Assessment of Hearing

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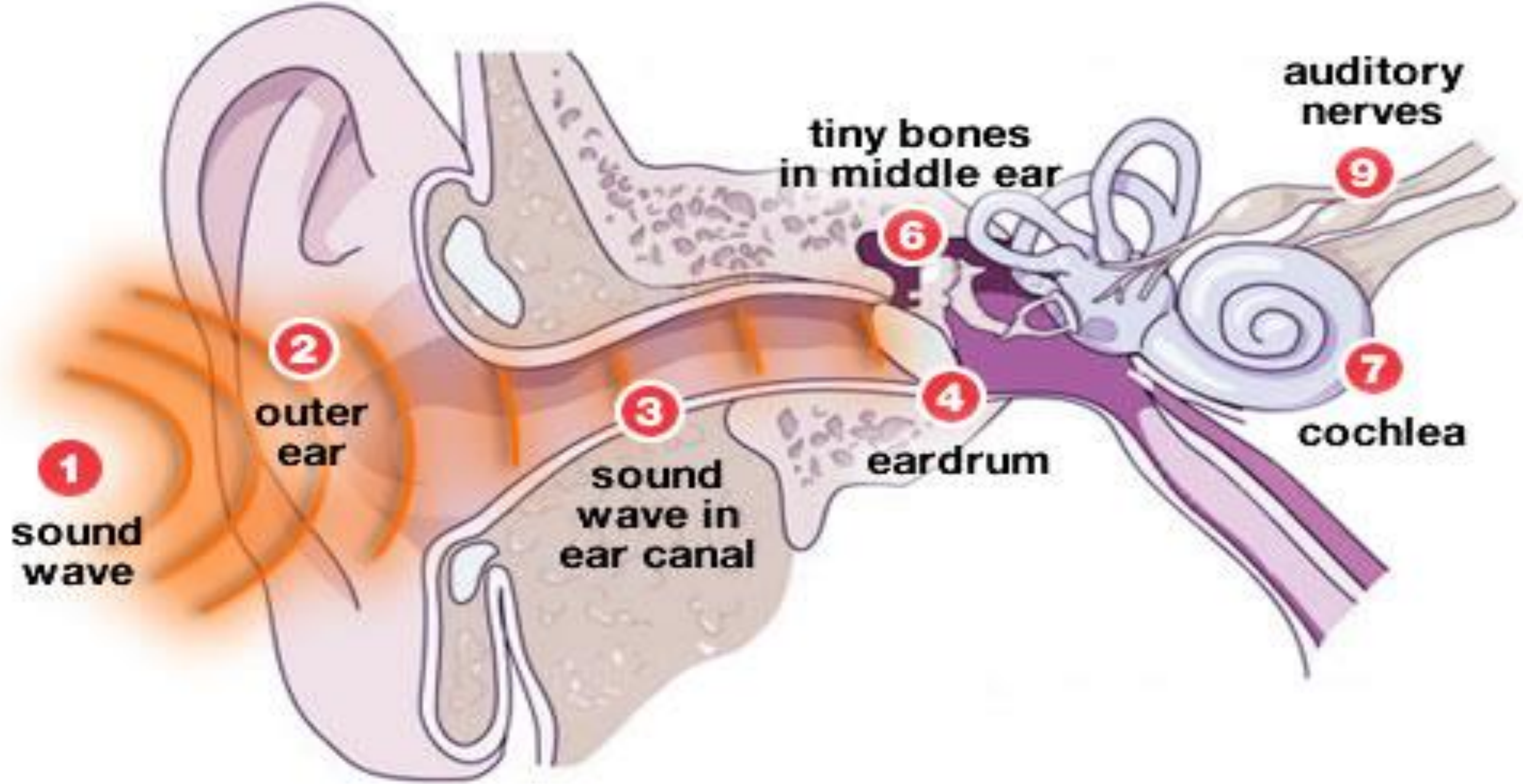
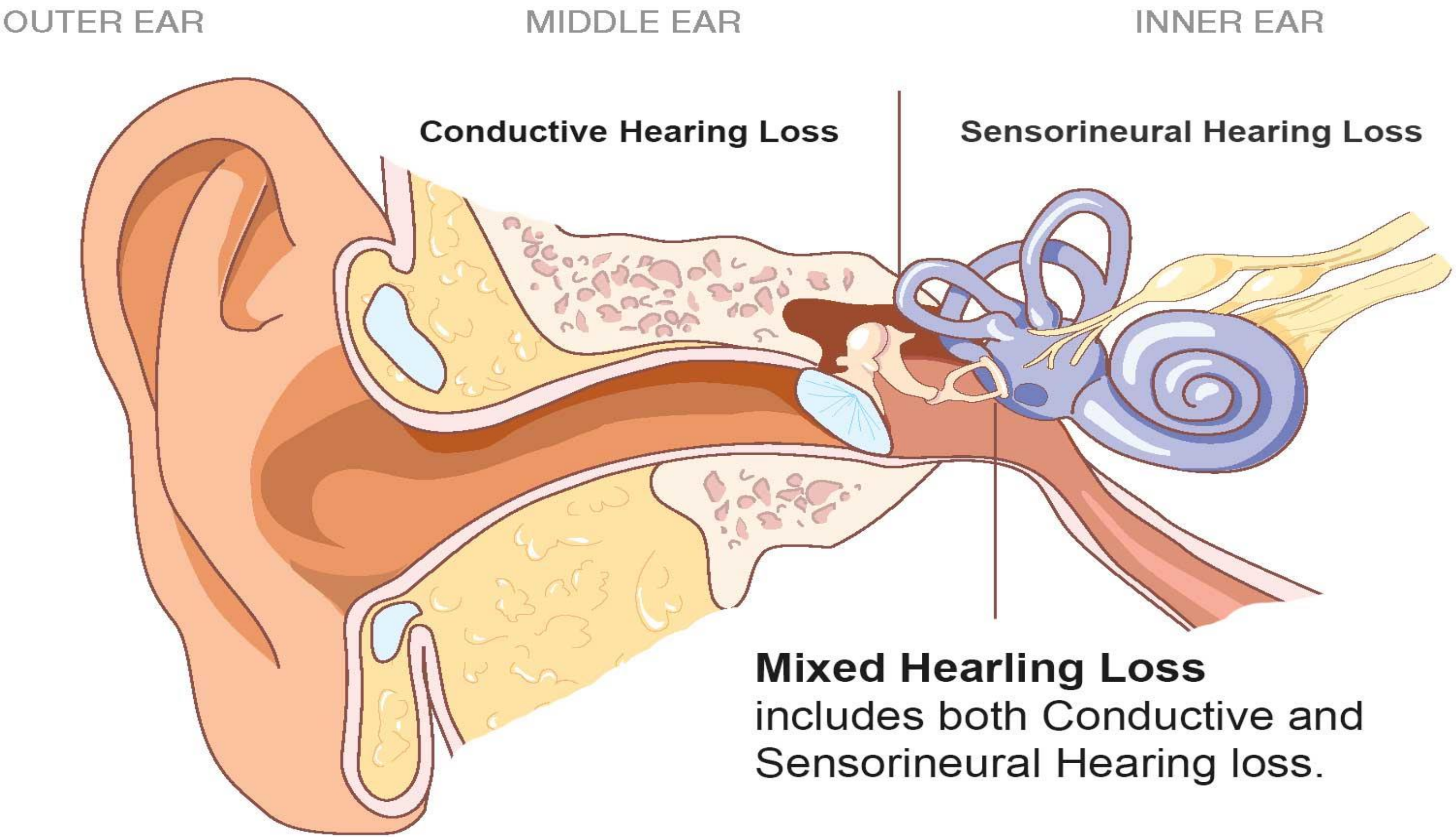
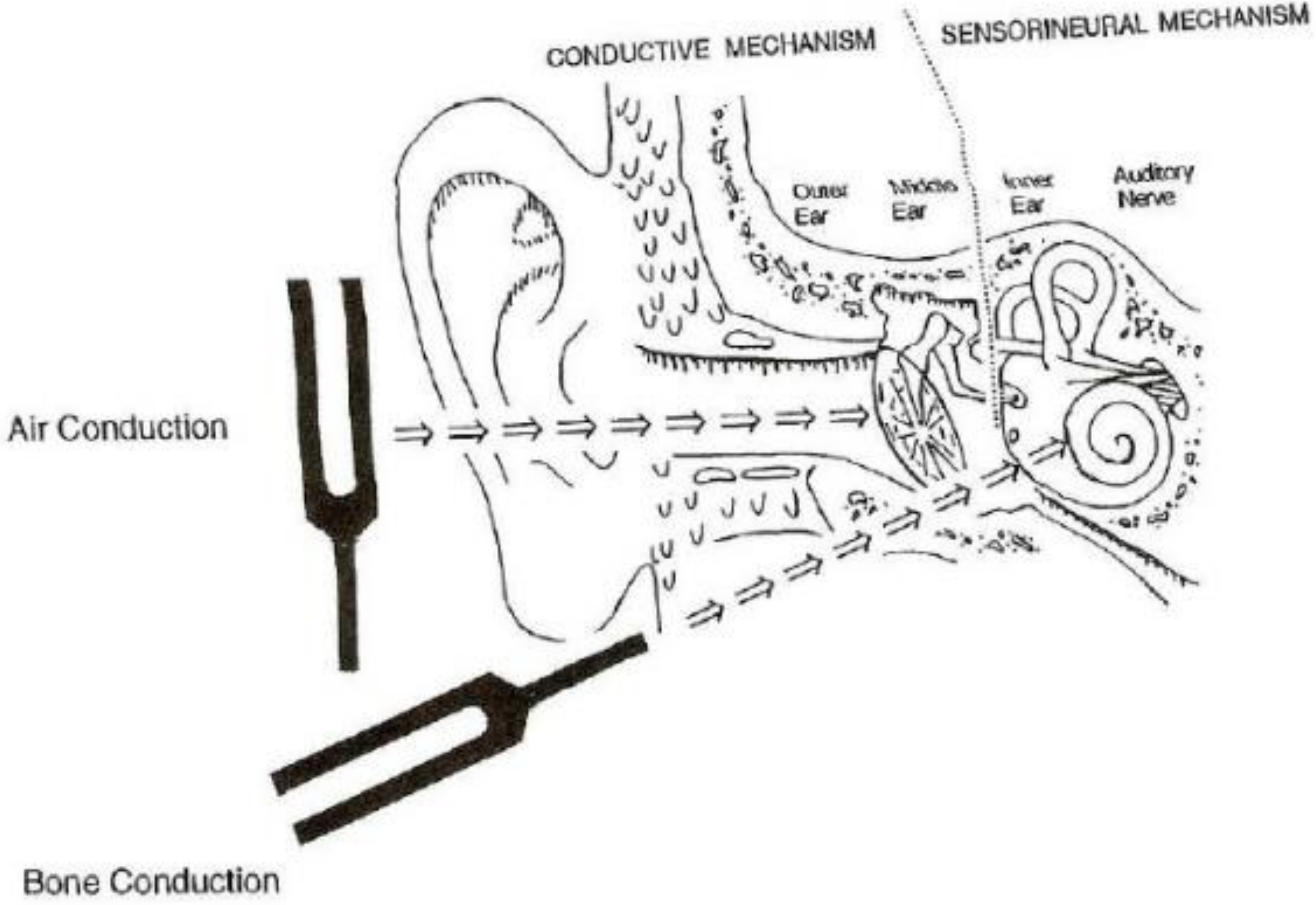
Physiology Of Hearing



