Lecture 1

Editing File

There is a long version of this lecture from 437 if you would like more info about this topic. Doctor said all the question won't come out of this lecture

Audiology

Presented by Dr. Murad Almamoni

Lecture Objectives:

- ★ PTA, tympanometry and impedence (speech & ABR in brief)
- ★ Vestibular tests in brief.
- ★ Identify type, degree and configuration of hearing loss.
- ★ Identify possible site of lesion for each type of hearing loss.
- ★ Determine middle ear function from Tympanometry measurement.
- ★ Understand origin, indications and clinical applications of OAE, ABR and speech audiometry.

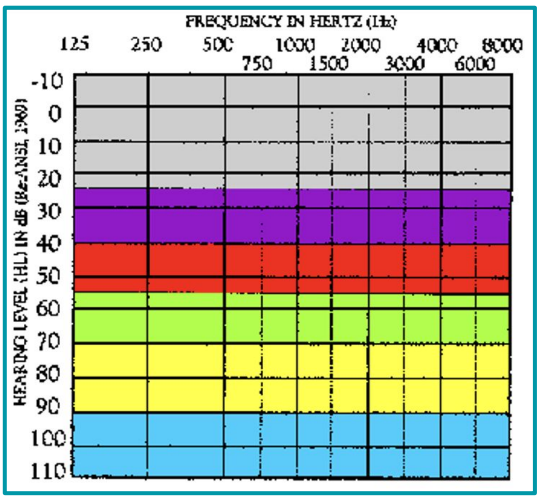
Color Index:

Important Original content Doctor's notes
Golden Notes Extra

Pure Tone Audiometry

◀ Ranges of Hearing Loss

- -10 – 25 dB HL = Normal range.
- 26 – 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



PTA (Audiogram)

Pure tone audiometry :
Play a tone and ask the patient to raise their hand if they hear it over multiple frequencies.
Air conduction : tested by using headphones. Bone conduction : tested by using oscillator "bone vibrator"

The purpose of PTA : provide a **quantitative** measurement of hearing thresholds
(" threshold"is the lowest intensity in which a patient can hear a tone 50% of the time)

- If the slope between 2 adjacent points is too big (>20 db difference) we need to test the interoctaves (e.g.between 500 & 1000).
- The decibel itself has no meaning unless we assign a reference to it known as sound pressure level (we don't use atmospheric pressure cause it's variable).

Audiometry results are recorded on an audiogram .
X-axis → frequency (in Hz) Tone

- Human ear can hear from 20-20000 hz but we test this range cause it's the most important (useful)
  - (include speech sounds, environmental sounds etc…), most sensitively (1000-4000 Hz)
- Speech sounds are usually below 8000 Hz (500-2000 Hz) → that's why we don't need to test higher frequencies "above 20000"(except in infection or ototoxicity because ototoxicity affects high frequencies first so we test extra-high frequencies in this case). (Ex: chemotherapy)

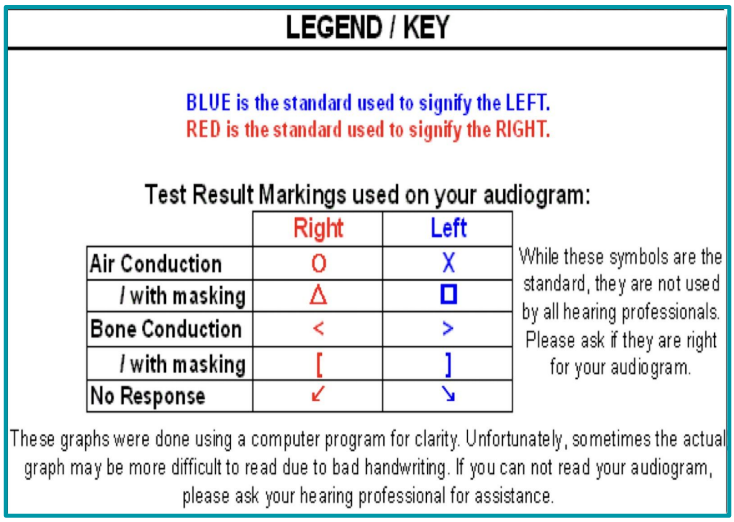
Y-axis → amplitude (in Db) Volume at which the pt can hear the tone

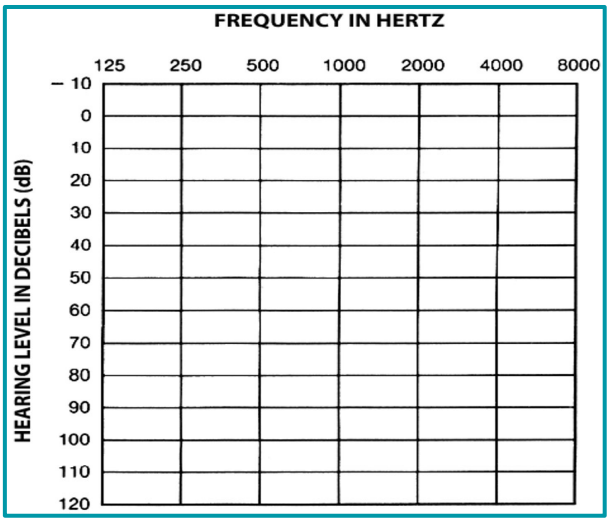
- **The 0** : Average hearing threshold "mean"
  - (measured by calculating the average of the hearing threshold of a group of people.)
- **Between -10 and 25** "the gray area" → Normal hearing
  - Anything above that is a degree of hearing loss.
- **- 10** : means the hearing pressure is better than the average of normal hearing.
  - It's a relative scale thus -ve values exist (relative to the general population).

