Physiological Tests of the Auditory System

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Part 1
Otoacoustic Emissions (OAEs)

- OAEs: sounds that originate in the cochlea and propagate through the middle ear and into the ear canal where they can be measured using a sensitive microphone.

Types

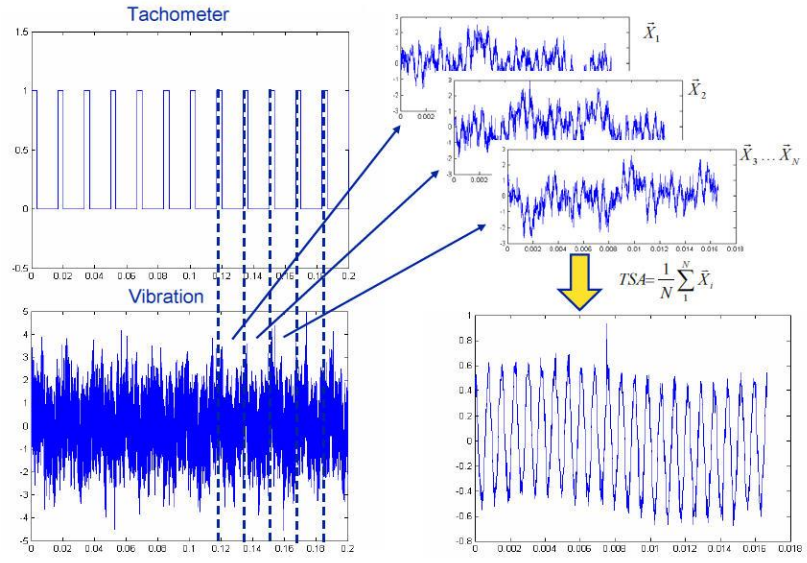
- SOAE
- EOAE:
  - TEOAE
  - DPOAE

Measurement of OAEs

- Probe: Houses the microphone and the sound source. Fits into the ear using a foam or rubber tips.
- Microphone: To record the OAEs coming from the ear.
- 2 Sound Sources.
- Amplifier.

Averaging

- OAEs are low level signals.
- Time-synchronous averaging is used.



Noise

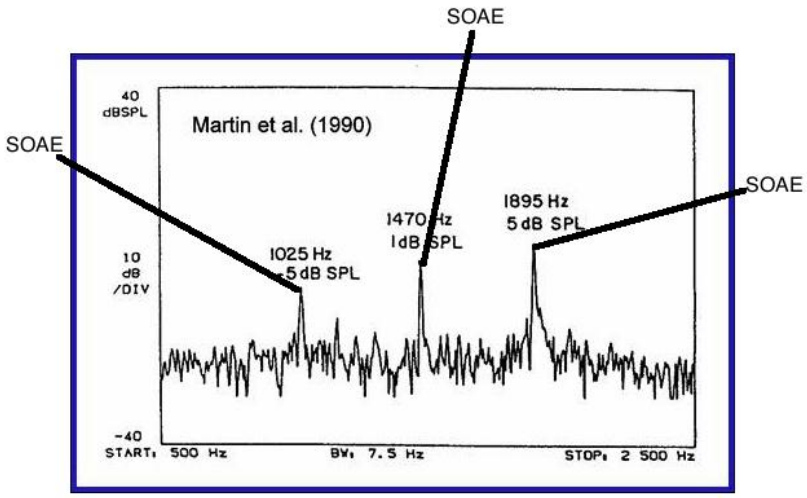
- Noise Sources: Environmental and internal.
- Effect on OAE size and test time.

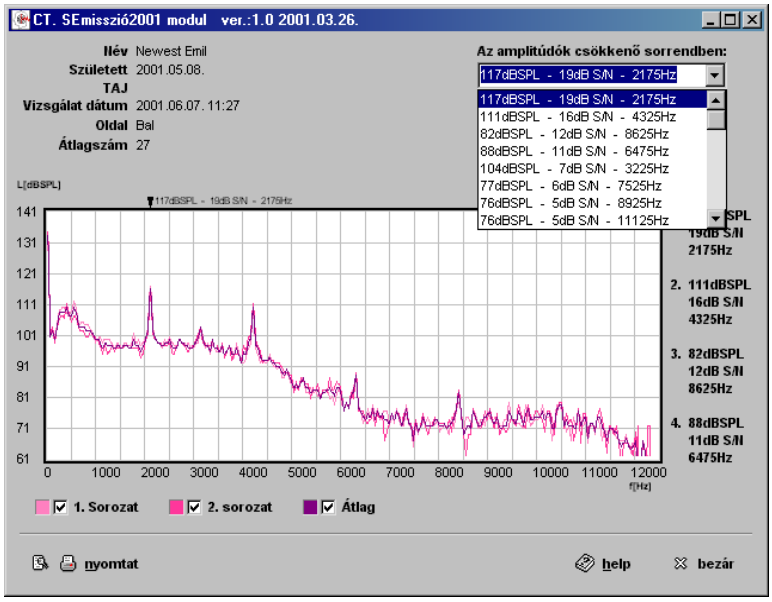
Types

- SOAE generated in the absence of an acoustic stimuli.
- TEOAE are generated by clicks or tone bursts.
- DPOAE are generated by tow continuous tones presented to the ear.

