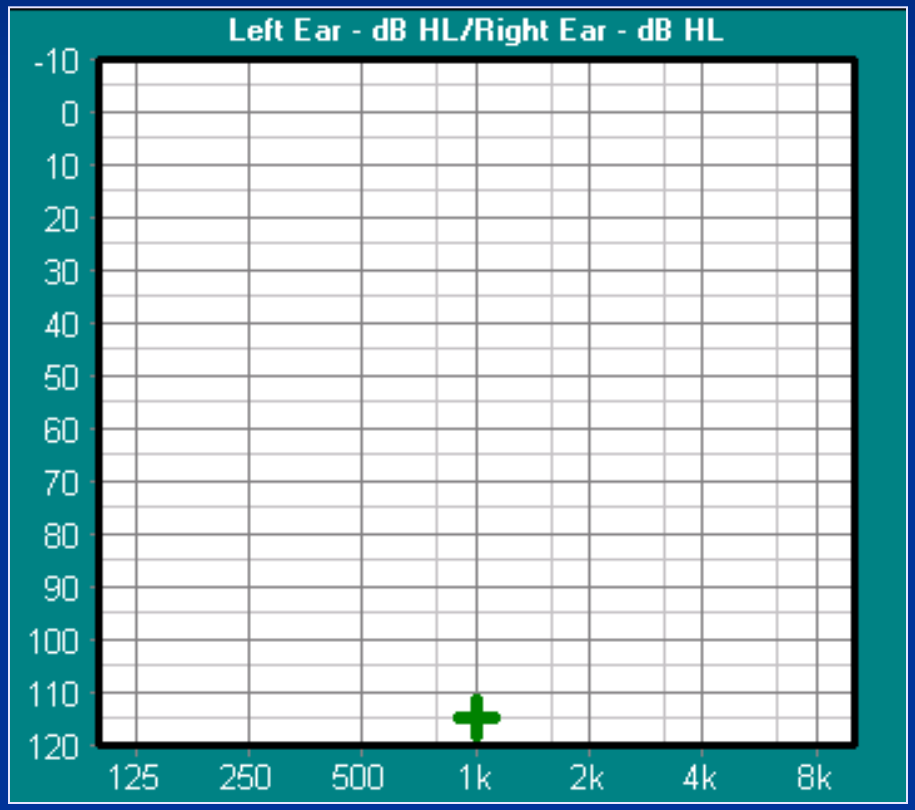

**Legend**

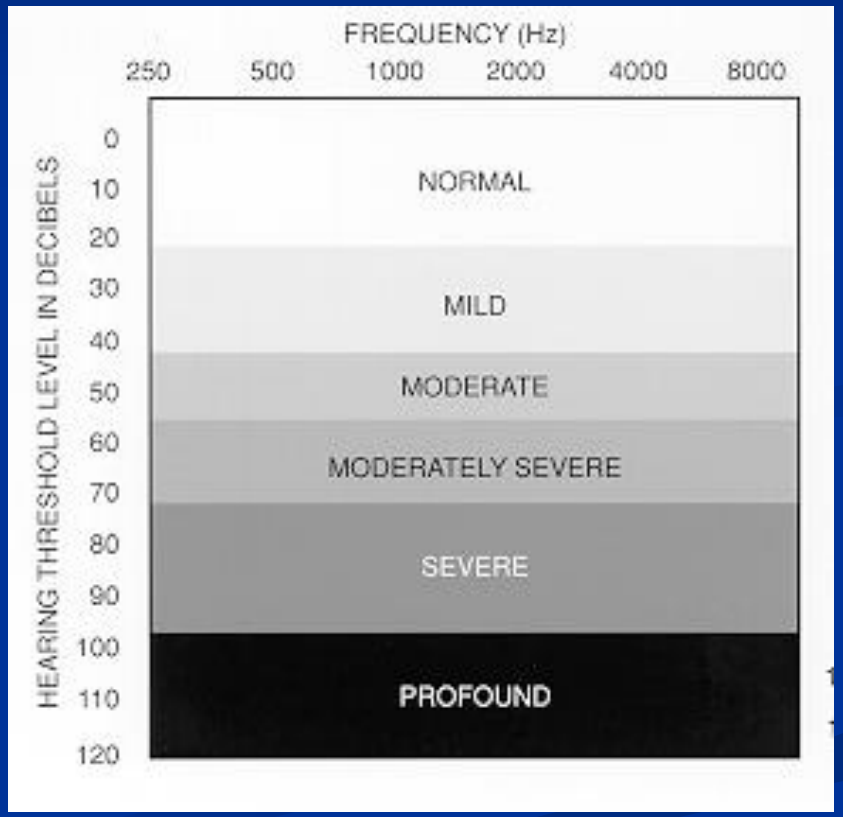
| | Right Ear | Left Ear |
|---|---|---|
| Air Conduction | O | X |
| with Masking | △ | □ |
| Bone Conduction | < | > |
| with Masking | [ | ] |
| No Response | ↙ | ↘ |