- Sound waves, collected by the Pinna, are transmitted along the Ear Canal to the Ear Drum, then it set the Ossicles into vibration. These Ossicles will amplify the vibration and transmit it from the Ear Drum to the Oval Window in the Inner Ear.
- Here, The vibration triggers movement of the fluid in the Cochlea and sets the hair cells into vibration. When Hair Cells vibrate, they translate the incoming sound signals into electrical impulses, and send it to the Cochlear Nerve.
- Nerve impulses are transmitted along the Vestibulocochlear Nerve to the Brain. In Central Auditory System, the impulse signals processes and translates into auditory information, so we can “hear”.

Types Of Hearing Loss




CONDUCTIVE MECHANISM
SENSORINEURAL MECHANISM
Outer Ear
Middle Ear
Inner Ear
Auditory Nerve
Air Conduction
Bone Conduction

Clinical Assessment Of Hearing

- **Whispered Voice Test**
- **Tuning Fork Tests**
  - **Rinne's Test**
  - **Weber's Test**
- **Audiometry**
  - **Pure Tone Audiometer**
  - **Speech audiometer**
  - **Impedance Audiometer**
  - **Electric response audiometer**

Whispered Voice Test

- Formal Assessment. Ask the patient to repeat words spoken by the examiner at different intensities & distances.
- <u>Examination sequence</u>
  - Stand behind the patient.
  - Start with your mouth about 15 cm from the ear you are testing.
  - Mask hearing in the other ear by rubbing the tragus.
  - Ask the patient to repeat your words. Use a combination of multisyllable numbers and words (1,2,3 or A,B,C). Start with a normal speaking voice to confirm that the patient understands the test. Lower your voice intensity to a clear whisper.
  - Repeat, but this time at arm's length from the patient's ear.

    People with normal hearing can repeat words whispered at 60 cm.

Interpretation of Results…

Normal

- **Patient is able to hear whispered speech accurately.**
- **Volume is the same in both ears.**

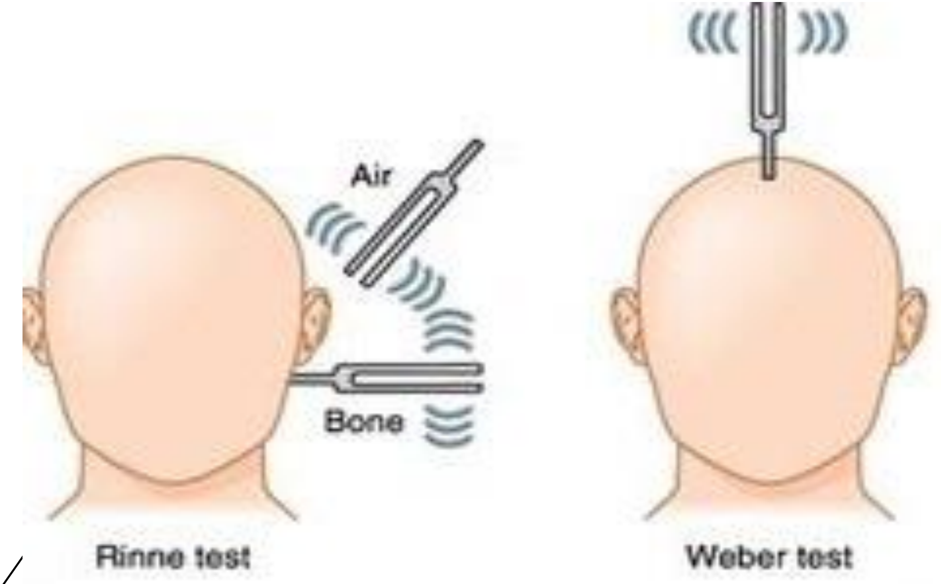
Abnormal

- **The patient is unable to hear whispered speech.**
- **The patient hears speech at a higher volume in one ear.**
- **The patient hears sounds but does not understand words.**

Tuning Fork Tests

- Two tuning fork tests are used to differentiate between conductive and sensorineural deafness using either a 512 Hz or a 256 Hz tuning fork.

  - Rinne's Test
  - Weber's Test



Rinne’s Test

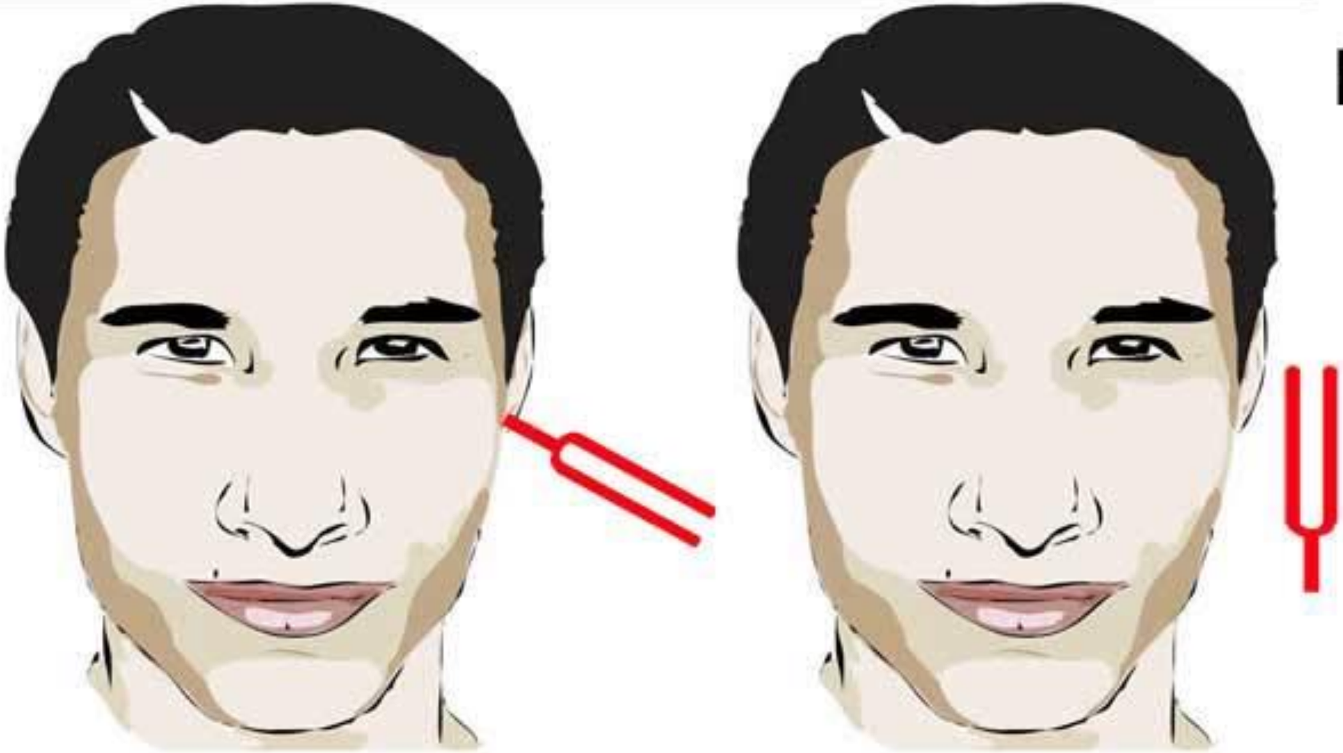
- **Compares the level of air and bone conduction of the same ear.**