Spontaneous Otoacoustic Emissions (SOAE)

- Microphone amplifies the output.
- The output is viewed in the frequency domain.
- Adults mostly 1 and 2 kHz.
- Infants mostly 2 and 5 kHz.
- Only in 50% of normal hearing individuals.
- Not useful clinical test.
- The typical frequency range is from 1000 to 3000 Hz, while the amplitude varies between -10 and +10 dB SPL.
- Inaudible to the person in whom it is measured.
- It is possible to have more than one SOAE in one ear and to have otoacoustic emissions in both ears.

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Név Newest Emil
Született 2001.05.08.
TAJ
Vizsgálat dátum 2001.06.07. 11:27
Oldal Bal
Átlagszám 27
Az amplitúdók csökkenő sorrendben:
117dBSPL - 19dB S/N - 2175Hz
111dBSPL - 16dB S/N - 4325Hz
82dBSPL - 12dB S/N - 8625Hz
88dBSPL - 11dB S/N - 6475Hz
104dBSPL - 7dB S/N - 3225Hz
77dBSPL - 6dB S/N - 7525Hz
76dBSPL - 5dB S/N - 8925Hz
76dBSPL - 5dB S/N - 11125Hz
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3. 82dBSPL 12dB S/N 8625Hz
4. 88dBSPL 11dB S/N 6475Hz
1. Sorozat
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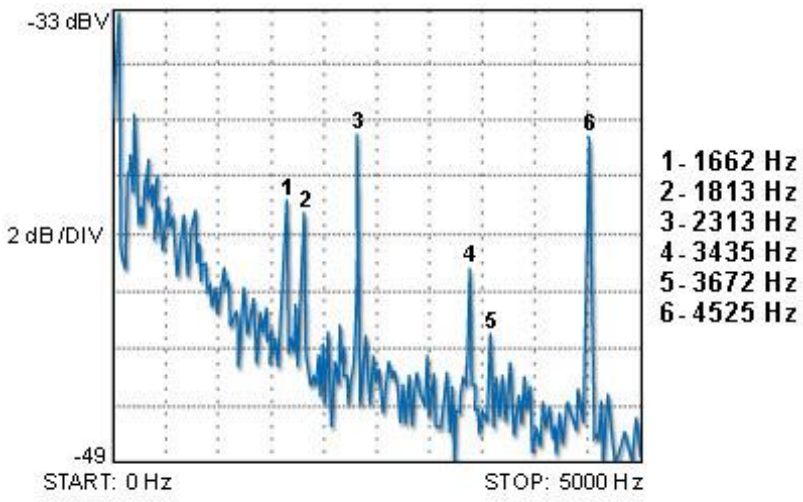
Átlag
nyomtat
help
bezár


-33 dBV
2 dB/DIV
-49
START: 0 Hz
STOP: 5000 Hz
1
2
3
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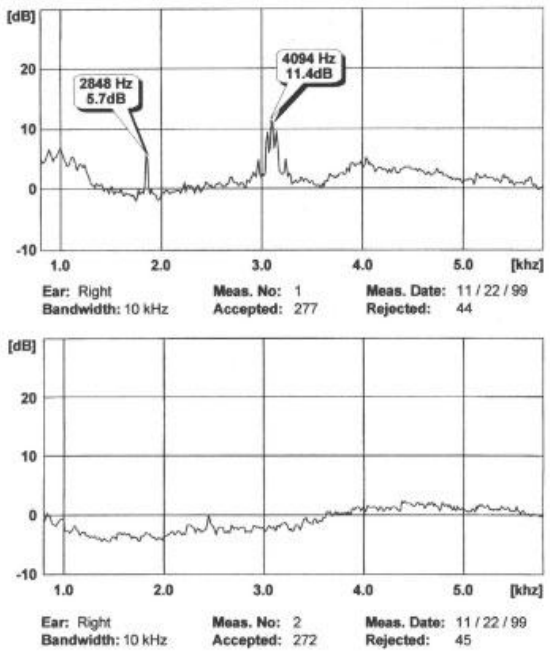
1 - 1662 Hz
2 - 1813 Hz
3 - 2313 Hz
4 - 3435 Hz
5 - 3672 Hz
6 - 4525 Hz

