Understanding Hearing Loss

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Disclosures

• None

Objectives

1. Review the basics of auditory anatomy and physiology

2. Discuss common etiologies conductive, sensory, and mixed hearing loss

3. Develop a limited differential of common hearing loss etiologies

4. Understand appropriate situations for referral.
The Auditory System

The Head, Pinna, and Ear Canal

- Resonant frequency is a function of length
  - Canal length approx 2.5 cm
  - Concha → resonance @ 3KHz
  - EAC → resonance @ 4KHz

- Combined effect results in approx 10-15dB boost in sound intensity for frequency region around 4,000 Hz

- Pinna features assist in sound localization

- Head attenuates sound > 2KHz
  - "head shadow effect"
  - Sound localization

Middle Ear (ME)

- The job of the ME space is to mobilize cochlear fluid efficiently
  - reliant upon a pressure differential between the round and oval windows

  - 99.9% of sound is reflected due to high impedance in transition from air to fluid
    - 30dB loss of sound

- An "impedence transformer"
  - Efficiency = reducing reflection of sound
  - High impedance → Low impedance
  - Impedance matching
Mechanisms of Impedance Matching

1. Area ratio of the ear drum to the stapes footplate
   - TM = 60mm², Footplate = 3mm²
   - Resulting 20:1 ratio
   - +26dB SPL

2) Lever action of the ossicles (1.3:1)
   - +2 dB SPL

3) Buckling of ear drum
   - +6dB SPL
   - 30dB lost due to cochlear impedance
   - 26dB + 2dB + 6dB = 34dB gained back

Measuring Acoustic Impedance

Defined: the resistance of the TM to being set in motion by sound

Impedance is the result of multiple structures
- TM
- Ossicles
- Ossicular ligaments
- Muscles of the middle ear
- Cochlear fluid

Tympanometry demonstrates impedance as a result of changing air pressure in the ear canal
- Inequalities in air pressure → difficulty with sound transmission
- TM perforation → TM mobility decreases in proportion to volume of sound passing through
- Middle ear fluid → impinges on TM mobility, volume > viscosity

The Inner Ear
Cochlear Anatomy

The Organ Of Corti

The Auditory Nervous System
**Pathologic Conditions Leading to Conductive Hearing Loss**

**Lesions of the Conductive Apparatus and Associated Hearing Loss**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Component Disrupted</th>
<th>Expected loss (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM Perforation</td>
<td>Loss of areal ratio, catenary leaver</td>
<td>Proportionate to defect size</td>
</tr>
<tr>
<td>TM Perforation/Ossicular discontinuity</td>
<td>Hydraulic lever, areal ratio, catenary leaver</td>
<td>38dB</td>
</tr>
<tr>
<td>Total loss TM/Ossicular Chain</td>
<td>Hydraulic lever, areal ratio, catenary leaver, phase cancellation</td>
<td>50dB</td>
</tr>
<tr>
<td>TM intact/Ossicular discontinuity</td>
<td>Hydraulic lever, areal ratio, catenary leaver, phase cancellation</td>
<td>≤55dB</td>
</tr>
<tr>
<td>TM intact/Ossicular discontinuity/Sealed Oval Window</td>
<td>Hydraulic lever, areal ratio, catenary leaver, phase cancellation, sound reflection</td>
<td>≤55-60dB</td>
</tr>
</tbody>
</table>

**Prognostic Value of the Fork Testing**

Weber: Ipsilateral conductive loss vs. contralateral sensory loss

<table>
<thead>
<tr>
<th>Rinne Test Result</th>
<th>Estimated Hearing Loss (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative 256 Hz</td>
<td>Mild conductive loss 20-30dB</td>
</tr>
<tr>
<td>Negative 256 &amp; 512 Hz</td>
<td>Moderate conductive loss 30-45dB</td>
</tr>
<tr>
<td>Negative 256, 512, and 1024 Hz</td>
<td>Severe conductive loss 45-60dB</td>
</tr>
</tbody>
</table>

*Negative Rinne test = B > A. Positive Rinne test = A > B

Case 1

HPI: 73 y/o female with a history of chronic sinus disease being seen in evaluation of muffled left ear and tinnitus. She’s had multiple endoscopic endonasal sinus procedures and also has a history of high grade B cell lymphoma of the orbit, for which she underwent chemotherapy 3 years ago.