Examination Sequence

- Place the vibrating prongs at the patient's external auditory meatus; ask if he can hear it.
- Now place the still-vibrating base on the mastoid process. Ask: 'Is it louder in front, or behind your ear?'

Alternatively:

- The Rinne’s test is performed by placing a vibrating tuning fork (512 or 256 Hz) initially on the mastoid process until sound is no longer heard, the fork is then immediately placed just outside the ear.
    - Normally, the sound is audible at the ear.



Rinne’s Test

With a 512 Hz tuning fork press against the mastoid bone and then hold it 1cm away from the ear.

‘Which is louder, behind the ear or in front?’

Interpretation of Results

Normal Findings

- Air conduction (AC) is better than bone conduction (BC) (AC > BC) this is Positive Rinne's.

Abnormal Findings

- Bone conduction is better than air (AC < BC) this is Negative Rinne's and indicates conductive hearing loss.
- In sensorineural deafness, bone conduction and air conduction are both equally depreciated, maintaining the relative difference of bone and air conductions.
    - AC>BC but both are depressed.

Additional Note

- If hearing in one ear is extremely poor there may be a false negative Rinne's.
  - The sound will be conducted through the bone to the opposite ear and give a false impression of better BC.

Weber’s Test

Examination Sequence:

- Place the base of the vibrating tuning fork in the middle of the patient's forehead.
- Ask: 'Where do you hear the sound?'
- Record which side Weber's test lateralizes to if not central.

Finding	Interpretation
No Lateralization (The sound is heard equally in both ears)	Normal/Healthy Patient
	Bilateral symmetrical Conductive Deafness
	Bilateral symmetrical Sensorineural Deafness
Lateralized to better/healthy ear	Unilateral Sensorineural Deafness
Lateralized to worse/affected ear	Unilateral Conductive Deafness

	Rinne's	Weber's
normal	positive	centeral
conductive	negative	lateralized to affected ear
sensorineural	positive	lateralized to the unaffected ear
profound	false negative	

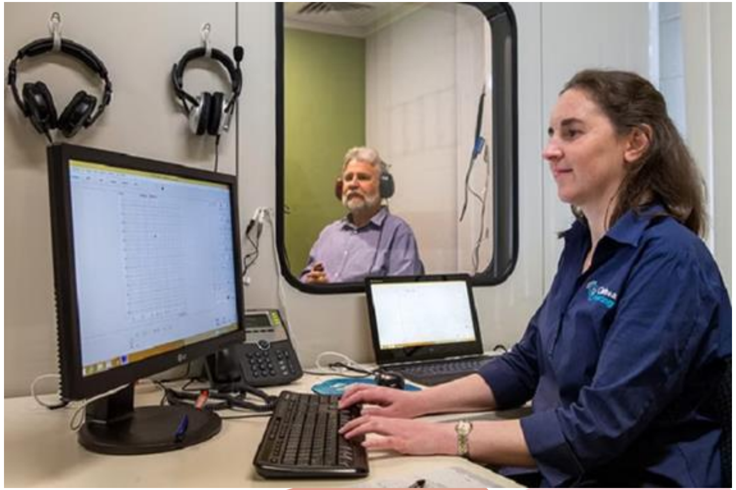
Important Terms

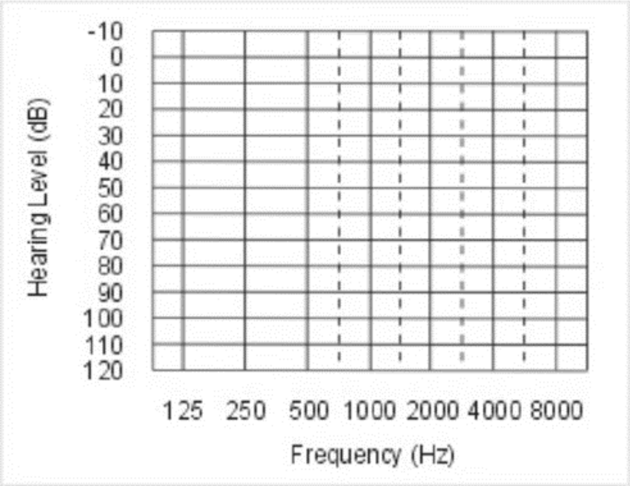
1. Frequency is cycles per unit of time.
2. Frequency is measured in hertz (Hz), which are cycles per second.
3. The ears are most sensitive to frequencies in the range of 1000-4000Hz
4. The range of human speech is between 400-3000 Hz.
5. Usually, frequencies of 250-8000 Hz are used in testing because this range represents most of the speech spectrum, although the human ear can detect frequencies from 20-20,000 Hz
6. The hearing threshold is the sound level below which a person's ear is unable to detect any sound. For adults, 0 dB is the reference level.

Pure Tone Audiometry

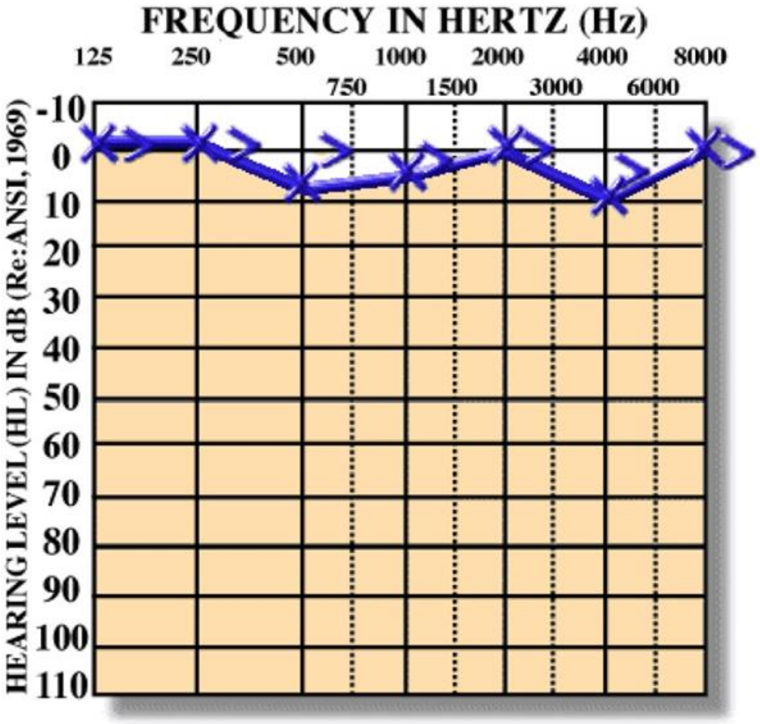
- ***Def :*** Electronic device that generates tones for determining hearing thresholds. Displayed on a graphic plot called ***audiogram***.

- ***Audiogram:*** Is a chart of hearing sensitivity, with frequency charted on the (x-axis) and intensity on the (y-axis).