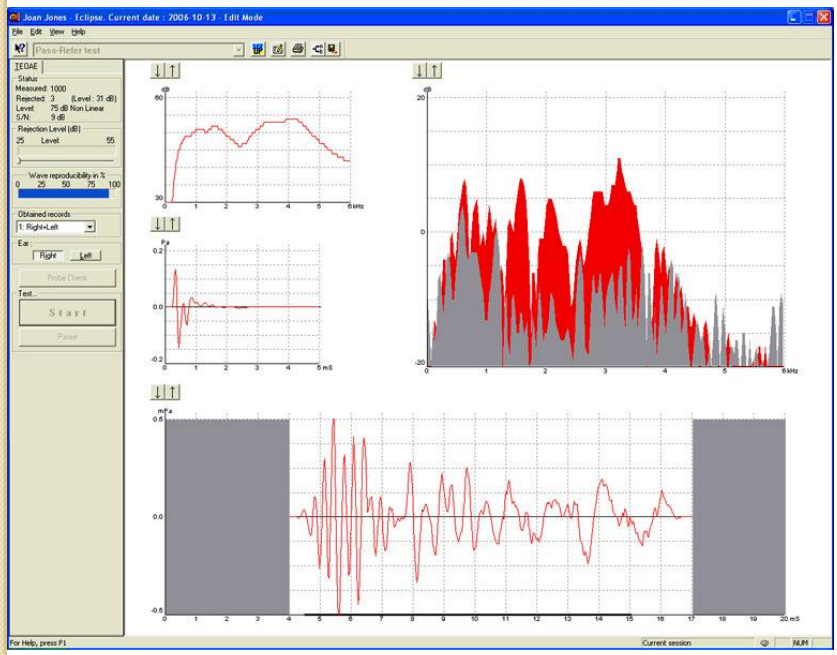


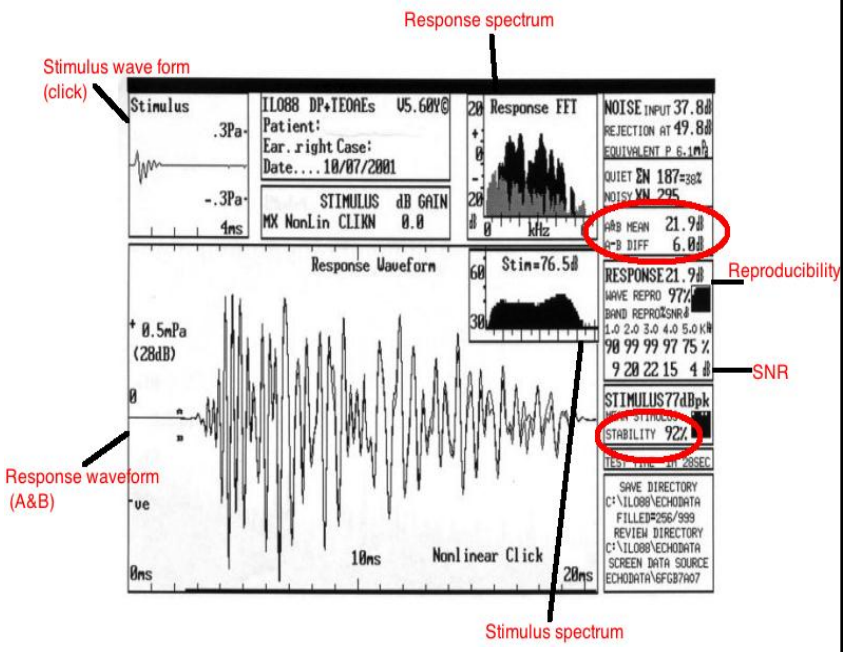
Evoked Otoacoustic Emissions (EOAEs)

- Occurs either during or immediately following acoustic stimulation.
- Two major types: TEOAEs and DPOAEs.
- EOAE testing has come into the clinical use in:
  - The differential diagnosis of sensory/neural hearing
  - Hearing screenings of infants and other difficult-to-test patients
  - The monitoring of outer hair cell function in high-level noise exposure patients or patients undergoing ototoxic medication

Transient-Evoked Otoacoustic Emissions (TEOAEs)

