Pure Tone Audiometry 1

By Wedad Alhudaib With Many Thanks to Mrs. Tahani Alothman
Definition:

- The procedure by which sensitivity thresholds for each ear are obtained for pure tone stimuli of different frequencies (250, 500, 1000, 2000, 4000 & 8000 Hz)
Threshold

- The least acoustic intensity which causes a sensation of hearing.

- The lowest intensity of sound that person needs to detect it’s presence.

- Clinically, it’s the lowest intensity at which the patient responds to the sound at least 50% of the time.
General information

- The testing signals are presented by either:
  1) Ear phone for air-conduction (AC)
  2) Bone vibrator (oscillator) for bone-conduction (BC)
  3) Loud-speakers for sound-field.
The AC and BC thresholds are first obtained and then compared to each other to distinguish between different types of hearing loss.

Test should not exceed 20 minutes for more reliable results if so, patients may benefit from having short breaks.
1. **Air conduction testing**

**Procedure:**

**Patient preparation**
- Case history and otoscopic examination should precede the test.
- Hearing aids, eye glasses or any interfering objects should be removed.
- Instructions should be given to the patient before placing the earphone. Why?
Instructions

- Patient should be instructed to set quiet and to interrupt whenever s/he feels discomfort.

- Patients with tinnitus should be instructed to ignore their tinnitus and just focus on the tone and if they found difficulty at any point they should say that and this should be written and recorded on the audiogram.
“ I am going to test your hearing by measuring the quietest sounds you can hear. As soon as you hear the sound (tone), press the button, raise your hand or node your head. Keep the button pressed as long as you hear the sound, no matter which ear you hear in. Release the button whenever you are no longer hearing the tone. No matter what is the sound and how faint it is just press the button as long as you hear and release it when it’s no longer heard”
Cont. Instruction

- Alternative wording acceptable as long it’s understandable.

- Hard copy of the instruction (written instructions) is a good choice;

- It can be emailed to the patient prior the appointment day
It could be handed to the patient on the reception upon the patient arrival.

It should never be used to replace verbal instructions.

Always ask the patient if s/he understand and repeat at any time if needed.
Response Strategy

- Two common strategies used with a cooperative adult patient:
  1. Handheld switch/button
  2. Hand/finger raising

- Asking the pt. to raise his hand/finger on the side corresponding to the ear in which they perceive the test signal helps to identify the location of the signal
Other used response formats (i.e. children or difficult to test persons):

- playing a game (take one block and put it in a certain game) = play Audiometry
Transducer Placement

- Now the ear phone should be placed on the patient ears (either supra-aural or the insert),

- Avoid ear collapsing when the supra-aural ear phone used

- Red = right, Blue = Left
Test order

- Start at 1000 Hz, Why?
- Start with the better ear: how do you know?
- Proceed to 2000, 4000, 8000, then 500, 250 Hz.
Fill in 750, 1500, 3000, 6000 Hz if the threshold difference between 2 consecutive frequencies > 20 dB.

3000, 6000 Hz are useful for tinnitus, HF hearing loss and HA fittings.

Retest 1000 Hz just for the first ear.

Retest the other frequencies if the threshold at 1000 Hz change by more than 5 dB.
Why start testing at 1000 Hz?

1. One of the mid-range frequencies to which the human ear is more sensitive to than lower or higher frequencies.

2. Has a pitch that is more familiar to most listeners.

3. Less affected by background noise and physiological noise than low frequencies.
4. The wavelength in relation to the length of the ear canal makes test retest reliability better at higher frequencies.

- **Test retest reliability:**
  Measure of the consistency of test results from one trial to the next
Stimulus presentation

- Start at intensity audible to the patient, 30dB for normal and 30 dB above the estimated threshold for others.

- Duration of the tone should varied from 1–3 seconds.

- Interval between the presentation between 1–3 seconds, timing should be unpredictable to avoid anticipated responses.
Testing Method

- Hughson-Westlake procedure used, 10 down up 5.

- If no response at initial presentation, increase in 10 dB until the response emerge.

- If 80 dB reached and still no response, increase in 5 dB steps and watch your patient for any discomfort.
Once the positive response seen, decrease in 10 dB steps until the response disappear.

Increase in 5 dB steps until the response re-appear.

Decrease by 10 dB and repeat the process until you get 2/2 or 3/4 at the same level.
- This could be taken as the patient threshold at that frequency.

- Move on to the next frequency and do the same.

- Use the audiogram to record the results using the correct symbols for right ear, left ear, Ac/BC, masked/unmasked.

- For un-masked AC threshold, use circle for the right ear and cross for the left ear.
Audiogram

- Quiet
- Loud

- Normal hearing

- Frequency (Hz)
- Hearing level (dB)

Low pitch
High pitch
Sample for audiogram
2. Bone conduction testing

- Bone conduction test bypass the external and the middle ear and stimulating the cochlea directly.