In the exam we'll have 2-3 questions:

- MCQ: we'll be given an **audiogram** and asked to interpret it (diagnosis), we'll also be asked about middle ear assessment, type of **tympanogram**,tympanometry results, interpret results, underlying cause (pathophysiology). Doctor said he might include question about OAE & ABR.
- SAQ: we'll be given a graph (audiogram, tympanogram, ABR) and asked what is the hearing level? What could have caused this hearing loss.

Pure Tone Audiometry Con.





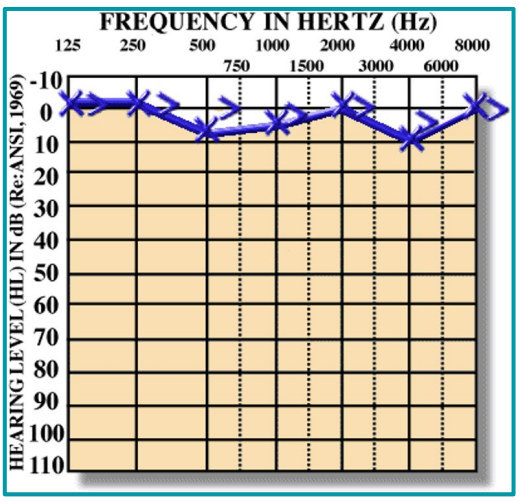
* **Important to know symbols**, and no need to know masking at your level

1. **Determine is it air or bone conduction by the symbols**
   a. Air conduction: Tested by headphones
   b. Bone conduction : Tested by Placing the bone vibrator on the mastoid or the temporal bone (mastoid is used because its prominent and there isn't much tissue around it)

   *Bone conduction is better than air conduction.
2. **Is the bone and air threshold within normal range ?**
3. **Determine type of hearing loss by : (Gap)**
   a. Comparing the bone threshold to the air threshold

Masking is applied to the opposite ear to prevent tones from stimulating the untested ear. Masking consists of playing a distracting sound in the non-tested ear, this creates a state of refractoriness in the opposite ear hair cells → not stimulated by sounds played in the tested ear

Normal Hearing



- This is a left ear (note blue lines)
- > = Bone conduction X = Air conduction.
- **Both air and bone conduction are normal**
- If air conduction is normal then no need to test bone conduction because bone conduction is always equal or better than air conduction.
- Hyperacusis will be less than -10 dB HL → one cause is facial nerve palsy.

Exam questions !

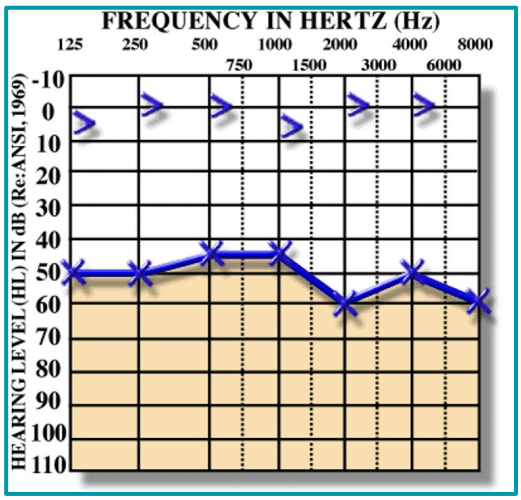
An audiogram:

1. Identify the type and degree of hearing loss
2. Where is the predicted lesion site ?
3. What is the management?

Pure Tone Audiometry Con.

◀ Ranges of Hearing Loss

In the exam there will be pictures asking type of hearing loss



Conductive Hearing Loss

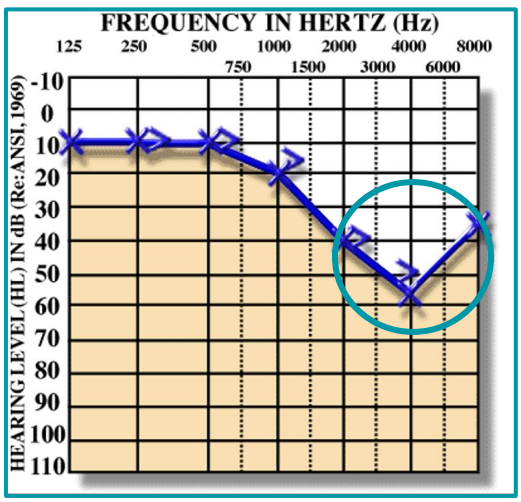
Bone conduction thresholds : Within normal range
Air conduction thresholds : Above the threshold (abnormal)
Gap between AC and BC : >10 dB

Etiology
Pathology in the conductive pathway (if there is anything in outer or middle ear) *Inner ear is normal