Soundfield **S**

Aided Soundfield **A**

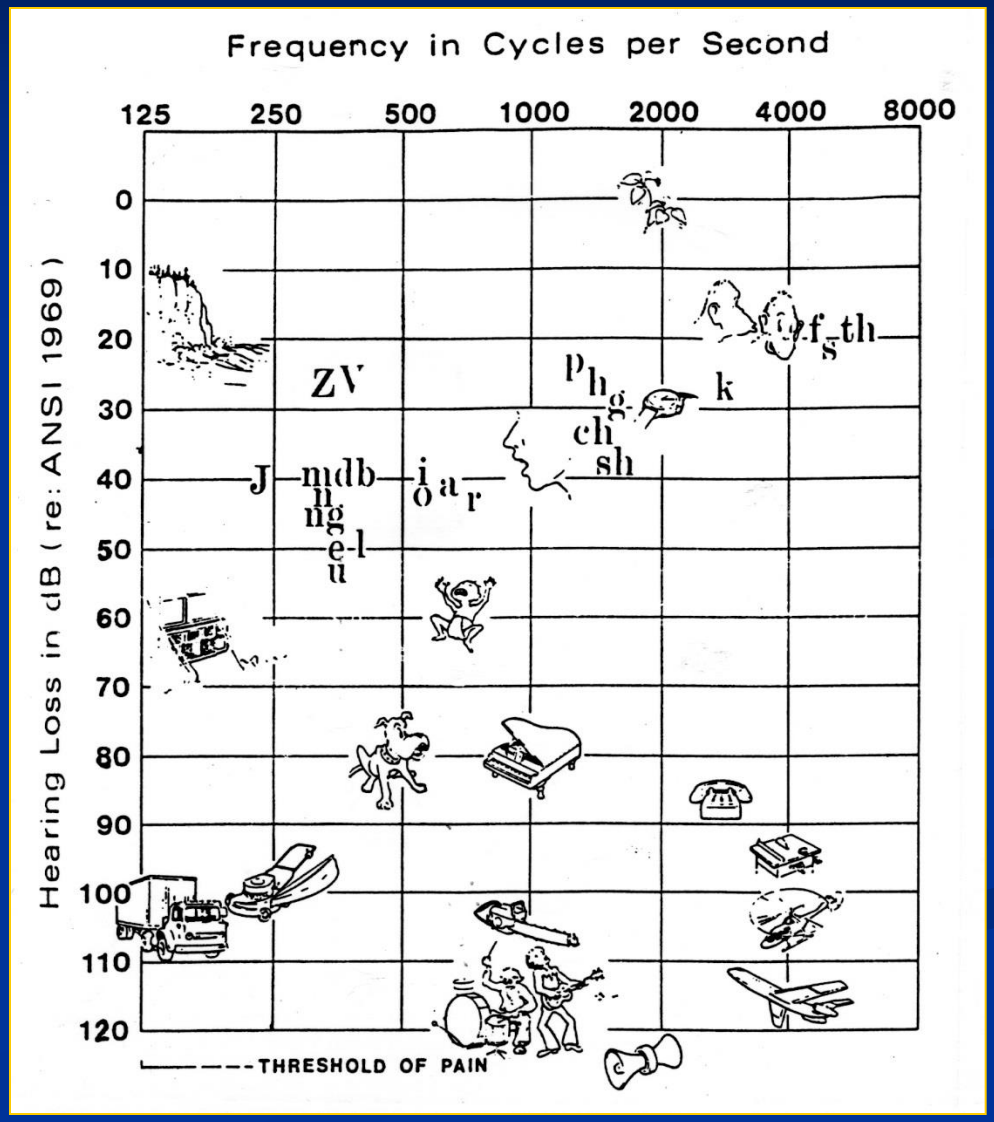
# Audiogram cont'd



# Familiar Sounds

| | |
|---|---|
| Jet Takeoff (25 M) | 150 dB |
| Aircraft Carrier Deck | 140 dB |
| Jet Takeoff (100 M) | 130 dB |
| Live Rock Music | 120 dB |
| Power Saw | 110 dB |
| Lawn Mower | 100 dB |
| Food Blender | 90 dB |
| Garbage Disposal | 80 dB |
| Telephone dial tone | 70 dB |
| Normal Conversation | 60 dB |
| Quiet Conversation | 50 dB |
| Library | 40 dB |