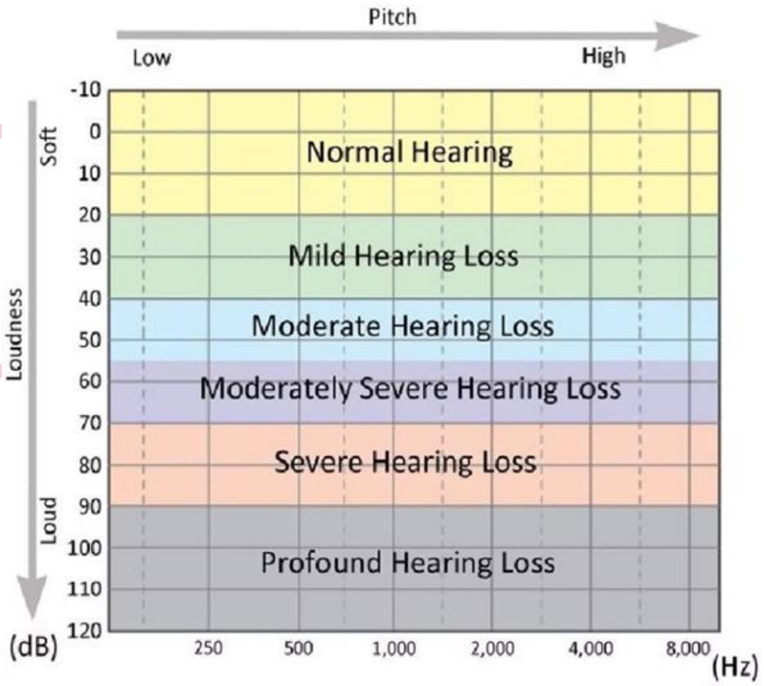
Normal hearing



	LEFT	RIGHT
Air Conduction (AC)	×	O
Air Conduction Masked	□	Δ
Bone Conduction (BC)	>	<
Bone Conduction Masked	]	[

❖ **Audiometric masking** is the process of presenting masking noise to the non-test ear while testing the other ear.

Ranges of Hearing Loss

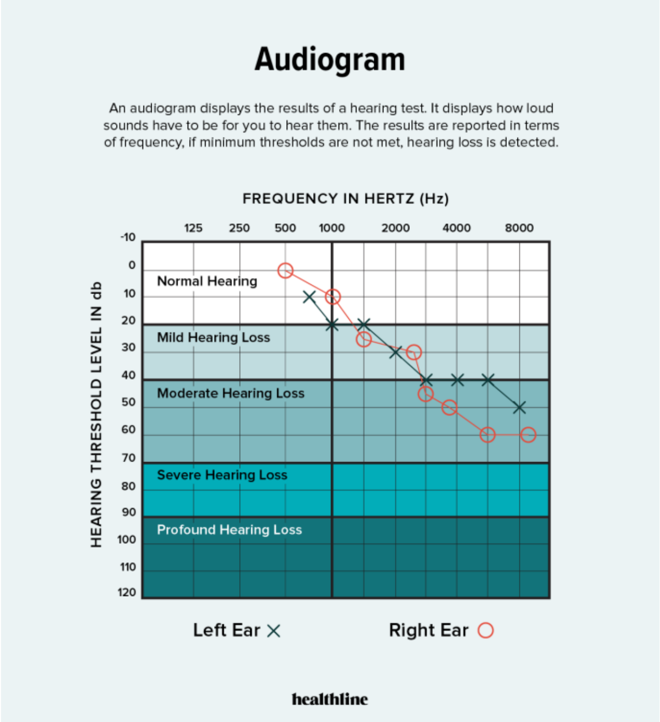


- -10 – 20 dB HL = Normal range
- 21 – 40 dB HL = Mild hearing loss
- 41 – 55 dB HL = Moderate
- 56 – 70 dB HL = Moderately Severe
- 71 – 90 dB HL= Severe
- Greater than 90 dB HL = Profound

Audiogram Interpretation

1. Hearing sensitivity by AC
2. Hearing sensitivity by BC
3. AC/BC difference (a.k.a. the air-bone gap):

- No air-bone gap = normal or SNHL
- AC worse than BC = conductive hearing loss

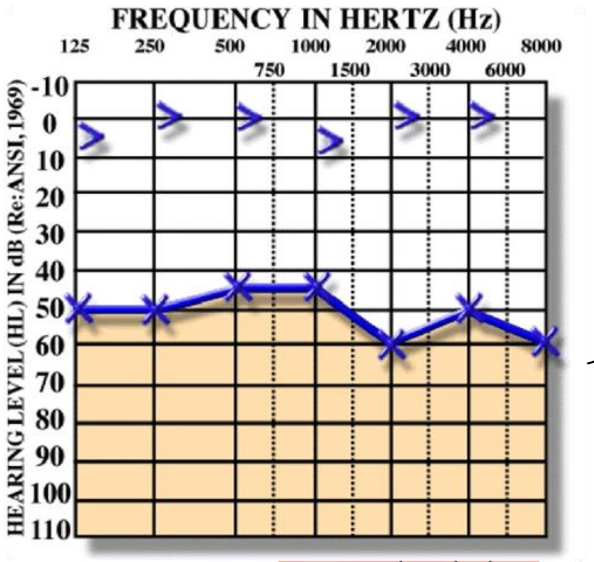


Conductive Hearing Loss

- Conductive hearing loss has **normal bone**-conduction thresholds, but **air**-conduction thresholds are **poorer than normal by at least 10 dB.**
- **There is air-bone gap.**
- Conductive hearing loss is secondary to an **outer ear or middle ear abnormality**, which can include abnormalities of the tympanic membrane.
- Examples of abnormalities include:

1. Occlusion of the external auditory canal by cerumen or a mass
2. Middle ear infection and/or fluid
3. Perforation of the tympanic membrane

Ossicular abnormalities

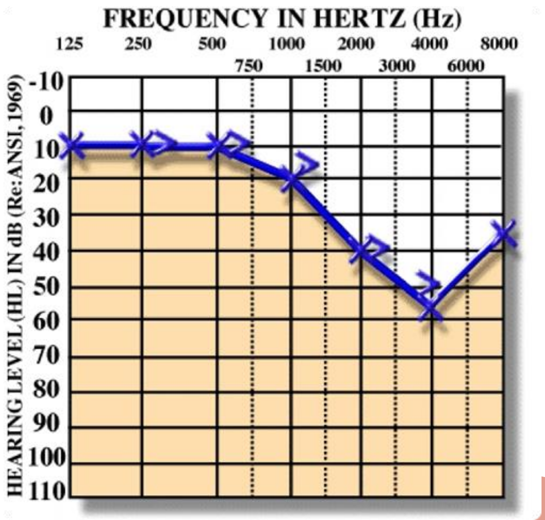


Sensorineural Hearing Loss

- Sensorineural hearing loss has **bone- and air-conduction thresholds within 10 dB of each other (within normal)**, and thresholds are higher than 25 dB HL.
- No air-bone gap {both are decreased equally}.
- Sensorineural hearing loss is secondary to **cochlear abnormalities** and/or an abnormality of the auditory nerve or central auditory pathways.
- Examples include:

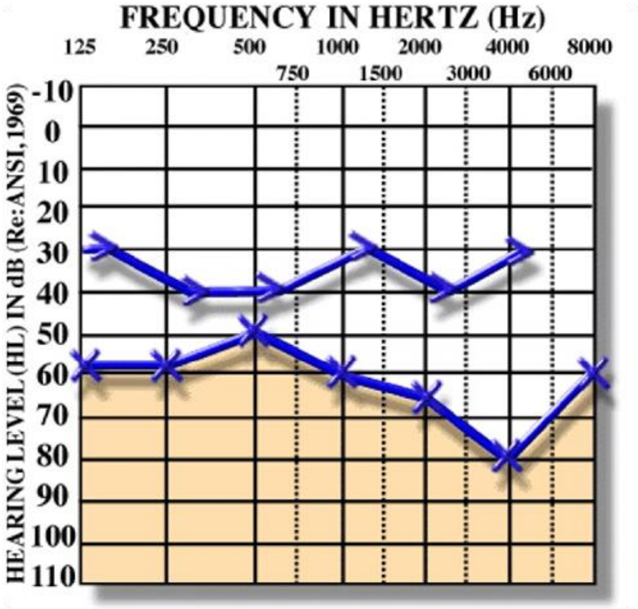
1. Presbycusis
2. Noise-induced hearing loss
3. Ménière disease

Retro cochlear lesions such as vestibular schwannoma



Mixed Hearing Loss

- Pure-tone air-conduction thresholds are poorer than bone-conduction thresholds by more than10 dB.
- There is air-bone gap.
- Bone-conduction thresholds are higher than 25