- Foreign body
- cholesteatoma
- Dislocation of ossicles
- Fluid accumulation
- Otitis media with effusion
- Tympanic membrane perforation
- Tumor
- Wax impaction
- **Otosclerosis:** shows Carhart's notch at around 2000 Hz

Management
Medical and surgical (release fluid from the middle ear, reconstruction of middle ear ossicles)

*Hearing loss is usually **temporary**



Sensorineural Hearing Loss

Bone conduction thresholds : Above the threshold (abnormal)
Air conduction thresholds : Above the threshold (abnormal)
Gap between AC and BC : <10 dB

- **Both** air and bone are **abnormal** (*more than 25 db) and there's **no gap** → **Sensorineural**.
  - A gab is (>10db)

Etiology

- **Inner ear :** (Noise exposure, labyrinthitis, cochlea fracture, Meniere's disease)
- **Nerve:** tumor (acoustic neuroma)
- **CNS :** (tumor in the pathway up to the brain, trauma)
- Otosclerosis starts conductive, then mixed, finally pure sensory neural)

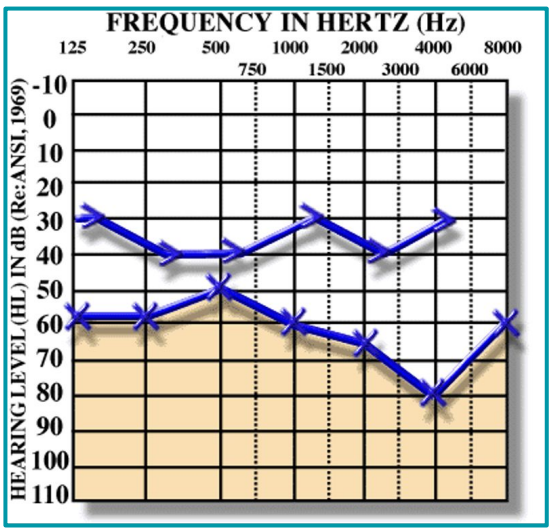
Management
Hearing aids, cochlear implant (Later)

*Hearing loss is usually **permanent** "once neurons are damaged they don't regenerate "

Noise exposure
Loud noises can cause SN hearing loss at higher frequencies without damaging the lower frequencies.

- This patient was exposed to loud noises (noises causes HL at 3000-4000 Hz range) → noises lead to a **Notched audiogram** at high frequencies (Boilermaker's notch)
- In the lower frequencies — Normal hearing. **High** frequencies — **Abnormal**.
- See the notch at high frequencies. **Notched Audiogram. (Blue Circle)**
- Ask the patient in history about work: could be in airport, working factories.

Pure Tone Audiometry Con.



Mixed Hearing Loss

Bone conduction thresholds : Above the threshold (abnormal)
Air conduction thresholds : Above the threshold (abnormal)
Gap between AC and BC : More than 10 dB

Both air and bone are **abnormal** and there's difference (**gap**) between bone & air conduction is more than 10 db
→ **Mixed hearing loss.**

Etiology
Both conditions of conductive and sensorineural

Otosclerosis
- More common in females , peak age 25-35
- It can be genetic and is worsened by pregnancy.

Early :
Initially there will be a **conductive hear loss** due to the calcification preventing the stapes from moving and transmitting the sound to the inner ear.

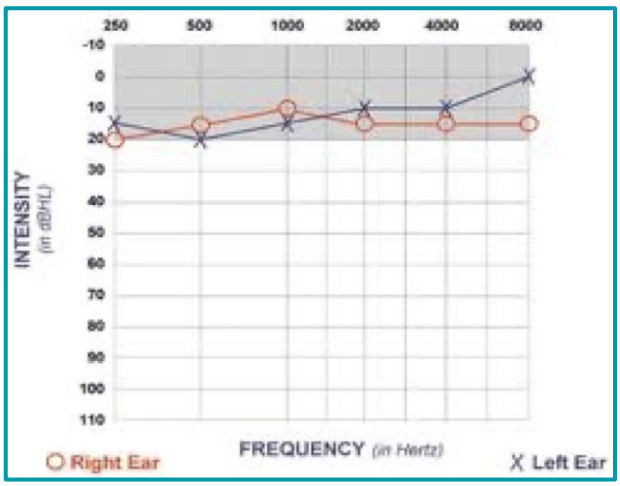
Late :
As the disease progresses there will be **sensorineural hear loss**; due to calcification affecting the cochlear sensory cells (hair cells)

It is the fixation of the stapes
Cause calcification on the oval window and inside the cochlea itself hence becomes mixed hearing loss.