| Quiet Living Room | 30 dB |
| Whisper, rustling leaves | 20 dB |
| Breathing | 10 dB |
| Weakest sound heard | 0 dB |

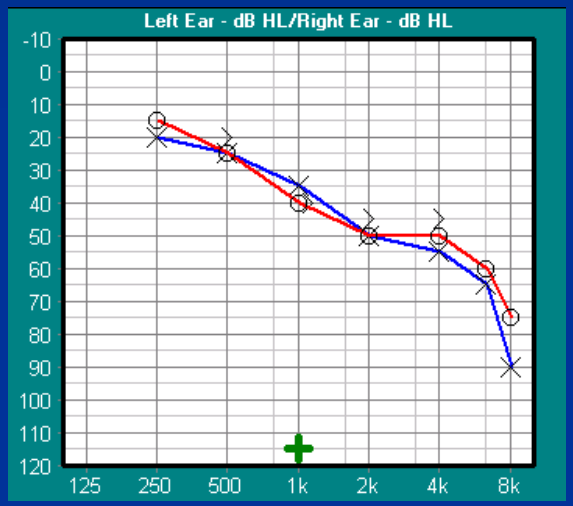


# Interlude: Air vs. Bone

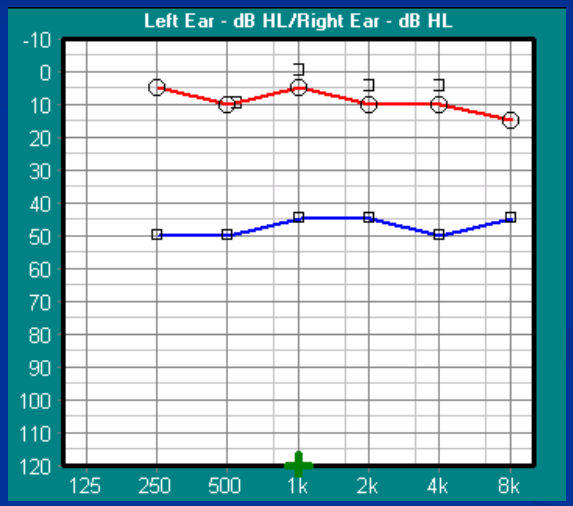
There are two ways to get sound to the inner ear. **Air conduction** pathways follow the normal anatomical pathways (outer ear, middle ear, inner ear). **Bone conduction** pathways have the vibration being transmitted through the skull to the inner ear directly.