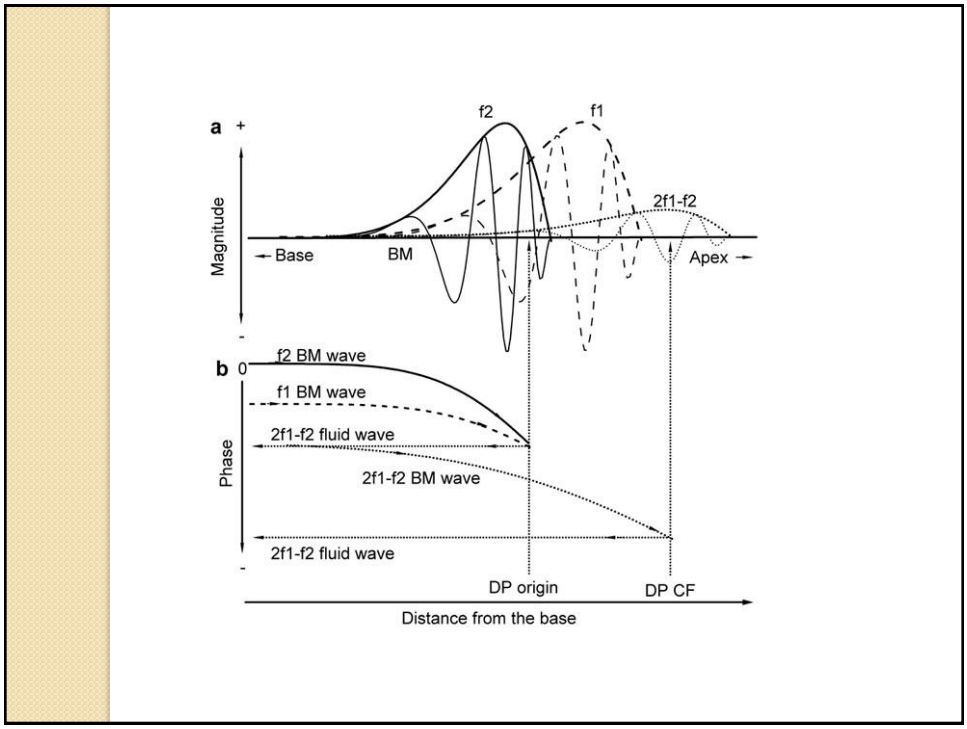
- TEOAEs are low level signals, such as clicks or tone pips.
- Signal-averaging equipment is used.
- Present in ears with normal sensitivity and normal middle ear function.
- Absent in the case of a SNHL that is about 40 dB.
- Stimulus wave form.
- Stimulus spectrum (the energy of clicks is always spread over a wide frequency range).

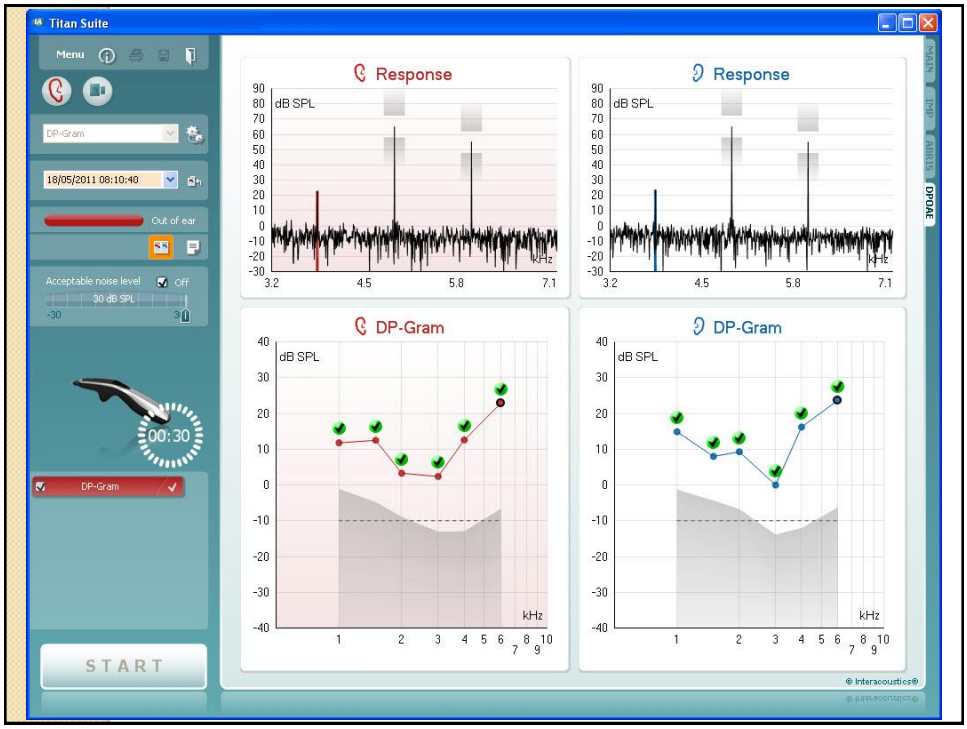




DPOAEs

- The cochlea acts as a nonlinear system.
- Distortion: the output of energy at frequencies other than those contained in the input stimulus.
- Measured simultaneously with the presentation of two pure tone (primaries).
- Frequencies F1, F2 while F2>F1
- Levels L1, L2.