Management
1. **Hearing aids**
2. **Stapedectomy** Removal of the stapes or part of it and replacing it with an artificial device
   a. Done to delay doing the cochlear implant
3. **Cochlear implant** when hearing aid is no longer useful

Conductive Hearing Loss	Sensorineural Hearing Loss	Mixed Hearing Loss
Air conduction is **abnormal**	Air conduction is **Abnormal**	Air conduction is **Abnormal**
Bone conduction is **normal**	Bone conduction is **Abnormal**	Bone conduction is **Abnormal**
The gap between air and bone conduction is >10 dB	The gap b/w air & bone conduction is **<10 dB**	The gap b/w air & bone **conduction is >10 dB**

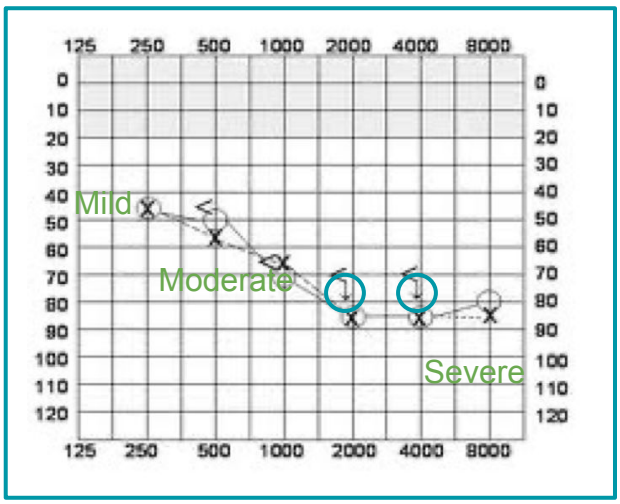
Pure Tone Audiometry Con.



Normal Hearing

Bone conduction thresholds : Within normal range
Air conduction thresholds : Within normal range
→ **Normal** hearing.

Hearing threshold for bone is **always** equal or better than air, so if air is normal bone can't be worse.



Bone conduction thresholds : Abnormal
Air conduction thresholds : Abnormal
Gap between AC and BC : < 10 dB
→ Mild sloping to severe SN hearing loss.

- Both air & air conduction abnormal + gap <10 dB
  → SN hearing loss.
- At the lower frequencies it is at the level of mild HL
- While at higher frequencies it slopes to severe HL.

Arrow : No response from the patient
Why we don't deliver a higher sound (80db) when the patient didn't respond to 70 db ?

- Because we can't produce a sound using bone vibrator with intensity more than 70db.

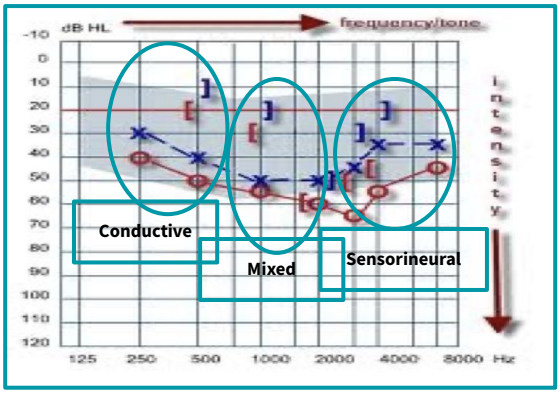
Therefore we can't know the bone hearing threshold form this audiogram (70 db is not the real threshold, the real one is probably more than 70 db).

How to determine the type of hearing loss ?
Based on this graph alone I will not be able to tell the type, we'll simply say I reached a maximum and there was no response, I need other test to determine the type by exclusion of other types

Rule out conductive hearing loss by

- **Tympanometry** (Middle ear assessment) : if there is no conductive pathology in middle and outer ear → it can't be mixed → sensorineural (by exclusion).

Pure Tone Audiometry Con.



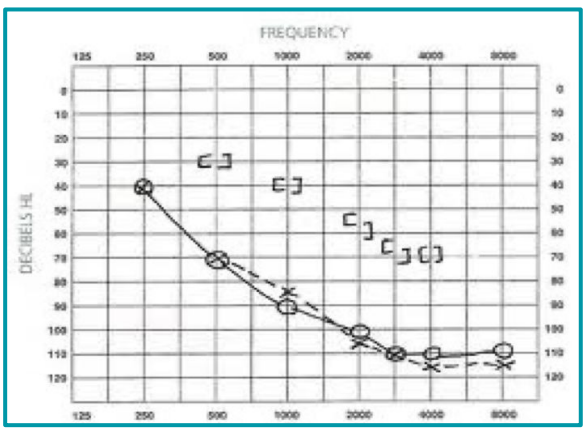
Moderate **conductive** hearing loss in **lower** frequencies
Moderate **mixed** hearing loss in **middle** frequencies
Moderate **sensorineural** hearing loss in **higher** frequencies.

Pathologies that can cause such an audiogram:

- Otosclerosis

Note** : we can have **more than one type** of hearing in the **same ear.

- **High** frequency tones stimulate : **Basal** turn of the cochlea (in the basilar membrane "BM")
  - The basal part is less protected → so most pathologies of the **inner ear** will have abnormal hearing of **higher frequencies** like ototoxicity which is usually not discovered until it's too late if we don't test the pressure frequently.
- **Low** frequency tones stimulate : **Apical** turn of the cochlea (in the BM)
  - **Middle** ear pathologies usually affect the **lower** frequencies.
- The **degree** of hearing loss is determined by the **AIR** conduction.

