Pure Tone Audiometry 2
Audiogram:

- It’s a graph that represents the hearing thresholds across frequencies.

- The audiometric worksheet might represent all or some of the following information:
  - Patient’s name.
  - Patient’s age (date of birth).
  - Patient’s gender.
Referral source.

MR No.

Equipment used (its name and model number)

Test results reliability (good, fair, poor).

Examiner name and signature.
Day and date of the examination.

PTA calculation

Speech tests results

Imittance tests results (Tymp, Reflexes)

Box to write any additional comments
Audiogram description

- The horizontal axis represents the Frequency in hertz (Hz) and the vertical axis represents the intensity in dB HL.

- There are 2 audiogram forms
  1. One–graph audiogram
  2. Two–graphs audiogram
1. Audiogram with one graph for both right and left ear results
2. Audiogram with 2 graphs, each graph represents the results of each ear, one graph for RE and one graph for LE.
# Audiometric symbols

**Figure 4.9** Symbols for unmasked and masked thresholds (top) and no response (bottom) recommended by the American Speech-Language-Hearing Association (1990) for use in pure-tone audiometry.

<table>
<thead>
<tr>
<th>Modality</th>
<th>Ear</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Conduction - Earphones</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmasked</td>
<td>O</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Masked</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Bone Conduction - Mastoid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmasked</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masked</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Bone Conduction - Forehead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmasked</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masked</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Air Conduction - Sound Field</td>
<td></td>
<td>$</td>
<td></td>
</tr>
</tbody>
</table>
The used symbols connected by solid line for AC results, dotted line for BC results and no connection between NR
Audiogram Interpretation

- **First,**
  - Is there a hearing loss or not?,
  - Compare the collected results with the normal hearing results

- **Second,**
  - If there is a hearing loss; what is the type of it?.
  - Compare the AC and BC results
Third, 
- What is its degree?
- Calculating the PTA or looking for whole frequencies’ thresholds

Forth, 
- Is it bilateral (both ears involved) or unilateral (just one ear affected).

Fifth, **In Bilateral cases**; is it
- Symmetrical (both side identical)
- Asymmetrical (both side non-identical)
Sixth,

- What is the hearing loss configuration?
- Shape of audiogram
Hearing loss present or not?!

Normal hearing

- Normal AC thresholds obtained across all tested frequencies. (< 20 dB)

- Normal BC thresholds obtained across all frequencies tested. (<20 dB)

- There is no significant difference between both AC and BC thresholds (Air–bone gape < 10 dB).
Audiograms with normal hearing
Conductive Hearing Loss (CHL)

- Abnormal AC threshold (> 20 dB HL) obtained across the tested frequencies.
- Normal BC thresholds (< 20 dB HL) obtained across the tested frequencies.
- Air–bone gap present (> 10 dB).
A typical CHL audiogram
Sensorineural hearing loss (SNHL)

- AC thresholds are abnormal ($> 20$ dB HL) across tested frequencies.
- BC thresholds are abnormal ($> 20$ dB HL) across tested frequencies.
- A.B gap absent ($\leq 10$ dB)
Audiograms for SNHL

Bilateral SNHL  Vs  Unilateral SNHL
Mixed hearing loss (MHL)

- AC thresholds were abnormal (> 20 dB HL) across tested frequencies.
- BC thresholds were abnormal (> 20 dB HL) across tested frequencies.
- A.B gap is present (> 10 dB)
Audiogram for MHL
Degree of hearing Loss

- **Pure Tone Average (PTA)** is usually used to summaries the degree of hearing loss.

- It’s useful for predicting the threshold for speech

- It gives a gross impression of the degree of communication problems resulted from hearing loss
## Degree of impact of hearing loss on the communication

**TABLE 4.1** Scale of Hearing Impairment Based on the Variable Pure-Tone Average of the Poorest Three Thresholds at 500, 1,000, 2,000, and 4,000 Hz*