a
+
-
Magnitude
f2
f1
2f1-f2
Base
BM
Apex
b
0
Phase
f2 BM wave
f1 BM wave
2f1-f2 fluid wave
2f1-f2 BM wave
2f1-f2 fluid wave
DP origin
DP CF
Distance from the base


Titan Suite
Menu
DP-Gram
18/05/2011 08:10:40
Out of ear
Acceptable noise level
Off
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Response
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DP-Gram
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kHz
DPOAE
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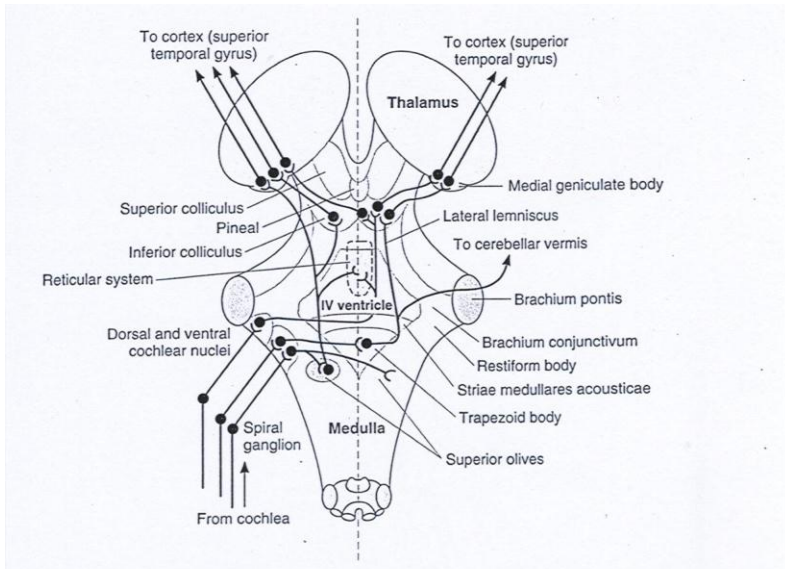
DPOAEs

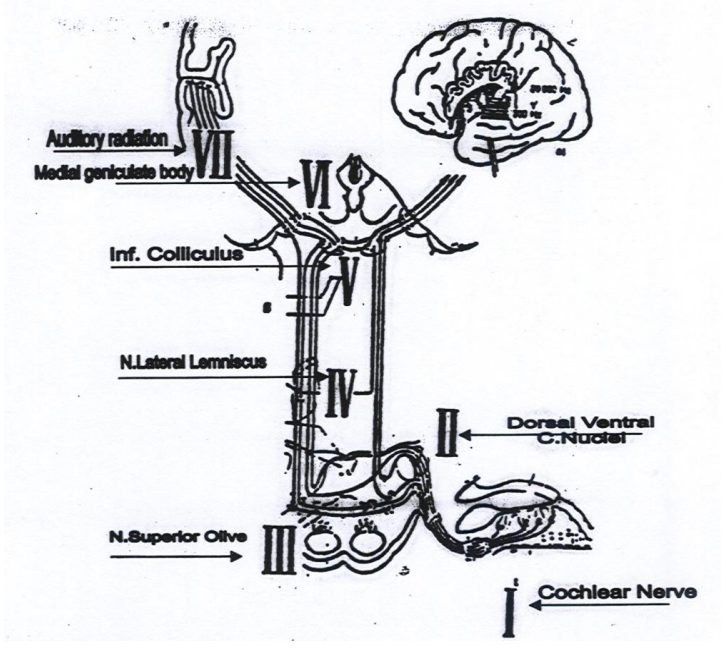
- Present in ears with normal sensitivity and normal middle ear function.
- The hearing loss must not exceed 40 – 50 dB like the TEOAEs

Part 2
Auditory Brain-Stem Response (ABR)

- Auditory brainstem response (ABR) is a neurologic test of auditory brainstem function in response to auditory (click) stimuli.
- It's a set of seven positive waves recorded during the first 10 milliseconds after a click stimuli. They are labeled as I - VII
- ABR typically uses a click stimulus that generates a response from the hair cells of the cochlea, the signal travels along the auditory pathway from the cochlear nuclear complex to the inferior colliculus in mid brain generates wave I to wave V.



i. Simplified diagram of main auditory pathways superimposed on a dorsal view of the brain stem. Cerebel-rebral cortex removed.