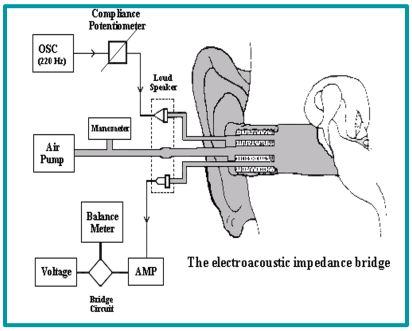


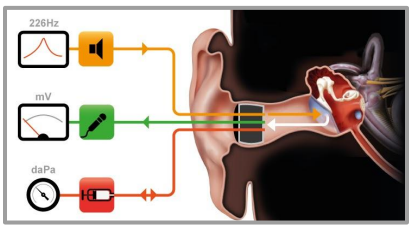
Mixed Hearing Loss

Mild sloping to profound **mixed** hearing loss.

Mixed because both air and bone conduction are abnormal + the gap is > 10 dB.

Tympanometry



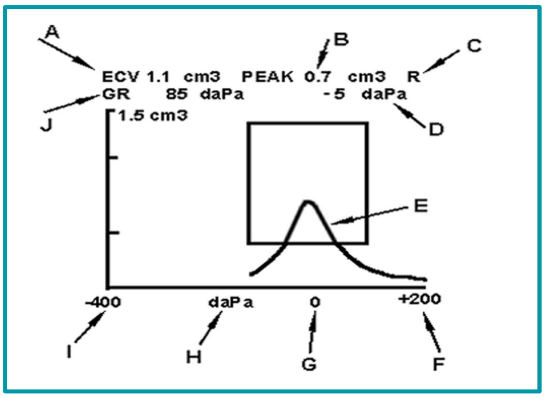


Use of tympanometry : Test middle ear function (where most pathologies occur) especially the Eustachian tube (as it functions in equilibrating the pressure between the middle air and the atmosphere. At this equilibrium state sound waves are maximally conducted through the middle ear)

The probe has 3 holes:

- Pump ⟶ for pressure
- Sound
- Mic ⟶ to see how much sound is reflecting back
  - More sound reflection means: more hearing loss
  - Less reflection means no or less HL

Tympanogram



Tympanogram
a graphic representation of the compliance of the tympanic membrane (TM) in response to different pressures, indicating how effectively the sound is transmitted into the middle ear

X-axis :
Represent the pressure
Pressure difference b/w the outer side of the tympanic membrane and inside.

- When they are equal (pressure difference is 0) ⟶ best pressure for hearing (peak ⟶ maximum compliance).
- Normal range is -100 to +50

Y-axis :
Represent the compliance of the TM (flexibility of the TM when different air pressures are introduced)

- Normal range from (0.3 - 1.4 in Adults, 0.2 - 0.9 in children).
- Unit ⟶ mmho (compliance unit)

ECV : Ear Canal Volume.

- External ear canal volume (normal range ⟶ 0.6-1.5).
- Differentiate between effusion and perforation
  - **Increases** with **TM perforation** (2.0 in children and 2.5 in adults is suggestive of perforation).
  - **Decreases** with **wax impaction.**
  - **Normal** : **Middle ear pathology (Effusion)**

Peak :
The point where maximum amount of sound is transferred through the middle ear.
(the pressure at which there is max compliance of the TM)

- Normal range is (-100 - +50). -5 daPa (in this patient)

Tympanometry Con.

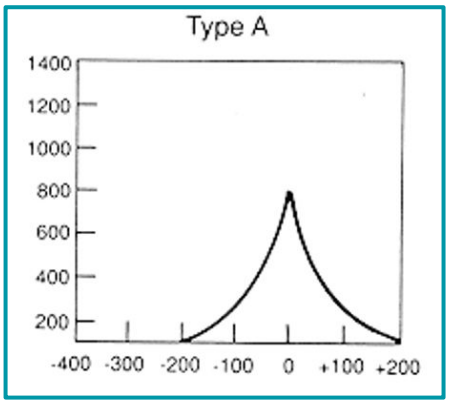
◀ Tympanometric Features

- Tympanometric shapes.
- Static acoustic admittance.
- Tympanometric width (gradient).
- Tympanometric peak pressure.
- Equivalent ear canal volume.

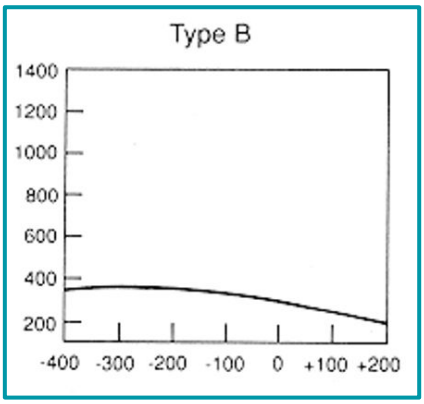
Notes:

- **Functions of the middle ear:**
  - Protection.
  - Amplification (17-20x).
- If there is no middle ear → pt will lose 50 dB of hearing → moderate conductive hearing loss (example → **Aural atresia** (congenital anomaly) where the inner ear is normal but the middle ear is ossified.
- In eustachian tube dysfunction → the compliance peak will be deviated to the negative side (left).

Exam Question !
Tympanogram with a case scenario
1. What is the type?