ROS: negative

PMH: HTN, OSA, GERD, Type 2 DM

PSHx: T&A, hysterectomy

Family hx: Heart disease, lung CA

Meds: diltiazem, nexium, humalog

Allergies: none

Physical Examination:

Right: patent canal, intact TM, aerated middle ear

Left: patent canal, amber ME effusion, nl TM architecture

Weber: left

Rinne’, 512Hz fork: + Ad, - As

Normal vestibular exam

Normal fiberoptic exam

Otitis Media with Effusion

- Defined: Persistence of serous/mucoid ME fluid > 3 mos
- MCC hearing loss in children in the developed world
- Peaks in incidence age 2-5
- Children with OME more likely to suffer from AOM

- Risk factors:
  * Day care attendance
  * Alternatives to breast feeding
  * Tobacco smoke exposure
  * Viral URI
  * Genetics
  * Immunodeficiency and birth defects
  * H&N radiation

- > 90% of middle ear effusions resolve by 90 days
Case 2 - TM Perforation

Case 3

HPI: 57 y/o female with 15 years of progressive right sided hearing loss. No vestibular symptoms. Grandmother was hard of hearing at a young age and her mother has worn 2 hearing aids since she was in her 30’s. No hx recurrent infection, otalgia, otorrhea, or prior otologic procedure.

ROS: negative
PMH: negative
PSHx: negative
Family hx: otherwise negative
Meds: none
Allergies: none

Physical Examination:

Right: patent canal, intact TM, aerated middle ear
Left: patent canal, intact TM, aerated middle ear
Weber → left
Rinne’, 512Hz fork → + Ad, - As
NI vestibular exam

Differential: Ossicular discontinuity, otosclerosis, tympanosclerosis, lateral chain fixation, middle ear mass
Otosclerosis

**Diagnostic Features**

- Onset fairly early in adult life
- Slowly progressive uni/bilateral loss
- No clear preceding cause for hearing loss
- Hearing loss in multiple generations
- Normal exam of TM/ME space

- Female to male 2:1
- Rapid progression during pregnancy/menopause
- Among the most common causes of acquired hearing loss

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Tympanosclerosis

**HPI:** 21 y/o male with hx RAOM requiring multiple sets of tubes. No infections or drainage in years. HA on right since high school.

- Common result of ME inflammation/trauma
  - Common AOM/OME sequelae
  - Common after ventilation tubes
- Hyalinization/Ca++ deposition in TM/ME
- White, "porcelain" like plaques
- Limited to TM → myringosclerosis
- ME involvement commonly results in lateral chain fixation and associated CHL
Case 4

HPI: 53 y/o female being seen in referral for balance problems. 30 year history of vertigo, spell seconds in duration. 10-20 episodes a day. Exacerbated by loud sound, and she reports hearing “body movements on the left.” She noticed that pushing on her tragus makes her dizzy. Longstanding left sided hearing loss.

ROS: negative
PMH: Sciatica, migraine
PSHx: Hysterectomy
Family hx: otherwise negative
Meds: none
Allergies: none

Physical Examination:

Right: patent canal, intact TM, aerated middle ear
Left: patent canal, intact TM, aerated middle ear. Nystagmus with insufflation
Weber ➔ midline
Rinne', 512Hz fork ➔ + AU

PTA: Right - 15dB, Left - 20dB
WRS: 100% AU    Reflexes: Present All
**Superior Semicircular Canal Dehiscence**

**Classic symptoms:**
- Vertigo induced by loud sounds (Tulio phenomenon)
- Increased sensitivity to bone conducted sounds- eye movements, vertebrae movement
- Vestibular symptoms with increased ICP (Valsalva, jogging, etc..)

**Diagnostic Features:**
- Vertigo induced by loud sounds (Tulio phenomenon)
- Nystagmus induced by EAC pressure changes (Henneberts sign)
- Conductive or Mixed loss with present acoustic reflexes

**Audiologic Features:**
- Classic low frequency CHL with + stapedial reflexes
- Supranormal bone conduction thresholds
- Low threshold cVEMP's

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**Types of Presbycusis**

**Sensory**
- Neural loss at the basal. High frequency loss with preserved speech frequencies and correlating discrimination scores.

**Neural**
- Neural loss over the entire cochlea. Loss of discrimination out of proportion to PTA.

**Strial/Metabolic**
- Patchy atrophy of the stria in the middle/apical turns. No neural loss. Flat PTA with excellent discrimination.

**Cochlear Conductive**
- Gradual sloping, high frequency loss of middle age. No pathologic cochlear changes. Proportionate decrease in discrim.
Sensorineural Hearing Loss - Case 2

HPI:
Patient is a 44 y/o male with participating in an annual work related physical. He has worked in a factory for 20 years. No other significant otologic history.
Medical history otherwise non contributory.
Normal physical examination

Noise Induced Hearing Loss

- Second only to age related hearing loss as the most prevalent form of hearing loss
- Exposure to 85dB for a period longer than 8 hours
- Always sensorineural, affecting IHC's
- First sign is notching at 3-6KHz (usually 4KHz), with recovery at 8KHz (no recovery at 8K with age related loss)