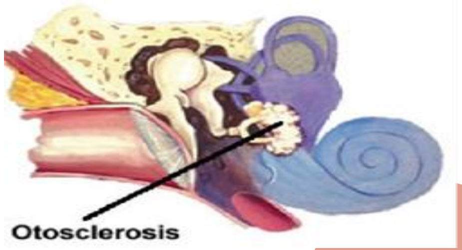
Examples of Characteristic Audiograms

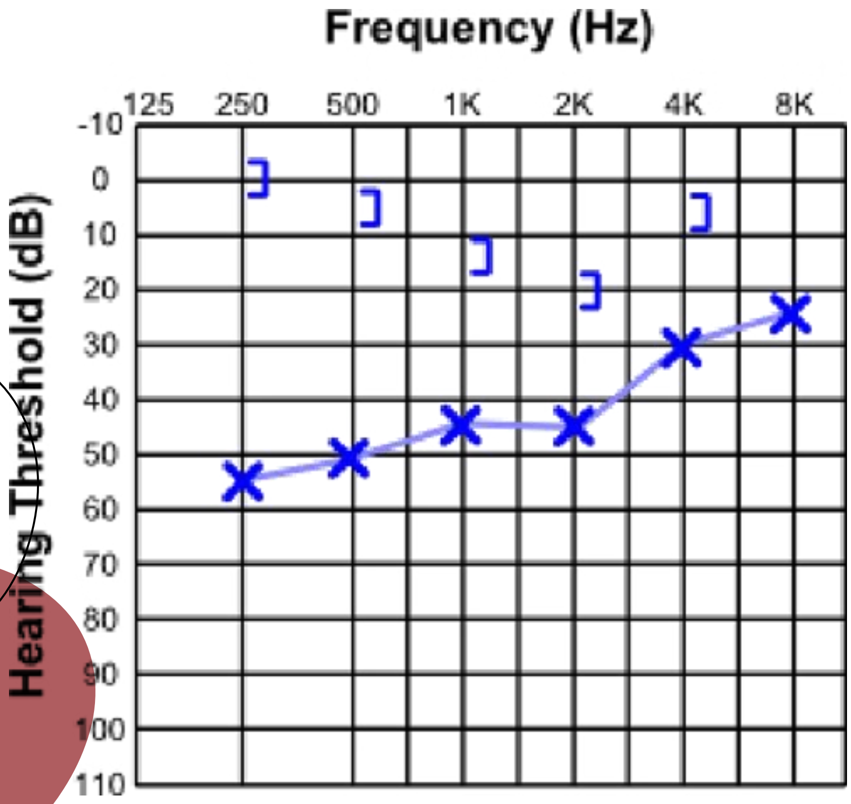
- **Conductive hearing loss:**
  - Otosclerosis

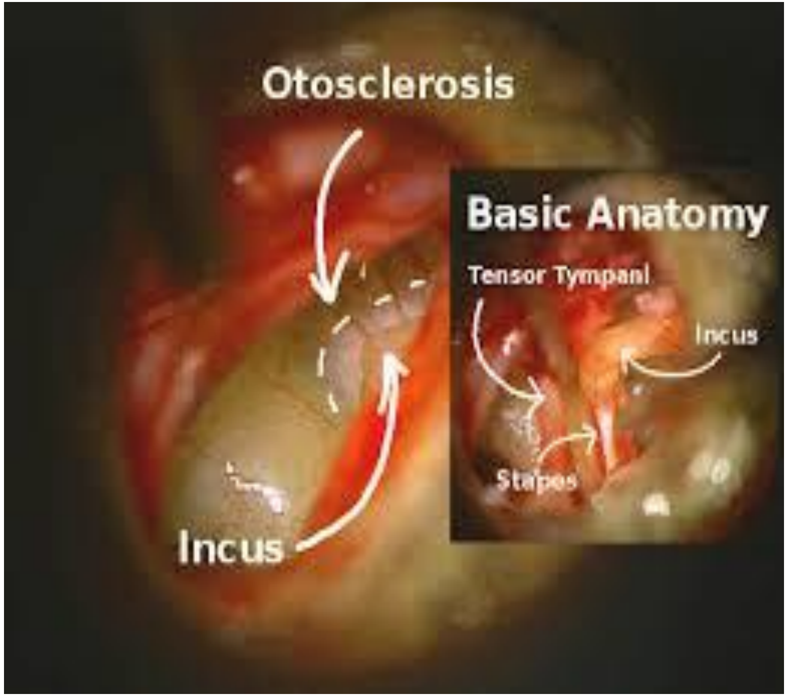
- **Sensorineural hearing loss:**
  - Noise-induced hearing loss.
  - Presbycusis {age related hearing loss}
  - Ménière's disease.
  - Retrocochlear lesions such as vestibular schwannoma.

Otosclerosis

- The condition is caused by stapedial fixation in the oval window, stiffening the middle ear system.
- Otosclerosis causes a slowly progressive conductive or mixed hearing loss.
- Stapes fixation produces an audiometric artifact known as the Carhart notch, {Carhart notch: Isolated depression(20-30 Db) around 2000 Hz in the bone-conduction audiogram of patients with otosclerosis.}
- Onset usually occurs when patients are aged 15-45 years, and otosclerosis is more common in women than in men.
- One half of patients report a family history of otosclerosis.

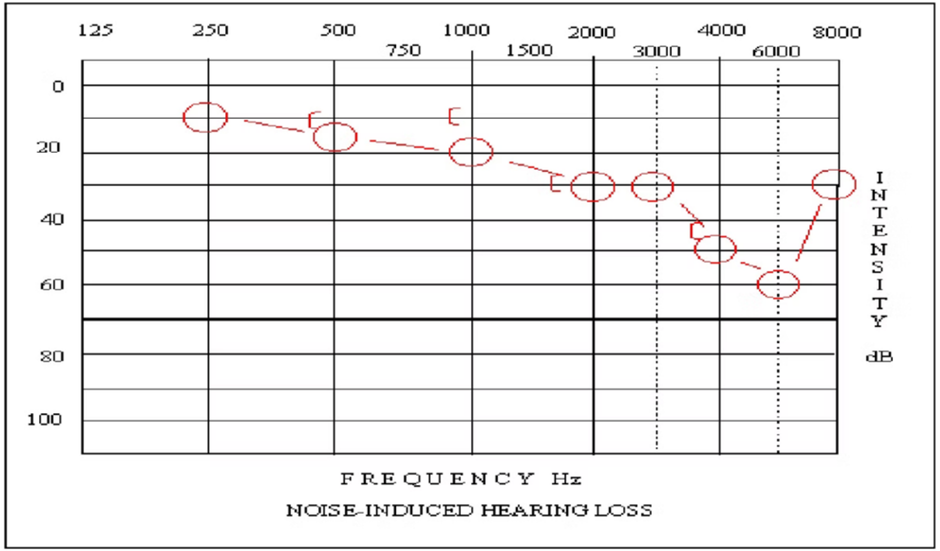


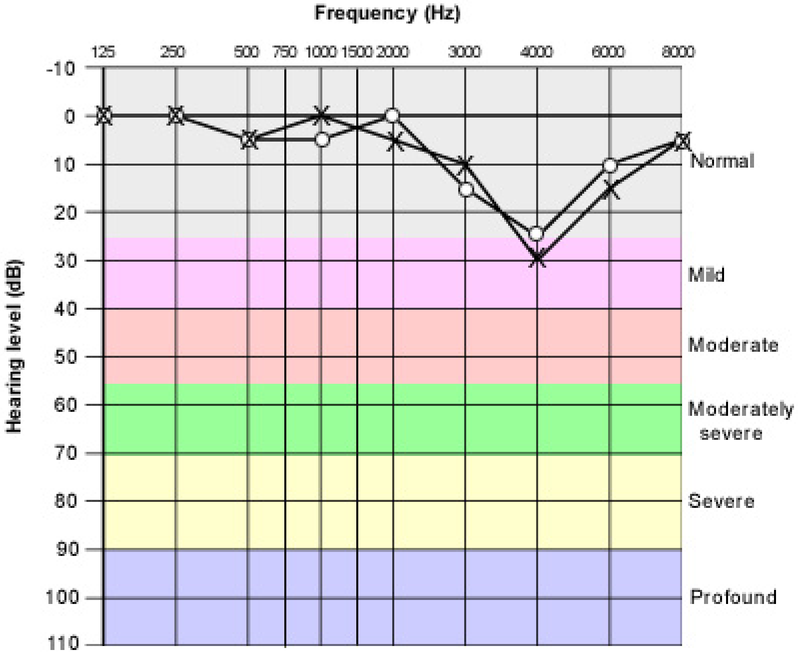

Frequency (Hz)
125 250 500 1K 2K 4K 8K
-10 0 10 20 30 40 50 60 70 80 90 100 110
Hearing Threshold (dB)


Otosclerosis
Basic Anatomy
Tensor Tympani
Incus
Stapes
Incus

Noise-induced Hearing loss

- Exposure to high-intensity noise may cause temporary or permanent hearing loss.
- Repeated exposure to noise trauma may change a temporary threshold shift (TTS) to a permanent threshold shift (PTS). (However, PTS can occur secondary to a single noise exposure in some cases).
- Degree of hearing loss ***depends on*** time exposure, sound intensity, and sound frequency characteristics.
- Noise-induced hearing loss is typically greatest in the 4000- to 6000-Hz region.
- Noise-induced hearing loss is sensorineural **except** in certain blast injuries with possible tympanic membrane and middle ear damage {conductive hearing loss}.