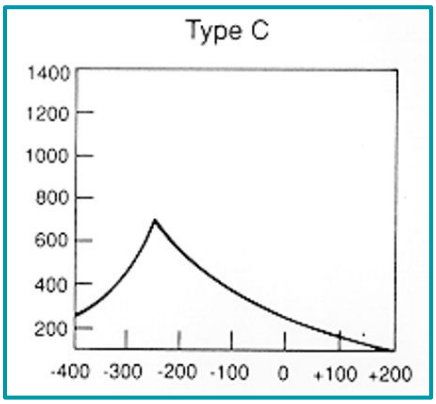
Normal
Peak between -100 & +50 daPa
(Peak within normal pressure and compliance)



Flat with no peak → either,
- Effusion of middle ear
- Perforation
- Thick TM or patent eustachian tube.

How to differentiate?
Look at **ECV**:

- High → perforation.
- Low → Wax/foreign body.
- Normal → Middle ear pathology: (Effusion)

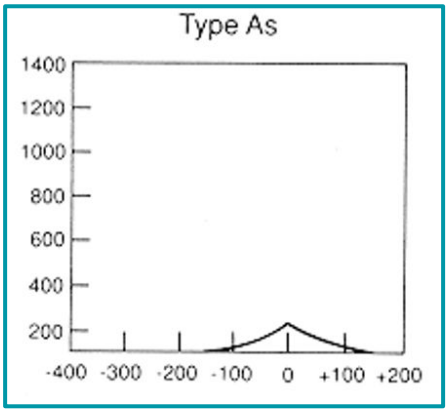


Eustachian tube dysfunction
Peak on the negative side (around -200)
Eustachian tube inflamed and won't open causing a -ve pressure

- Painful conductive hearing loss

Seen in :
Tympanic membrane retraction

Tympanometry Con.

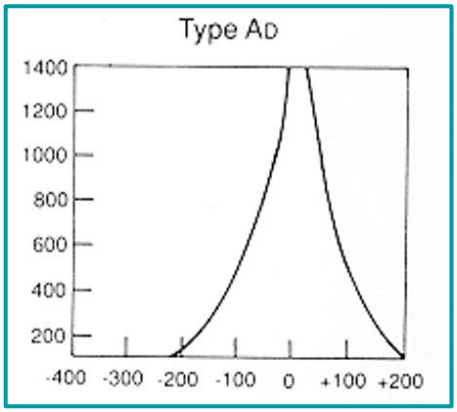


Peak : **Shallow** peak. (Less compliance)

Etiology

- Could be normal
- **Ossicular fixation**
- elderly patients (they lose elasticity of TM)
- **Otosclerosis**
  - ↓ movement of TM.
  - Conductive HL → later it becomes mixed → then pure SN HL
  - It is a congenital anomaly
  - More common in females

A subcategory of Type A;
S: stiff / shallow
Hypo-mobile admittance (low admittance)
Seen in pt in whom the stapes has become partially immobilized



Peak : TM easily movable resulting in a **high** peak.
→ Ineffective movement of the TM

Etiology

- **Dislocation of ossicles**
  - Mostly caused by accident (head trauma)
  - Multiple episodes of middle ear effusion → erosion
  - It leads to conductive hearing loss.
- **Thin and lax tympanic membrane.**

A subcategory of Type A;
D: deep / discontinues
Hypermobile admittance (high admittance)

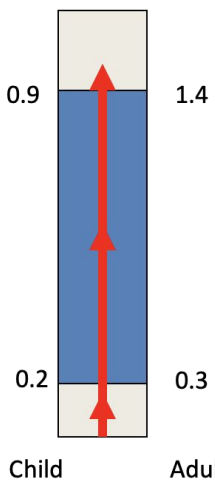
◀ Static Compliance (Peak Compliance)

- Acceptable Range by Age:

	Peak Compliance (mmho or cc)	Ear Canal Volume (cc)
Mean	0.5	0.7
90% range	0.2 to 0.9	0.4 to 1.0

Adults

	Peak Compliance (mmho or cc)	Ear Canal Volume (cc)
Mean	0.8	1.1
90% range	0.3 to 1.4	0.6 to 1.5



Flaccid: disarticulation, flaccid TM, etc.

Normal mobility

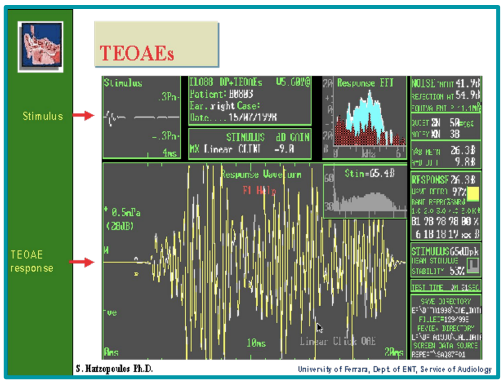
Stiff: otosclerosis fluid, tympanosclerosis, etc.

Otoacoustic Emissions

◀ Origin of OAE

Purpose of OAE : it's used to know the health of the Outer hair cells + Cochlea.