- Tone will travel to both cochleae and perceived by the better one; therefore without masking, it’s not possible to know which ear has detected the signal.
Hearing by bone conduction is resulted from the interaction of 3 events:

1) **Osseo–tympanic stimulation:** Movement of the skull leads to vibration of air column in the ear canal initiating AC response.
2) Inertial stimulation:
Inertia of the ossicular chain lag relative to the skull movement cause stapes to move in and out of the oval window into the cochlea similar to AC.

3) Distortional/Compressional stimulation:
Direct stimulation of the cochlea. When the skull set into vibration by TF or BV, it becomes distorted and leads to distortion of cochlear structures, that in turn initiate electrochemical activities relative to that in AC root.
Instruction

- Patient should be instructed same as in AC.

- Emphasize the need for response whenever the tone is heard regardless in which ear the tone was heard.
Transducer placement

- Bone vibrator placed either:
  - Over the mastoid of the worse ear (per AC), close to but not touching pinna and avoid touching the hairline
  - OR
  - On the middle of the forehead.
Mastoid process placement is probably chosen because;

1) BC tones louder at mastoid process for normal hearing persons,
   - The placement near to ossicular chain

2) Each mastoid process near to ear being tested,
   - The notion that placing the BV on the right mastoid is stimulating the right ear and vise versa is not true as both cochleae stimulated equally
FIGURE 4.11 Vibrations of the skull result in bone-conducted stimulation of both inner ears, whether the vibrator is placed on (A) the mastoid or (B) the forehead.
Advantages of Forehead placement:

- Artifacts and test retest differences are less in Forehead placement than mastoid one

- Due to its near placement to the ear canal, AC stimulation is more in mastoid placement

- Easier to fix in its place

- Eyeglasses need not to be removed
Disadvantages of forehead placement:

- More intensity needed to stimulate normal hearing person (about 10 dB greater), decrease the maximum level for testing

- However, with available disadvantages of mastoid process placement, it’s still preferred by most of audiologists
Test order

- Test frequencies: just from 500 to 4000 Hz.

- Test order: 1000, 2000, 4000 then 500 Hz and no need to retest 1000 Hz.

- Which ear to start with is not of importance, why?
Stimulus presentation

- Start the test at AC threshold level for each frequency.

Testing method

- Same as AC method used to search for the threshold (down 10, up 5).
Stop the test and record the result as NR when:

- The intensity level reached **55 dB at 500 Hz**, **70 dB at 1000, 2000 and 4000 Hz**, since at levels greater than these levels patient may perceive the tone as vibration (vibrotactile) and not as a sound.
Limitations of bone vibrator:

- At higher frequencies (3000 and 4000 HZ), airborne sound generated by the bone vibrator, this may lead to false Air–bone gap (improve the BC threshold).

- Therefore, using ear plug may help to prevent this problem.
However, ear plug shall not be used at lower frequencies $\leq 2000$ Hz as the occlusion effect may raise the threshold at these frequencies.
Occlusion effect (OE)

- Covering the ear by any means (ear mould, ear phone, ear plug) during BC testing, stronger signal will reach to the cochlea, this boost know as OE.

- It usually happens at 1000 Hz or less.

- So occluded BC thresholds are better than un-occluded ones.
OE happens only when the cartilaginous part of the ear is covered and not the bony portion only.

OE is absent in CHL cases. Only can be experienced by normal hearing subjects or with SNHL.
Uses of OE

1) It used clinically to help in diagnosing CHL as used in Bing test.

2) It used also to determine the amount of masking needed.
OE values

The amount of OE can simply found by calculating the difference between un-occluded and occluded BC thresholds.

- At 500 Hz >> OE = 20 dB
- At 1000 Hz >> OE = 10 dB
- At 2000 Hz >> OE = 0 dB
- At 4000 Hz >> OE = 0 dB
OE implications for test procedure

- At low frequencies ≤ 1000 Hz, when masking required keep the non-tested ear (NTE) covered with the earphone and do not close the tested ear by any mean.

- At 3000 & 4000 Hz, ear plug should be used to block the TE while the earphone covering the NTE (to deliver the noise) to prevent BC thresholds enhancement (decreased) at these frequencies.
Some Rules about Bone Conduction

- People with normal AC thresholds have normal BC thresholds. In other words, BC thresholds are always the same or better than AC thresholds.

- Sometimes, BC thresholds are 10 dB poorer than AC thresholds and this may be seen because of allowable variability.

- But BC thresholds should not be significantly poorer than AC thresholds.
In case of greater differences, re-testing with careful attention to bone vibrator placement and test procedure may resolve the problem.

BC thresholds are normally tested unless AC thresholds are 0 dB HL or better.
Finally after both AC and BC thresholds have been obtained, they should be recorded on the audiogram using the correct symbols.

The audiogram will be used to diagnose the possible type and degree of hearing loss the patient has.
The diagnosis is done by comparing the AC and BC thresholds and calculating the PTA, Pure Tone Average might be enough to show the degree of hearing loss impact in patient’s communication.
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.

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