# Audiogram cont'd

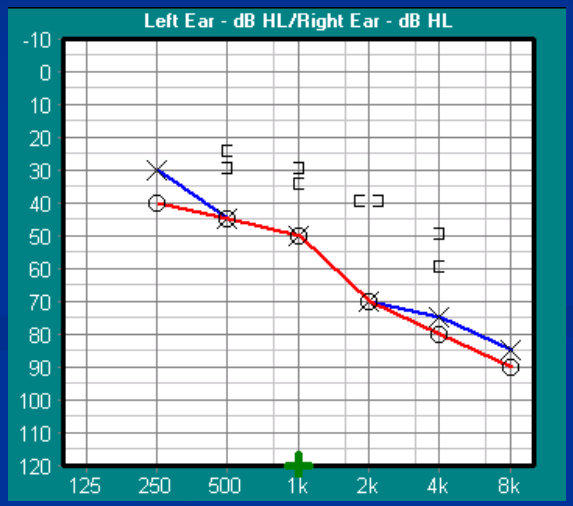
Sensorineural




Conductive

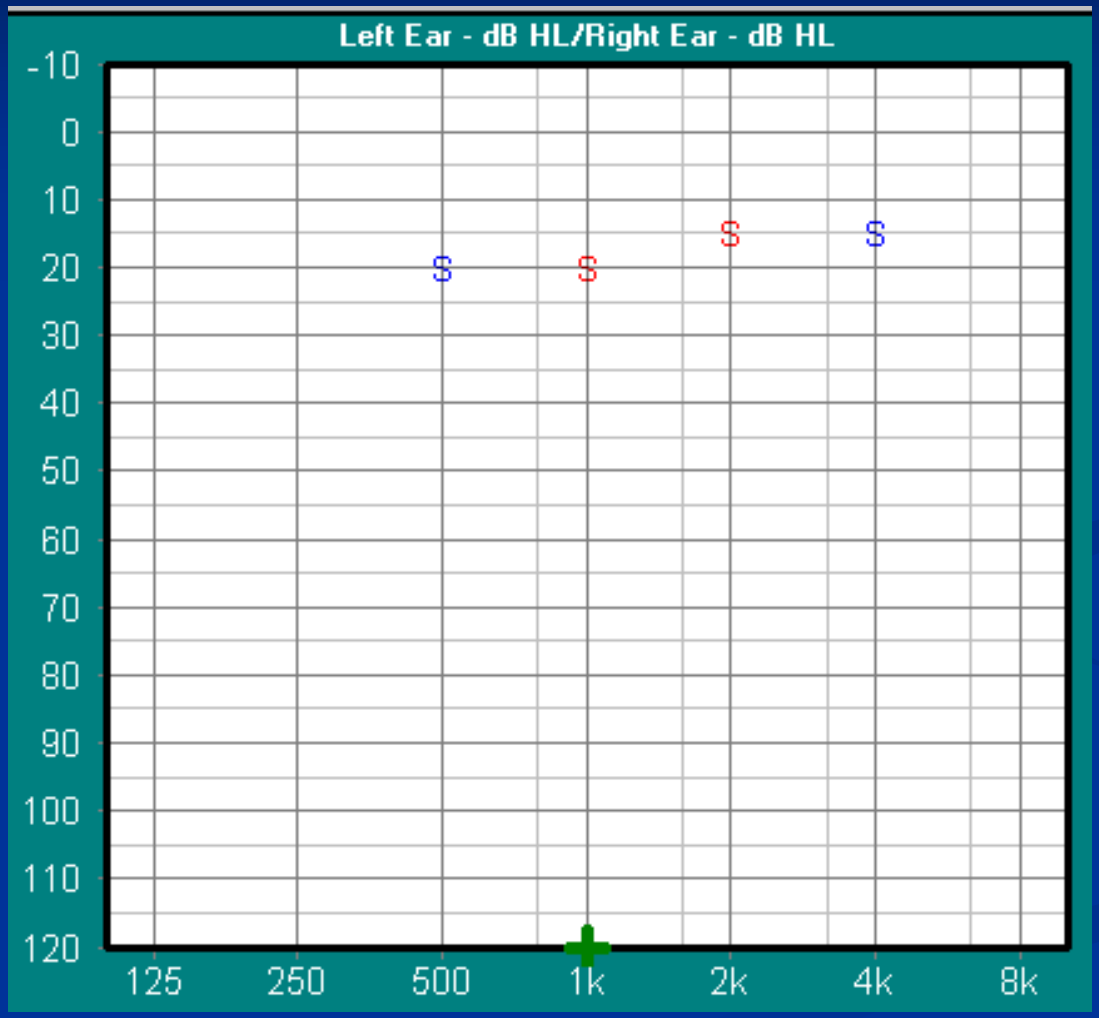



Mixed




# Pediatric Testing in the Booth

# Peds Audio Results




Tymps normal in both ears
SAT 15 dB

How do you report the test results?