<table>
<thead>
<tr>
<th>VPTA (dB)</th>
<th>Degree of Communication Impact</th>
<th>Consider Hearing Aid</th>
<th>Consider Communication Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>−10 to 15</td>
<td>None</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>16 to 25</td>
<td>Slight</td>
<td>Possibly, especially for children</td>
<td>Possibly</td>
</tr>
<tr>
<td>26 to 40</td>
<td>Mild</td>
<td>Probably for adults, definitely for children</td>
<td>Probably</td>
</tr>
<tr>
<td>41 to 55</td>
<td>Moderate</td>
<td>Definitely</td>
<td>Definitely</td>
</tr>
<tr>
<td>56 to 70</td>
<td>Moderately severe</td>
<td>Definitely</td>
<td>Definitely</td>
</tr>
<tr>
<td>71 to 90</td>
<td>Severe</td>
<td>Definitely</td>
<td>Definitely</td>
</tr>
<tr>
<td>&gt;91</td>
<td>Profound</td>
<td>Consider cochlear implant</td>
<td>Definitely</td>
</tr>
</tbody>
</table>

*Hearing levels refer to the ANSI-2004 scale.
PTA calculation

- Traditionally, it’s the mean of the AC thresholds at 500, 1000 and 2000 Hz because it often agrees with hearing ability for speech.

PTA = \( \frac{500 \text{ Hz} \ (T) + 1000 \text{ Hz} \ (T) + 2000 \text{ Hz} \ (T)}{3} \)
Variable pure tone average (VPTA), is the pure tone average of the poorest three threshold of (500, 1000, 2000 and 4000), (Clark. 1981)

May be it’s more reflective for degree of communication impact of hearing loss than the traditional method

The PTA is usually compared with what’s known as Speech Recognition (reception) threshold (SRT) and any significant difference (> 5–8dB) between PTA and SRT considered of clinical significant.
The 2 frequency pure tone average (the lowest 2 thresholds at 500, 1000 and 2000 Hz), better 2, may be recorded and it’s been stated to be more predictor of hearing for speech than the traditional way.

It is used instead of the 3 frequencies PTA for comparison, whenever the audiogram shape does not allow the straight comparison and agreement between PTA and SRT.
Sometimes **one frequency** comparison used (250 or 500 Hz).

- When the PTA does not reflect the actual Hearing loss patient has, the degree could be describes based on the audiogram shape
Degree of hearing loss classification
Degree of hearing loss classification

- Normal Hearing: 00 - 15 dB
- Slight Loss: 16 - 25 dB
- Mild Hearing Loss: 26 - 40 dB
- Moderate Loss: 41 - 55 dB
- Moderately Severe: 56 - 70 dB
- Severe: 71 - 90 dB
- Profound: > 90 dB
Is it Bi/ Unilateral?

- **Bilateral:** When the hearing loss affects both ears.
Unilateral:

When one ear is with normal hearing and the other ear is showing hearing loss,
Asymmetrical

When the hearing loss is bilateral but one ear shows greater loss than the other (hearing loss degree differs),

Is it symmetrical/ asymmetrical HL?
Is it symmetrical/ asymmetrical HL?

- **Symmetrical**
  When the hearing loss is bilateral and the degree and configuration of the hearing loss is identical for both ears,
Audiogram Configuration is the criteria that summaries the audiogram slop and shape;
- Flat (difference between the thresholds just from 5–10 dB)
- Steeply slopping (sharp slop).
- Gradually slopping.
- Rising.
- HF hearing loss.
- LF hearing loss.
- Audiogram with dip/ notch.
- Cookie byte. (Saucer shape)
- Reversed Cookie byte.
Flat audiogram
Sharply sloping Vs gradually sloping
Rising audiogram
High frequency   Vs   Low frequency

– like presbycusis.

– like Menier’s
Notched Audiogram

- Audiogram with a notch at high frequencies. Like 3000-6000 Hz notch, indicates Noise Induced hearing loss.
Notched Audiogram

- Audiogram with a notch at 2000 Hz (Carhart notch), AC meets BC threshold at that frequency, indication of otosclerosis.
Important tips to consider

- In a summary, to diagnose you have to include:
  - Bi/ unilateral/ degree of hearing loss/ audiogram configuration whenever possible/ type of hearing loss.
- **Example:** bilateral symmetrical high frequency moderately– severe SNHL.
If it’s **Unilateral hearing loss**, states which ear;

(Unilateral (RE) mild CHL)

- If it’s **bilateral asymmetrical hearing loss**, start to describe the less effected side first.