- Initially reported by Kemp in 1978.
- OAE are considered a by-product of sensory outer hair cells (OHCs) transduction and represent cochlear amplifier that thought to be as a result of the contraction of OHCs in synchrony with basilar membrane (BM) displacement.
- The contraction of the OHCs (movement) is then propagated outward toward the middle ear and moves the TM.
  - OHCs ⟶ basilar membrane ⟶ perilymph ⟶ oval window ⟶ middle ear ⟶ external ear to be picked up
- This in turn creates acoustic energy that is picked by the OAE probe. We put a mic behind the TM
- In order to record OAE in EAC we need to have normal middle ear function.



If waves are absent ⟶ problem of the cochlea or pathway is obstructed.

- If the **OHCs are intact** we can assume the **cochlea is intact too**
  - OHCs are the weakest, they're the first one to be affected in any ear pathology (Ototoxicity, infection, noise,..)
- OAE are **present** when the **OHCs are healthy.**
- OAE are **absent** when **OHCs are damaged.**
- If the **auditory nerve** or its subsequent pathway is **damaged** and **OHCs are intact** ⟶ **Normal OAE**, thus it differentiates between cochlear and retrocochlear causes of hearing loss.
  - (retrocochlear means beyond the cochlea into the neural pathway)

Types of OAE

- 1. Spontaneous OAE: produced without stimulus
- 2. Evoked OAE: with stimulus
  - Transient evoked (TEOAE): produced by individual tones, usually used for for 500-4000 Hz hearing loss, most sensitive at 500-1000 Hz
  - Distortion product OAE (DPOAE): produced by two simultaneous tones, usually used for 1000-8000 Hz hearing loss. Most sensitive at 4000 Hz

Exam Questions !

- **If the OAE is Normal, what is the expected type of tympanogram ? Normal type A**
- **Type B tympanogram, what do expect about OAE ? OAE Should be absent**

Otoacoustic Emissions

◀ Clinical applications of OAE

1. Can be used in **newborn hearing screening.** The results will indicate either fail or pass.
   Fail means that hearing thresholds are worse than 30 dB HL.
   Pass results means hearing thresholds are 30 dB HL or better. So, we can not use this tool to measure threshold of hearing.
   - TEOAE can be recorded in all non-pathologic ears that do not display hearing loss of greater than 30 dB.
   - OAE can be recorded in both adults and infants.
   - Accordingly TEOAE and DPOAE can be used to **screen for hearing loss in infants.**
   - DPOAE provide more frequency specific evaluation that TEOAE.

2. In **differential** diagnosis of hearing loss (site of lesion). This can help in differentiating **sensory** from **neural** hearing loss.

3. Monitoring of the effect of **ototoxicity or noise exposure** (can detect it earlier than pure tone audiometry, DPOAE is used as it is most sensitive for high frequency hearing loss).

4. Although still under research: DPOAE can be used to screen for the **carriers of the recessive hearing loss genes**: many studies found that DPOAE is larger (especially at high frequencies) in carriers than in non carriers when using f2/f1 of 1.3 and low stimulus levels of 50-60 dB.

5. Testing in in **uncooperative, mentally** challenged or **sedated** individuals.

6. Can also be used to uncover malingering patients (along with ABR, see next page)

◀ Clinical Limitations

- Problems because of middle ear disease.
- Not sensitive for neonates within 24 hours of birth.
- Results affected by test conditions, Noise.
- Not a test of hearing- limited application.
- False -ve results if the pathology causing the HL is beyond the cochlea (Auditory neuropathy) , need more tests (ABR)

ABR (Auditory Brainstem Response)

◀ Definition

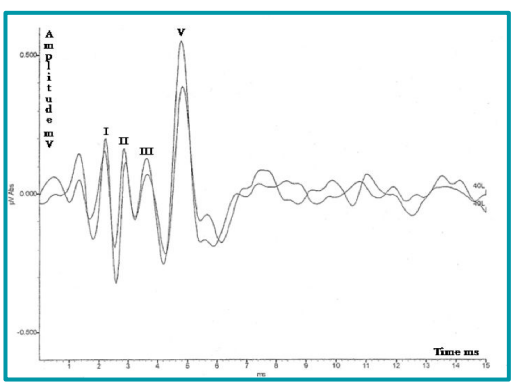
The auditory brainstem response (ABR) is an auditory evoked potential extracted from ongoing electrical activity in the brain and recorded via electrodes placed on the scalp.

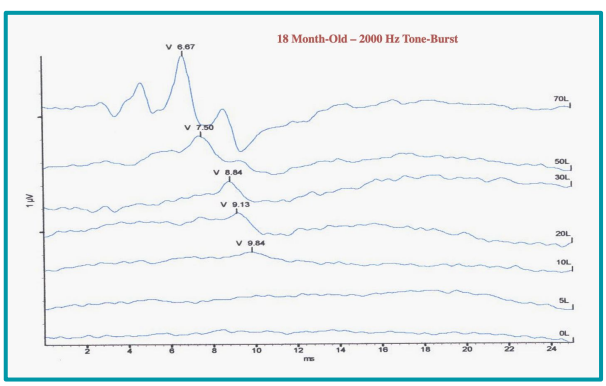
- It is used to localize retrocochlear causes of hearing loss
- Used when it is difficult to test the patient subjectively
  - (newborn, comatose etc).
- Screening process in newborns
  - Low-risk newborns: OAEs (if OAEs are abnormal do ABR to localize retrocochlear pathology)
  - High-risk newborns: Do OAEs and ABR together