# Speech testing

- Part of Ear:  Inner
- Type of HL: Conductive/Sensorineural
- Type of Test: Subjective
- Description: Functional measure of a patient's ability to use the sounds they are hearing through words and sentences (aka "Listening")

# Speech Testing cont'd

Things to Consider with Speech Testing:

- Age of the patient
- Normative age of test
- Open or Closed set task
- Presentation mode
- Language Ability

# Speech Audiometry

- Speech Discrimination/Word Recognition
  - Percent of words patient was able to correctly repeat
  - Words presented at specific level (MCL vs +40dbSL)
  - "Say the word . . ." Should be Recorded material

| Percent Correct | Descriptive Term |
|---|---|
| 90 – 100% | Excellent |
| 76 – 88% | Good |
| 60 – 75% | Fair |
| 50 – 58% | Poor |
| Below 50% | Very poor |

# A word about Malingering…

- Stenger test for assymetry
- Battery of tests concept

# A word about "other" hearing tests…

- Bekesy Audiometry
- Automated Audiometry (OSHA testing)
- Hearing test Apps
- "How old are you?" hearing tests

# Otoacoustic Emissions (OAE)

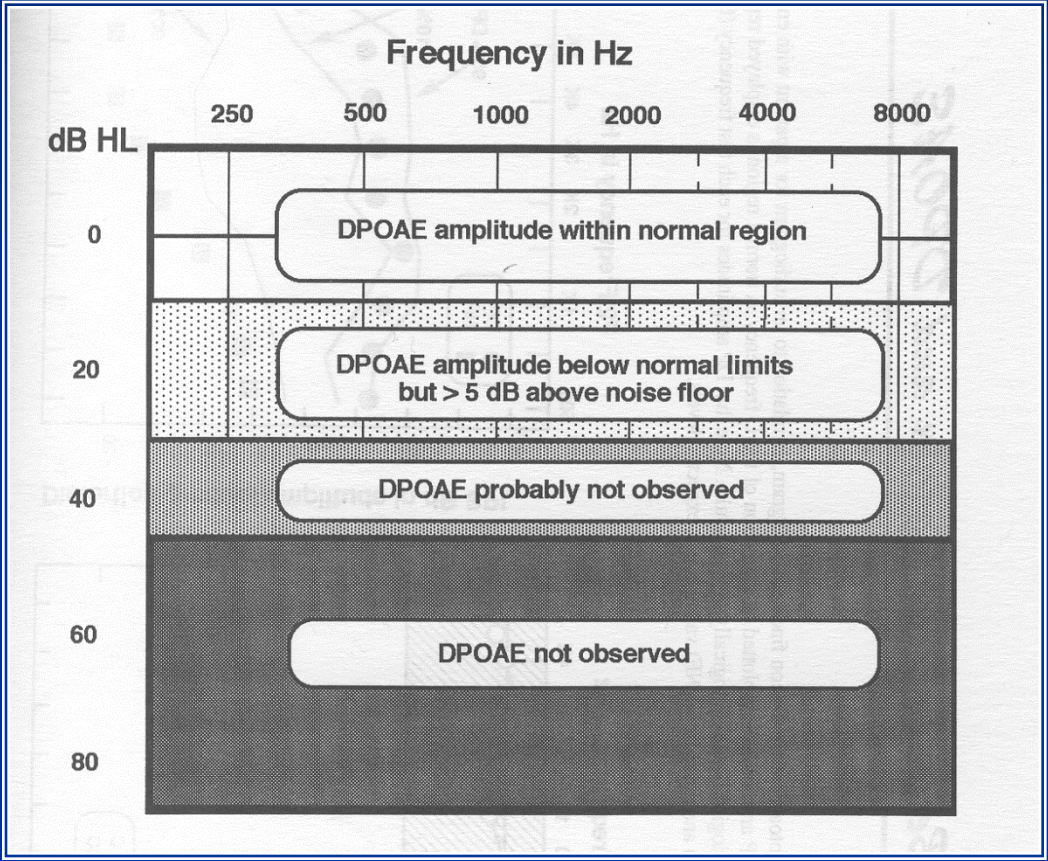
- Part of Ear:  Inner
- Type of HL: Sensorineural
- Type of Test: Objective
- Description: Measurable sounds generated within the normal cochlea, either spontaneously or in response to acoustic stimulation.  A function of the outer hair cells.