- Do not forget to indicate to fluctuating audiogram.
Factors affecting Pure tone results

1– False responses;

- The responses that may mislead the examiner and give false results.

- They are either false positive or false negative.
False positive

- when the patient respond without stimulus presentation.

- **It usually happened with**
  a) Children as they are highly motivated to respond
  b) Patients with tinnitus if the stimulus resembling their tinnitus frequency.
These could be overcome by either

- Slow down the test and watch carefully
- Reinstruct the patient.
- Present another tone type to help the patient differentiate the stimulus from their tinnitus like (FM tone)
False negative

- When the patient does not response in the presence of the stimulus.

- May happen as result of poor attention, patient needs to be reinstructed.

- It may reflects unreliable responses in patients who are faking their hearing loss for any reason (pesudohypercusis).
2– Standing wave;

- It is usually seen at 6000–8000 Hz threshold.

- It happened as the distance between the eardrum and the headphone diaphragm can be very close to the 8000 Hz wavelength, so the tone and its reflection will be about 180 degree out of phase and they will cancel each other and no tone heard.
The threshold at this frequency may be come higher than the real one.

It is mostly happened if 8000 Hz threshold better than 4000 Hz one.

Using the insert earphone helpful in that case.
3– Tactile response;

- Vibrotactile sensation of low frequency BC signals.

4– Acoustical radiation

- Sound escapes from the BV at 3000–4000 Hz and improve the BC threshold.
5– Collapsed ear canal;

- Collapsing of the cartilaginous part of the ear canal during the AC testing. Which obstruct the sound flow.

- It results in high frequency CHL with A.B gap range from 10–50 dB and poor test-retest reliability.

- Extra care considered when high frequency A.B gap detected.
Methods could used to overcome the problem:

1) Insert a tube to avoid the collapsing,
2) Hold the headset loosely beside the ear,
3) Use the insert earphone,
4) Test while the jaw is open.
5) Use rubber foam
Practicing Examples *(Let’s try)*

- Record the following results in the audiogram using correct symbols
- Find out the type of hearing loss
- Calculate PTA
- Write down your full final diagnosis (include the cause if possible)
Case “1”

AC test results

<table>
<thead>
<tr>
<th>Freq.</th>
<th>250 Hz</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
<th>8000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RE</strong></td>
<td>45 dBHL</td>
<td>40 dBHL</td>
<td>50 dBHL</td>
<td>55 dBHL</td>
<td>55 dBHL</td>
<td>50 dBHL</td>
</tr>
<tr>
<td><strong>LE</strong></td>
<td>50 dBHL</td>
<td>45 dBHL</td>
<td>50 dBHL</td>
<td>55 dBHL</td>
<td>60 dBHL</td>
<td>55 dBHL</td>
</tr>
</tbody>
</table>

BC test results

<table>
<thead>
<tr>
<th>Freq.</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RE</strong></td>
<td>0 dBHL</td>
<td>0 dBHL</td>
<td>0 dBHL</td>
<td>10 dBHL</td>
</tr>
<tr>
<td><strong>LE</strong></td>
<td>0 dBHL</td>
<td>0 dBHL</td>
<td>0 dBHL</td>
<td>0 dBHL</td>
</tr>
</tbody>
</table>
## Case “2”

### AC test results

<table>
<thead>
<tr>
<th>Freq</th>
<th>250 Hz</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
<th>8000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RE</td>
<td>10 dBHL</td>
<td>15 dBHL</td>
<td>10 dBHL</td>
<td>10 dBHL</td>
<td>15 dBHL</td>
<td>15 dBHL</td>
</tr>
<tr>
<td>LE</td>
<td>50 dBHL</td>
<td>50 dBHL</td>
<td>55 dBHL</td>
<td>60 dBHL</td>
<td>60 dBHL</td>
<td>65 dBHL</td>
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</table>

### BC test Results

<table>
<thead>
<tr>
<th>Freq.</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RE</td>
<td>15 dBHL</td>
<td>5 dBHL</td>
<td>10 dBHL</td>
<td>20 dBHL</td>
</tr>
<tr>
<td>LE (Masked)</td>
<td>15 dBHL</td>
<td>5 dBHL</td>
<td>10 dBHL</td>
<td>20 dBHL</td>
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</tbody>
</table>
### Case “3”