125 250 500 1000 2000 4000 8000
750 1500 3000 6000
0
20
40
60
80
100
INTENSITY
dB
FREQUENCY Hz
NOISE-INDUCED HEARING LOSS


Frequency (Hz)
125 250 500 750 1000 1500 2000 3000 4000 6000 8000
Hearing level (dB)
-10
0
10
20
30
40
50
60
70
80
90
100
110
Normal
Mild
Moderate
Moderately severe
Severe
Profound

Ménière disease

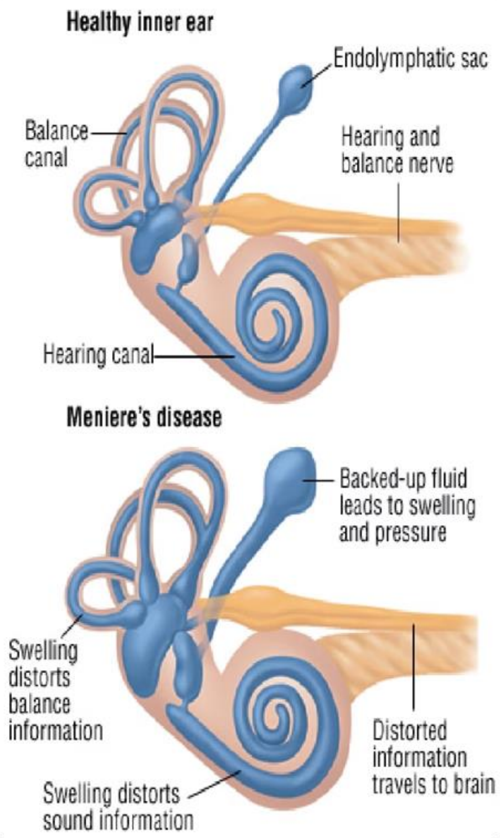
- It is idiopathic disease, but it is believed to be linked to endolymphatic hydrops, an excess of fluid in the inner ear.
- It is thought that endolymphatic fluid bursts from its normal channels in the ear and flows into other areas, causing damage (in the vestibular membrane).
- Ménière disease affects the cochlear and vestibular systems.
- Attacks lasting from 20 minutes to several hours generally include some combination of vertigo, hearing loss, sensation of aural fullness, and tinnitus.
- Tinnitus and hearing loss may persist between attacks.

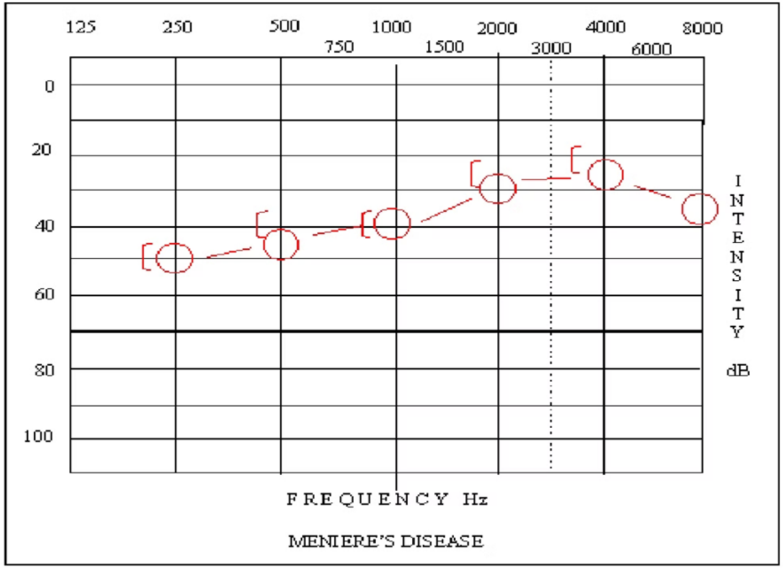
- Hearing loss is usually unilateral, at least in the early stages, usually in lower frequencies and fluctuant, but it typically develops into a permanent sensorineural hearing loss

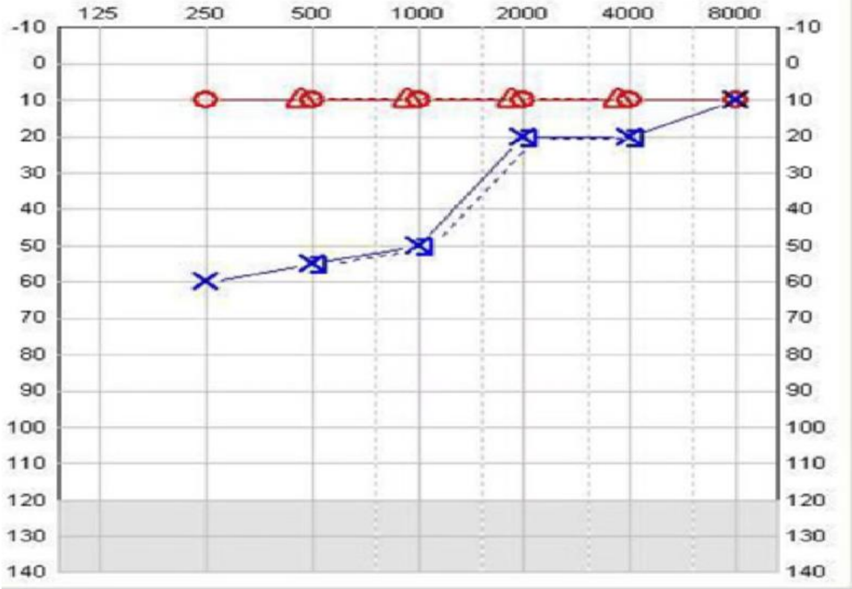
- Many patients report increased sensitivity to loud noises (recruitment) in addition to the listed symptoms.

- Onset for approximately one half of patients occurs when aged 40-60 years.

- The disease is rare in children.







Unilateral SNHL Evident {Meniere}

Presbycusis {Age-related hearing loss}

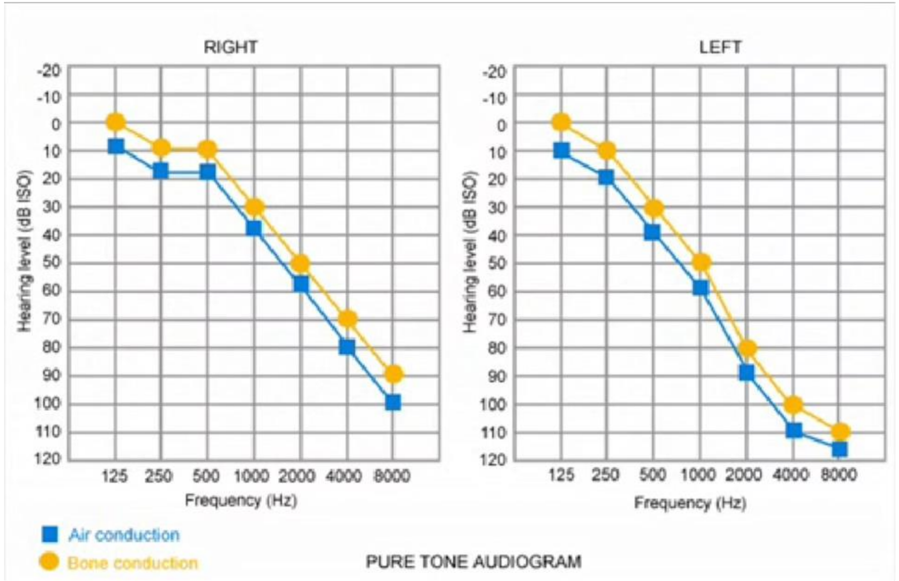
- Presbycusis usually manifests as a bilateral and symmetrical sensorineural hearing loss.