# Otoacoustic Emissions

Types of OAEs:

- Spontaneous – signal emitted in approx 50% of human ears in the absence of acoustic stimulation
- Transient – frequency dispersive responses following a brief acoustic stimulus
- Distortion Product – emissions result from the interaction of two simultaneously presented puretones. Two frequencies ($F_1$ and $F_2$) are presented externally, a third tone ($2F_1$-$F_2$) will be produced internally.

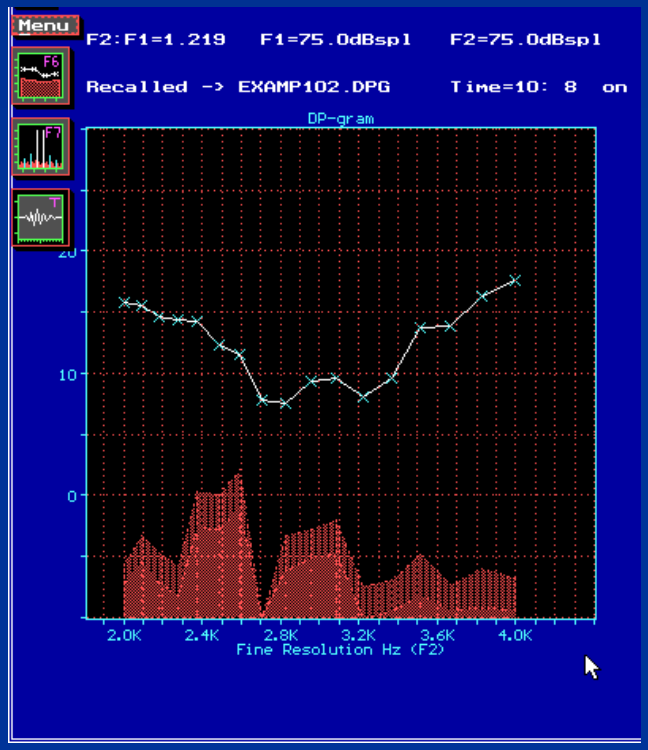
# Applications of OAE

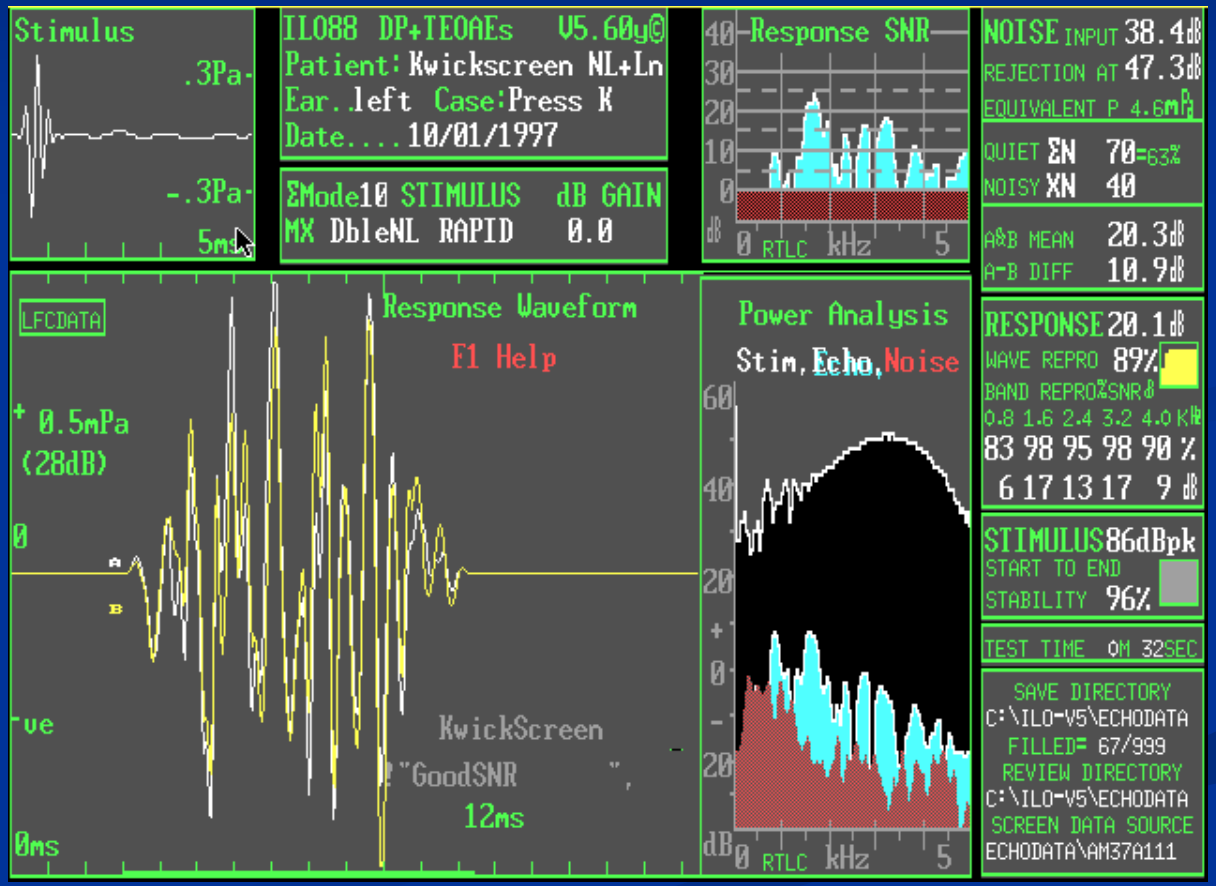



Clinical Applications:

- Newborn hearing screening
- Pediatric audiometry
- Suspected malingering activity
- Monitoring ototoxicity
- Tinnitus
- Noise exposure

# OAE cont'd


Menu
F2:F1=1.219 F1=75.0dBspl F2=75.0dBspl
Recalled -> EXAMP102.DPG Time=10: 8 on