◀ The normal ABR waveform:

- Characterized by 5-7 peaks.
- Occurs in a latency epoch of 1.4 - 8.0 ms.
- Responses are usually displayed with positive peaks reflecting neural activity towards the vertex.
- These peaks are labeled with roman numerals I through XII
- The most prominent waves are I, III, and V.
- Usually 3-7 waves are present
- Waves I, III, V are present in all normal ears

Proposed sites of waves (**EE COLI**)
Wave I: **E**ighth cranial nerve (distal part)
Wave II: **E**ighth cranial nerve (proximal part)
Wave III: **C**ochlear nucleus
Wave IV: Superior **O**livary nucleus
Wave V: **L**ateral lemniscus
Wave VI and VII: **I**nferior colliculus





- The lowest amplitude wave V exists at ⟶ is the **hearing threshold.**
- Here we can see that wave V disappears at amplitude of 10 dB ⟶ so this is normal hearing (because hearing threshold is within the normal value of (-10 - 25 dB).

ABR (Auditory Brainstem Response) Con.

◀ Using ABR to Estimate Hearing Thresholds

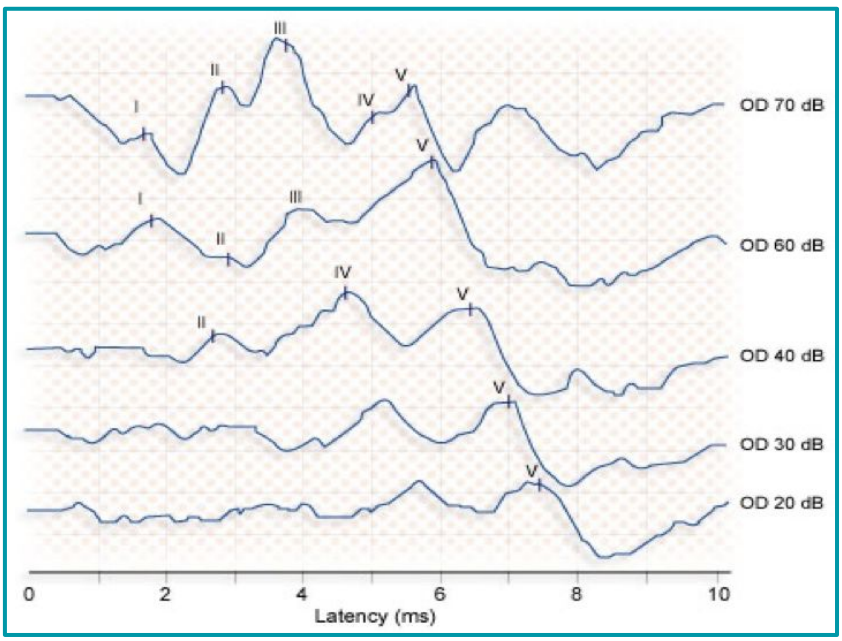
Hearing threshold: The lowest amplitude wave V exists at (Lowest sound that can provoke an electrical activity in the brain stem

- Can be obtained by progressively decreasing intensity of the stimulus (click or toneburst) and observing **wave V.**
- The **last intensity that wave V appears** at is considered its threshold.
- ABR threshold is within 10-20 dB from the subjective threshold.

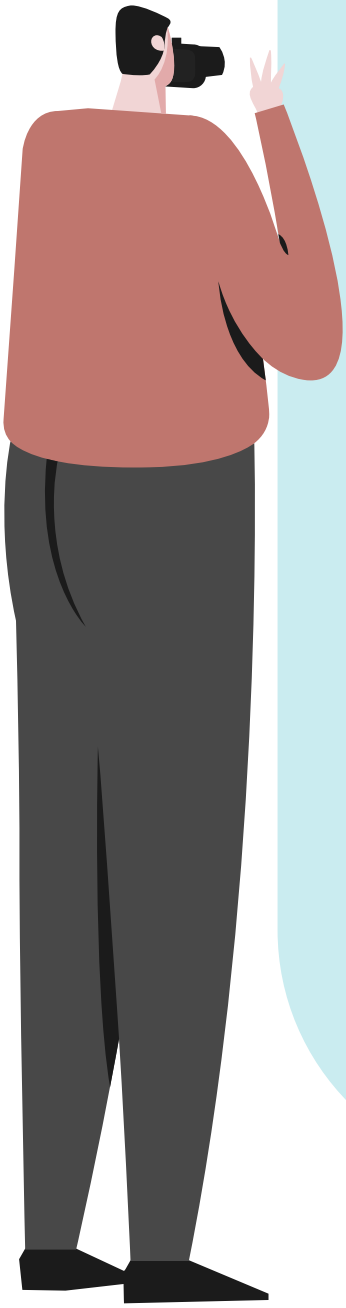
Exam Question !

Graph with labeled waves (I-V), what is the threshold ?

For example in this graph it's 20dB



THANK YOU!



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