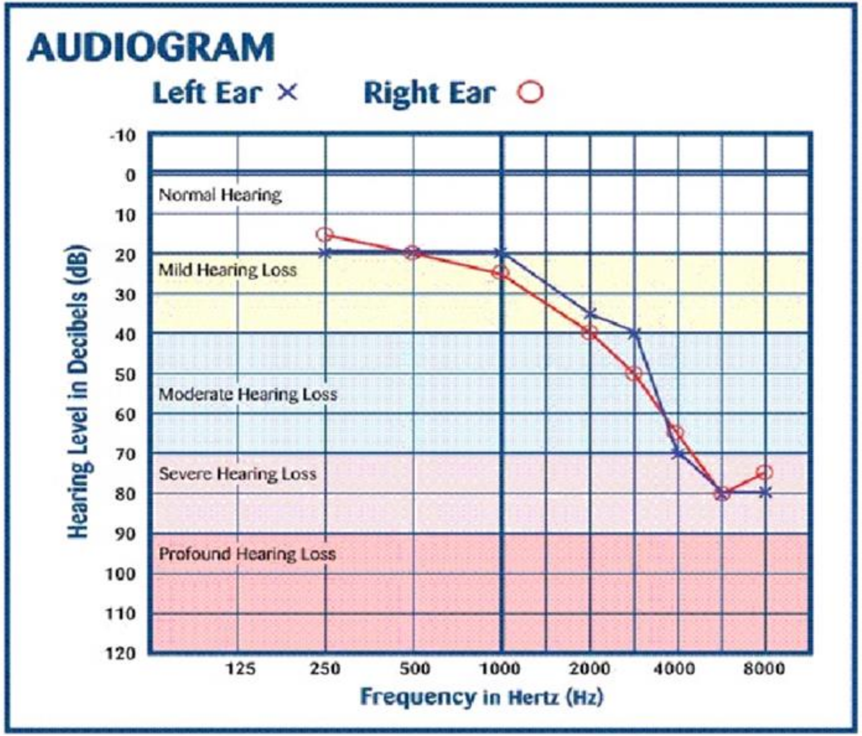
- Usually, the higher frequencies are most severely affected

- Onset of presbycusis typically occurs in middle-aged or older patients.

- Hearing loss is secondary to degeneration of the cochlea, cranial nerve VIII, and/or the central auditory system.

- The condition is usually slowly progressive.





* An example presbyacusis (sloping high-frequency hearing loss) synonymous with the ageing process.

Speech audiometry

Two parameters are studied:

(i)Speech recognition threshold

(ii)Speech awareness

speech-recognition threshold (SRT)

The speech-recognition threshold (SRT) is sometimes referred to as the speech-reception threshold.

The objective of this measure is to obtain the lowest level at which speech can be identified at least half the time.

Speech-awareness threshold (SAT)

- Speech-awareness threshold (SAT) is also known as speech-detection threshold (SDT).
- The objective of this measurement is to obtain the lowest level at which speech can be detected at least half the time.

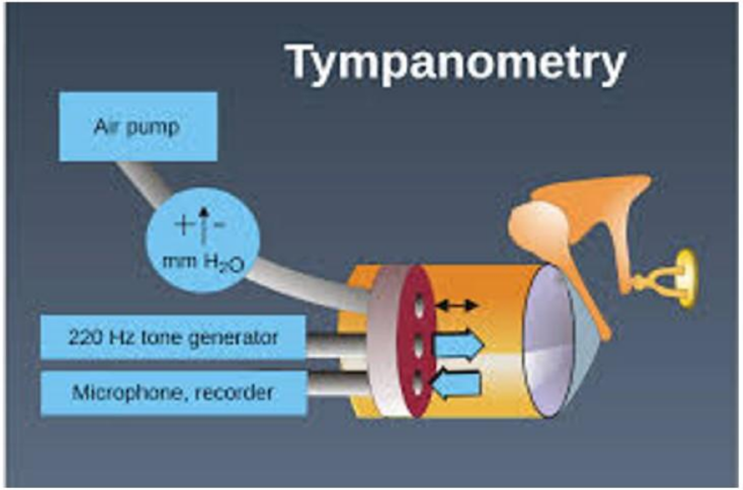
- The SAT is especially useful for patients too young to understand or repeat words.

- The SAT may also be used for patients who (1) speak another language or who (2) have impaired language function because of neurological insult.

- For patients with normal hearing or somewhat flat hearing loss, this measure is usually 10-15 dB better than the speech-recognition threshold (SRT) that requires patients to repeat presented words.

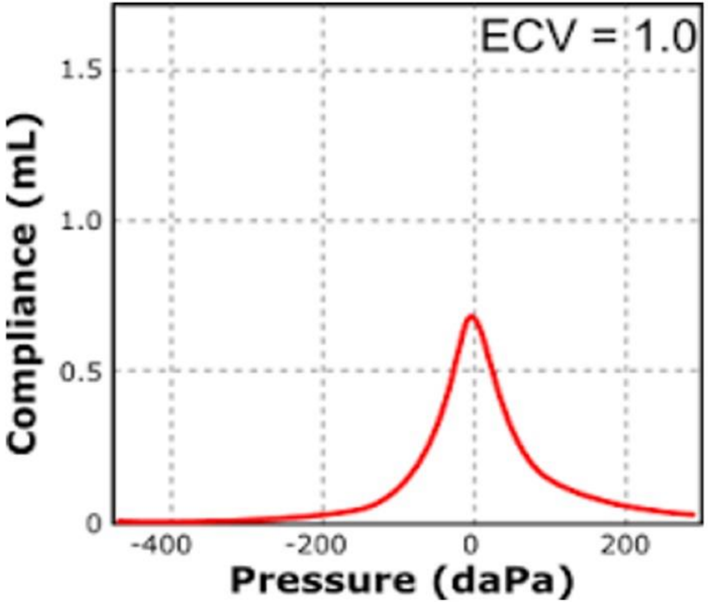
Impedance audiometry (Tympanogram)

- The primary purpose of impedance audiometry is to determine the status of the tympanic membrane and middle ear via tympanometry



- A **type A** response suggests **normal** middle ear function, but it occurs in some otosclerotic ears, particularly in early stages.

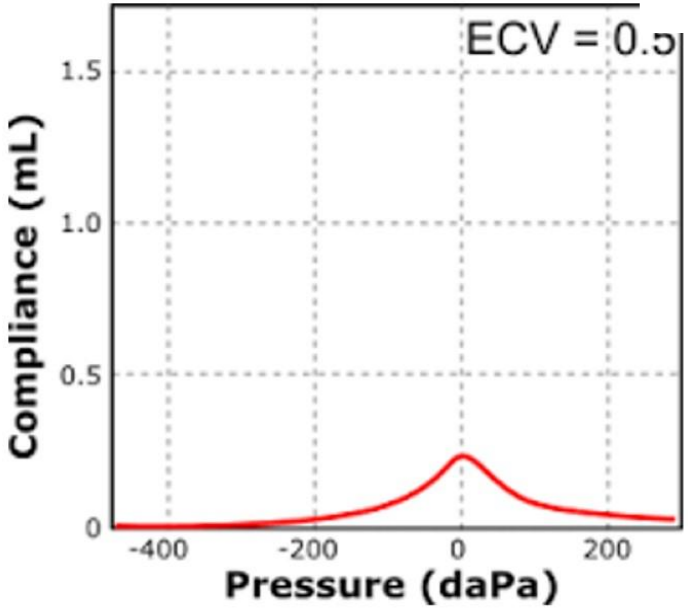
Peak is between +/- 100 daPa
Compliance from 0.3-1.5 ml



Type As (A shallow) suggests a **stiffened** (less compliant) middle ear system.

- Peak is between +/- 100 daPa
- Compliance is less than 0.3 ml

This type may suggest, **otosclerosis and malleus fixation**

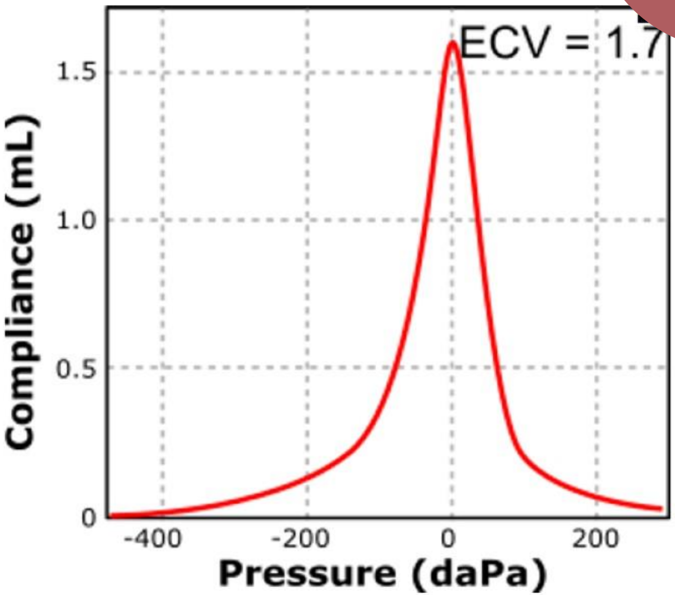


Type Ad High compliance at or near normal pressure.