DP-gram
2.0K 2.4K 2.8K 3.2K 3.6K 4.0K
Fine Resolution Hz (F2)


Stimulus
.3Pa
-.3Pa
5ms
ILO88 DP+TEOAEs V5.60y©
Patient: Kwickscreen NL+Ln
Ear..left Case:Press K
Date....10/01/1997
ΣMode10 STIMULUS dB GAIN
MX DbleNL RAPID 0.0
Response SNR
RTLC kHz
NOISE INPUT 38.4dB
REJECTION AT 47.3dB
EQUIVALENT P 4.6mPa
QUIET ΣN 70=63%
NOISY XN 40
A&B MEAN 20.3dB
A-B DIFF 10.9dB
LFCDATA
Response Waveform
F1 Help
+ 0.5mPa
(28dB)
-ve
KwickScreen
"GoodSNR ",
12ms
0ms
Power Analysis
Stim,Echo,Noise
RTLC kHz
RESPONSE 20.1dB
WAVE REPRO 89%
BAND REPRO%SNR dB
0.8 1.6 2.4 3.2 4.0 KHz
83 98 95 98 90 %
6 17 13 17 9 dB
STIMULUS 86dBpk
START TO END
STABILITY 96%
TEST TIME 0M 32SEC
SAVE DIRECTORY
C:\ILO-V5\ECHODATA
FILLED= 67/999
REVIEW DIRECTORY
C:\ILO-V5\ECHODATA
SCREEN DATA SOURCE
ECHODATA\AM37A111