Origin of each wave

Wave	Origin
I	Cochlear nerve
II	Dorsal & Ventral cochlear nucleus
III	Superior olivary complex
IV	Nucleus of lateral lemniscus
V	Inferior colliculus
VI	Medial geniculate body
VII	Auditory radiation(cortex)

Electrode placement (Montage)

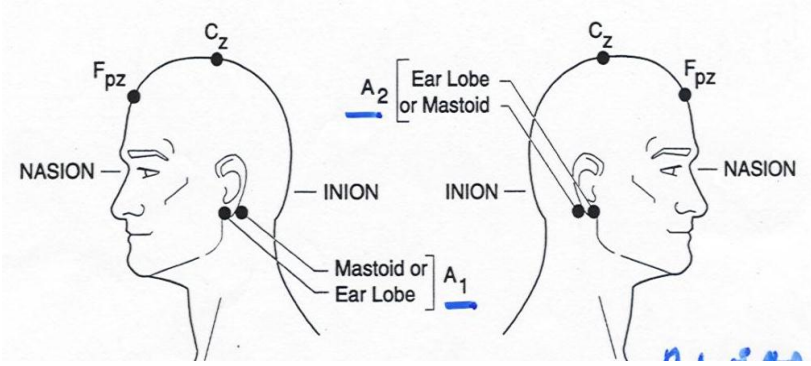
- Cz (at vertex) (recording electrode)
- Ipsilateral ear lobule or mastoid process (reference electrode).
- Contra lateral ear lobule (act as a ground)

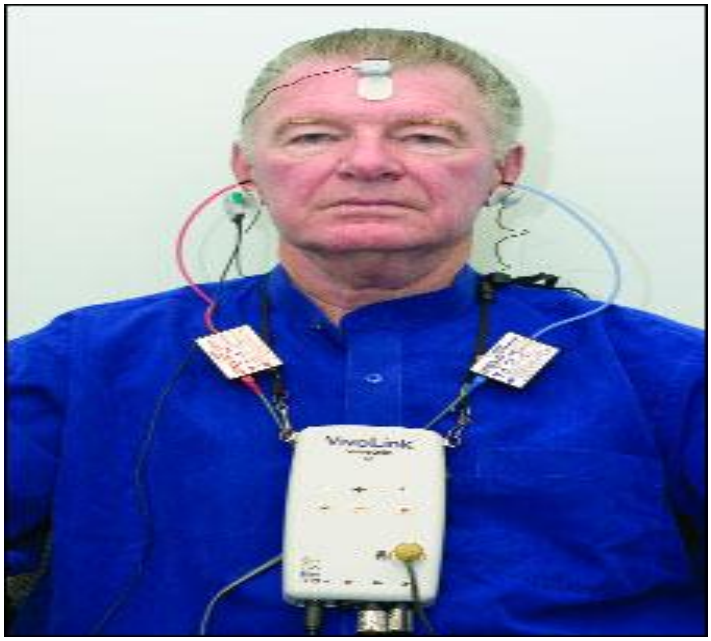
Procedure

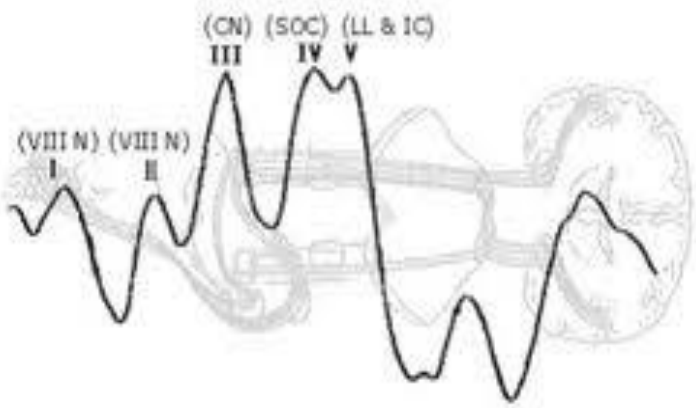
- Subject is seated in a comfortable chair or lay down on a bed with a pillow under his head.
- Room should be quite and the lights are dimmed.
- Clean the skin & apply a conductive paste or gel then attach the electrodes.
- Check the impedance.
- Apply the ear phone (red for the right ear & blue for the left ear)
- Select the ear in the stimulator

Procedure

- Stimulation rate : 11/sec.
- Repetition : 1000 to 2000 clicks
- Find out the threshold of hearing.
- ABR should be done at around 70 dB nHL.
- Start averaging process & continue until the required repetition accomplished.
- Calculate the peak – interpeak latencies for the ABR waves.




VivoLink


(CN) (SOC) (LL & IC)
III IV V
(VIII N) (VIII N)
I II

Normal values

- Peak latency of a wave = less than the next higher nomber wave
- Or just add 1 to that wave, latency will be less than that.

eg. Latency of wave 1 is less than 2.

Wave	Latency
I	<2mSec.
II	<3 m.sec
III	<4 m.sec
IV	<5 m.sec
V	<6 m.sec
VI	<7 m.sec

Identification of waves

- Identify wave V which is the most persitent wave. It comes as IV-V complex, and wave V comes to the base line.
- Go in reverse order, wave IV, III, II, & I.
- Also observe their latencies, eg. latency of wave I will be less than 2mSec.