- Peak is between +/- 100 daPa
- Compliance is more than 1.5 m

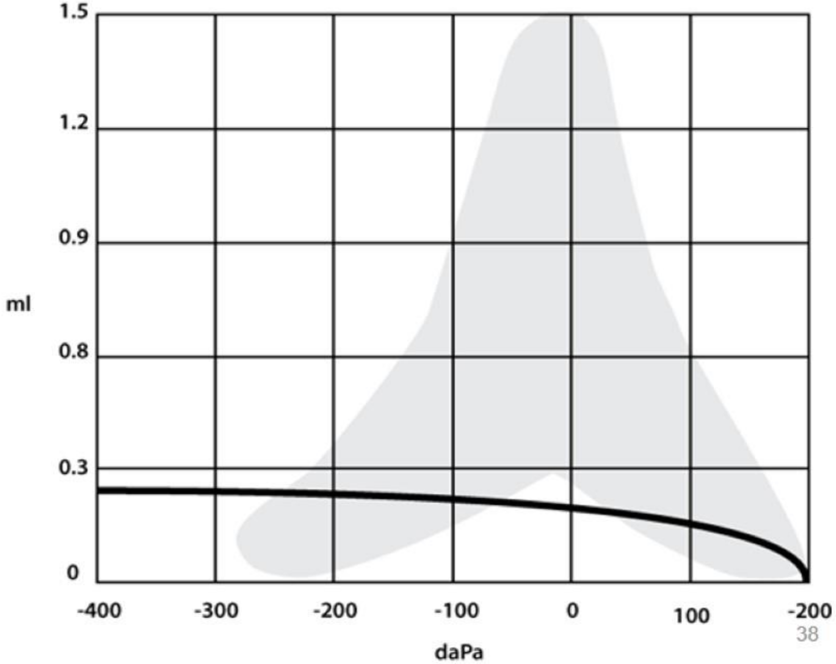
Seen in **ossicular discontinuity or thin and lax tympanic membrane**

Post-stapedectomy.



Type B tympanogram

Type B A flat or dome-shaped graph. No change in compliance with pressure changes.



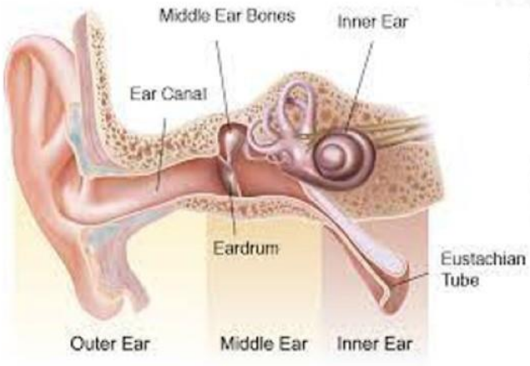
Type B tympanogram

- . Type B tympanograms must be interpreted in conjunction with **ear canal volume** readings.
  - Average ear canal volumes for children are 0.5-1.0 mL.
  - Average adult volumes are 1.0-1.5 mL.
- Type B (**normal** ear canal volume) usually suggests **otitis media.**
- Type B (**small** ear canal volume) may suggest that the ear canal is occluded with **wax/debris** or that the immittance **probe** is pushed against the side of the ear canal.

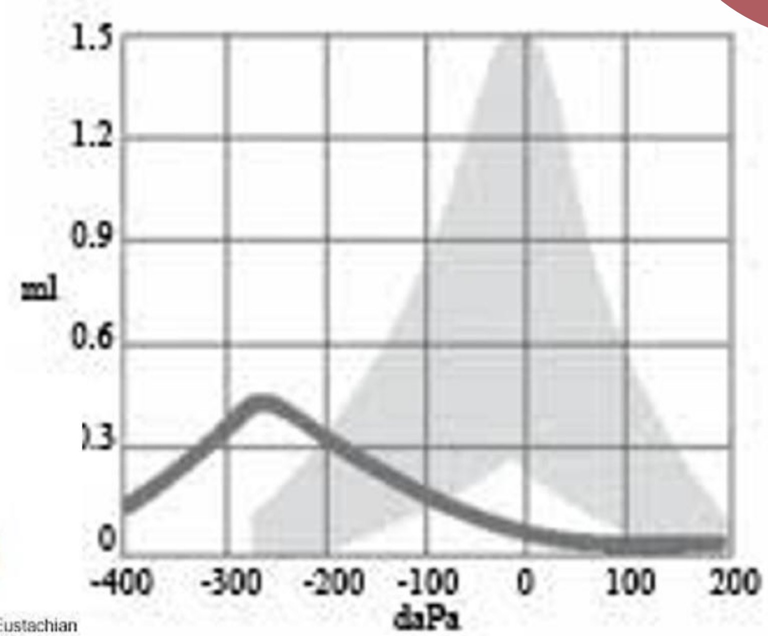
Type B (**large** ear canal volume) suggests a **perforation of the tympanic membrane**. (because middle ear volume is added up to the volume of external ear canal)

Type C suggests significant negative pressure in the middle ear system

Additionally, this type indicates a **malfunctioning eustachian tube.**



Peak is below –100 daPa
Compliance from 0.3-1.5 ml



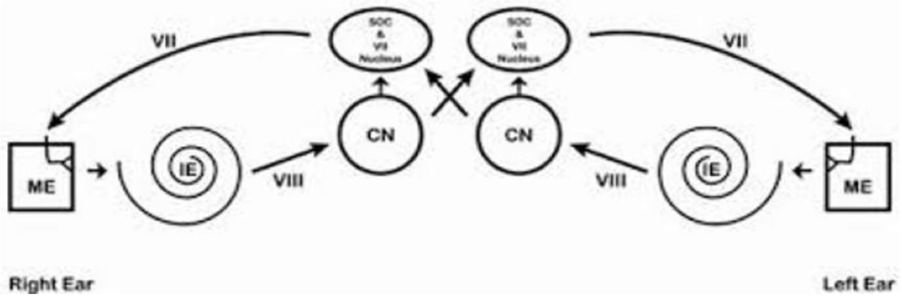
Acoustic reflex

It is based on the fact that a loud sound, 70 - 100 dB above the threshold of hearing of a particular ear, causes bilateral contraction of the stapedial muscles which can be detected by tympanometry

- A person who feigns total deafness and does not give any response on pure tone audiometry but shows a positive stapedial reflex is

a malingerer

- In otosclerosis >decreased reflex

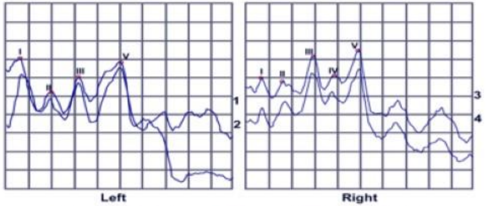


Brainstem Evoked Response Audiometry (BERA)

Alternative Name: Auditory Brainstem Response (ABR) Audiometry

ABR Audiometry

- Auditory brainstem response (ABR) audiometry is a neurologic test of auditory brainstem function in response to auditory (click) stimuli.
  - It is a test of the ***central pathways***.
- Used for **screening for retrocochlear pathology(**such as **an acoustic neuroma** or **vestibular schwannoma.), universal newborn hearing screening**, and **intraoperative monitoring**.



I	1.60 ms	I-III	2.56 ms	I	1.68 ms	I-III	2.32 ms
II	2.96 ms	III-V	1.88 ms	II	2.64 ms	III-V	1.96 ms
III	4.16 ms	I-V	4.44 ms	III	4.00 ms	I-V	4.28 ms
IV		V/I		IV	4.92 ms	V/I	
V	6.04 ms			V	5.96 ms		
Contra V				Contra V			

Left Right

Normal adult ABR waveform response. I-V absolute latencies and interpeak intervals (I-III, III-V, I-V) are within normal limits bilaterally. Interaural differences for the I-V interpeak intervals (1.16ms) and wave V absolute latencies (.08 ms) are within normal limits.

Otoacoustic Emission

- The primary purpose of otoacoustic emission (OAE) tests is to determine **cochlear status, specifically hair cell function**.
- This information can be used to:
  - Screen hearing (particularly in neonates, infants, or individuals with developmental disabilities)
  - Partially estimate hearing sensitivity within a limited range
  - Differentiate between the sensory and neural components of sensorineural hearing loss.
  - Test for functional (feigned) hearing loss
- Does not measure the central pathway

THANK YOU