# Auditory Brainstem Response (ABR)

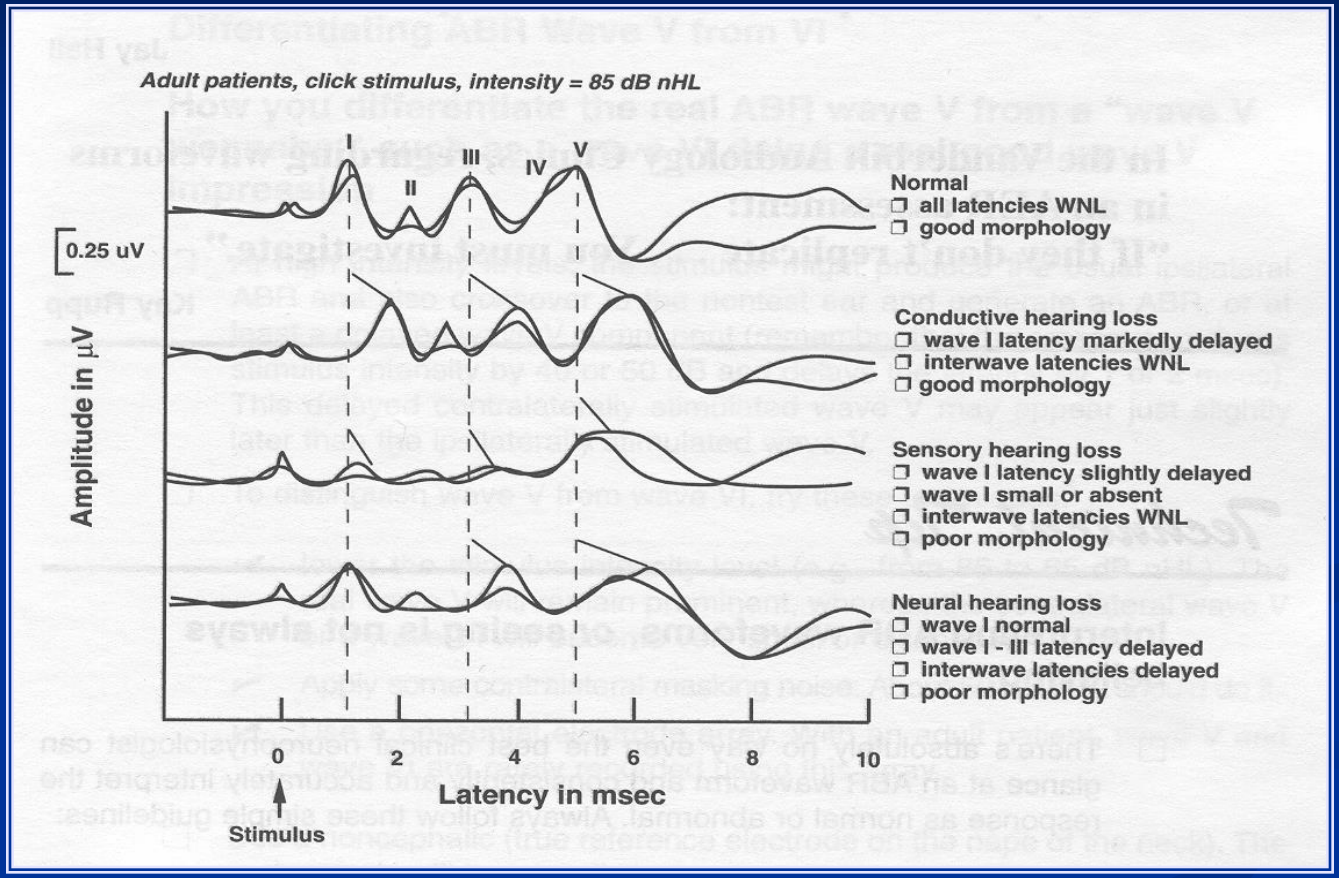
- Part of Ear: 8th nerve/Brainstem
- Type of HL: Sensorineural/Other
- Type of Test: Objective
- Description: Measures the electrical potentials generated by the 8th nerve and lower brainstem in response to stimulation.

# ABR cont'd

**Clinical Applications:**

- Neurodiagnosis of 8th nerve or auditory brainstem dysfunction
- Estimation of auditory threshold in young children, difficult to test populations, and malingering patients
- Intraoperative monitoring of 8th nerve
- Newborn hearing screenings

# ABR cont'd




Classically defined ABR waveform patterns.

# Final Thoughts….

- There are exceptions to every rule.
- There is a difference between hearing and listening.
- Test results should be consistent with History and Medical findings.

# Questions…..