Calculation & Analysis

- Write down the absolute peak latencies for the waves
- Find out the interpeak latencies of I – III, III – V and I – V.

Interpretation

- Wave I : small amplitude, delayed or absent may indicate cochlear lesion
- Wave V : small amplitude, delayed or absent may indicate upper brainstem lesion
- I – III inter-peak latency: prolongation may indicate lower brainstem lesion.
- III – V inter-peak latency: prolongation may indicate upper brainstem lesion.
- I – V inter-peak latency: prolongation may indicate whole brainstem lesion. Shortening of wave the interval with normal latency of wave V indicate cochlear involvement.

Part 3
Tympanometry

- Is a test of middle-ear function by measuring the middle-ear pressure (the mobility of the tympanic membrane)
- One of the audiological test battery procedures

Tympanometer Components

- Three main tubes in the probe (probe tube)

1- loudspeaker: generates the tone and is transmitted through the speaker (low pitch constant sound into the ear canal, 226 Hz for adults and 1k Hz for children less than 6 months years old).

2- microphone: picks up the sound in the external ear canal

3- manometer: pressure pump (ranges from – 400 to + 200)

- Probe tip according to ear canal size

What does it measure?

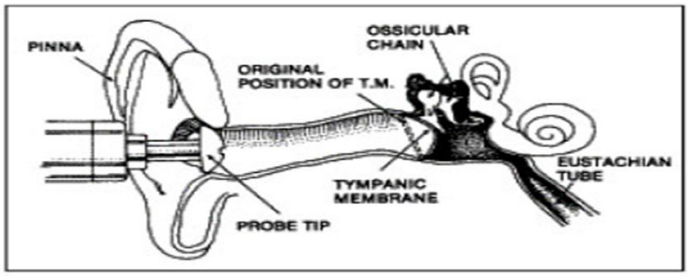
- Impedance (mobility) of the TM & Ossicles when exposed to pressure.
- Ear canal volume.
- Pressure in the ME.

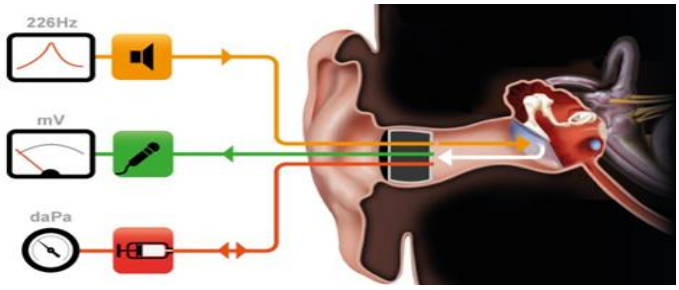
Physics of the Tympanogram

- The tympanometer measures the "admittance" or "compliance" of the tympanic membrane while different pressures are being applied to the external ear canal.
- The compliance of the TM is measured in cubic centimeters, and the pressure in the ear canal is measured in decapascals (daPa).
- The probe has different size "plugs" that provide a seal at the entrance to the external ear canal. The tip of the probe has a pressure transducer that changes the pressure in the external ear canal from negative, through atmospheric pressure, to positive pressure (-400 to +200). While the pressure is changing, a sound transmitter sends a sound wave to the tympanic membrane. The wave that is reflected from the TM is then picked up by a microphone in the probe. The tympanometer measures the energy of the reflected sound.

Physics of the Tympanogram

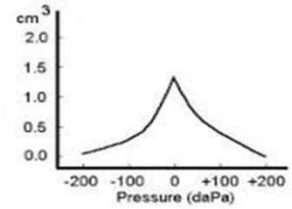
- A normal ear drum absorbs most of the sound so the least amount of sound is reflected toward the microphone.
- A tympanic membrane that is bulging or retracted it ends up stiff which results in less sounds absorbed and more sound reflected back to the chamber.





Results

- According to the shape of the graph , tympanogram is divided into 3 basic types (A,B,C) and 2 subtypes (As,Ad).
- Type A

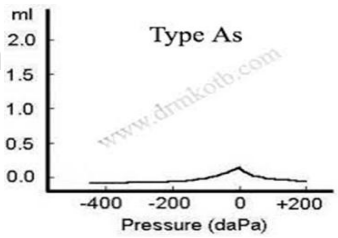


- ECV for children 0.3-0.9, and for adults 0.9-2.0
- Admittance/compliance 0.3 to 1.7
- Pressure -50 to +50