#### AC Test Results

<table>
<thead>
<tr>
<th>Freq Ear</th>
<th>250 Hz</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
<th>8000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE</td>
<td>10 dBHL</td>
<td>5 dBHL</td>
<td>10 dBHL</td>
<td>10 dBHL</td>
<td>15 dBHL</td>
<td>15 dBHL</td>
</tr>
<tr>
<td>LE (Masked)</td>
<td>50 dBHL</td>
<td>55 dBHL</td>
<td>55 dBHL</td>
<td>55 dBHL</td>
<td>60 dBHL</td>
<td>65 dBHL</td>
</tr>
</tbody>
</table>

#### BC Test Results

<table>
<thead>
<tr>
<th>Freq Ear</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE</td>
<td>15 dBHL</td>
<td>10 dBHL</td>
<td>5 dBHL</td>
<td>15 dBHL</td>
</tr>
<tr>
<td>LE (Masked)</td>
<td>35 dBHL</td>
<td>35 dBHL</td>
<td>35 dBHL</td>
<td>40 dBHL</td>
</tr>
</tbody>
</table>
Case “4”

AC test results

<table>
<thead>
<tr>
<th>Freq</th>
<th>250 Hz</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
<th>8000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RE</td>
<td>35 dBH</td>
<td>30 dBH</td>
<td>50 dBH</td>
<td>65 dBH</td>
<td>75 dBH</td>
<td>80 dBH</td>
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<tr>
<td>LE</td>
<td>55 dBH</td>
<td>50 dBH</td>
<td>60 dBH</td>
<td>65 dBH</td>
<td>55 dBH</td>
<td>65 dBH</td>
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BC test Results

<table>
<thead>
<tr>
<th>Freq</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RE</td>
<td>30 dBH</td>
<td>45 dBH</td>
<td>60 dBH</td>
<td>65 dBH</td>
</tr>
<tr>
<td>LE</td>
<td>50 dBH</td>
<td>50 dBH</td>
<td>60 dBH</td>
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</tbody>
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Case “5”

AC test results

<table>
<thead>
<tr>
<th>Freq. Ear</th>
<th>250 Hz</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
<th>8000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE</td>
<td>90 dBHL/NR</td>
<td>120 dBHL/NR</td>
<td>120 dBHL/NR</td>
<td>120 dBHL/NR</td>
<td>120 dBHL/NR</td>
<td>100 dBHL/NR</td>
</tr>
<tr>
<td>LE</td>
<td>15 dBHL</td>
<td>10 dBHL</td>
<td>5 dBHL</td>
<td>5 dBHL</td>
<td>10 dBHL</td>
<td>10 dBHL</td>
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</table>

BC test results

<table>
<thead>
<tr>
<th>Freq. Ear</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE (Masked)</td>
<td>55 dBHL/NR</td>
<td>70 dBHL/NR</td>
<td>70 dBHL/NR</td>
<td>70 dBHL/NR</td>
</tr>
<tr>
<td>LE</td>
<td>10 dBHL</td>
<td>0 dBHL</td>
<td>5 dBHL</td>
<td>5 dBHL</td>
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</table>
Case “6”

AC test results

<table>
<thead>
<tr>
<th>Freq</th>
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<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
<th>8000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RE</td>
<td>15 dBHL</td>
<td>20 dBHL</td>
<td>30 dBHL</td>
<td>40 dBHL</td>
<td>50 dBHL</td>
<td>55 dBHL</td>
</tr>
<tr>
<td>LE</td>
<td>20 dBHL</td>
<td>20 dBHL</td>
<td>25 dBHL</td>
<td>40 dBHL</td>
<td>45 dBHL</td>
<td>55 dBHL</td>
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BC test results

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<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
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</thead>
<tbody>
<tr>
<td>Ear</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RE</td>
<td>20 dBHL</td>
<td>20 dBHL</td>
<td>25 dBHL</td>
<td>35 dBHL</td>
</tr>
<tr>
<td>LE</td>
<td>20 dBHL</td>
<td>20 dBHL</td>
<td>25 dB HL</td>
<td>40 dB HL</td>
</tr>
</tbody>
</table>