Results

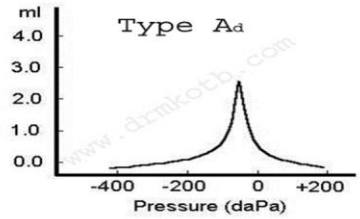
- Type As

- Normal ECV and normal pressure, but the peak compliance is shallower ≤ 0.2
- It is often associated with tympanic membran scaring and ossicular fixation and may result in fairly flat hearing loss with normal Eustachian tube function



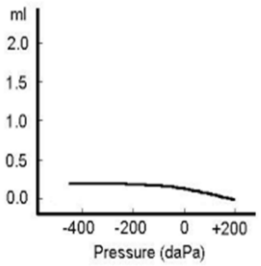
Results

- Type Ad
- Normal ECV and normal pressure, but the peak compliance is very high /off chart
- it is associated with ossicular disarticulation and may result in fluctuating ,flat hearing loss with normal Eustacian tube function



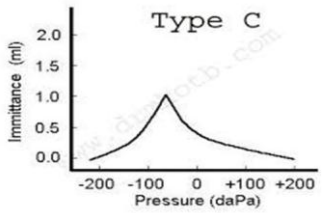
Results

- Type B (Flat)
- Normal ECV, but the pressure is below -50 (dapa)
- It indicates the presence of middle ear Effusion (fluid) behind the tympanic membrane.



Results

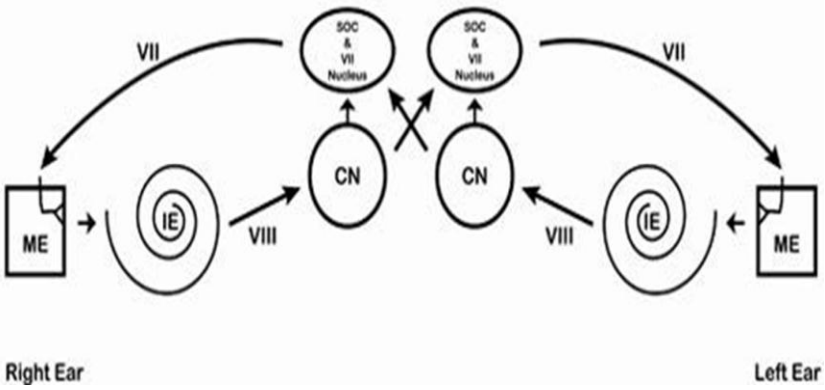
- Type C
- Normal ECV and normal compliance, but peak pressure is below -50(dapa).
- The peak falls on the negative middle ear side of the chart indicating negative middle ear pressure, usually consistent with Eustachian tube dysfunction ,allergy ,or the end stages of ear infection or cold.



Part 4
Acoustic Reflexes

- What is an acoustic reflex?
- The reflexive contraction of the stapedius muscle in response to a loud sound. This causes the tympanic membrane to stiffen.
- Acoustic reflex threshold is the softest sound that can cause a reflex of the stapedius muscle.
- The reflex is presented as a deflection (curve) on the immittance monitor.
- Stimulus levels may be measured SPL, SL, or HL

Acoustic Reflex Pathway



Acoustic Reflex Measurement

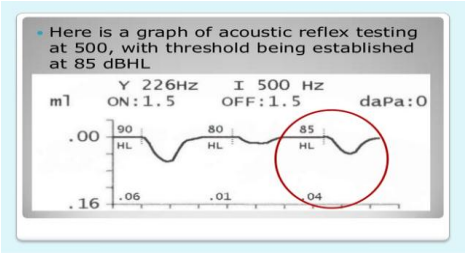
- Stimulation of one ear leads to reflex contractions in both ears.
- Two types ipsilateral and contralateral.
- The ear with the probe in (being tested) = probe ear.
- The ear receiving stimulus sound= stimulus ear.
  - For ipsilateral, a probe with a built in reciever is used.
  - For contralateral, a probe is in the probe ear, and an ear phone/inser ireciever is placed in the stimulus ear.
- Contralateral testing: sending the sound through one ear and across the auditory pathway and monitoring the reflex of the opposite ear.
- Ipsilateral Testing: sending the sound through one ear and across the auditory pathway and monitoring the reflex of the same ear.
- Terminology: identify by stimulus and configuration.

  Left contralateral: stimulus is in the left ear and the probe is in the right ear

  Right ipsilateral: stimulus and probe are in the right ear.

Procedure

- The signal used is called “reflex-activating stimulus (RAS)”, it can be a pure tone or BBN.
- tested frequencies: 500, 1000, 2000 Hz and 4000Hz.



- A response is when a change in compliance is observed. It is seen as “dips” by a minimum size of 0.02 mmho.
- The louder the tone, the larger reflex.

Results

- Normal ART ranges from 85-100 dB SPL in pure tone stimuli.
- BBN thresholds are usually 20 dB less than pure tone.
- In HL, the responses range from 80-90 for pure tone stimuli and about 20 dB less for BBN.