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Audiology

This article forms part of our 'Tests and results' series for 2011 which aims to provide information about common tests that general practitioners order regularly. It considers areas such as indications, what to tell the patient, what the test can and cannot tell you, and interpretation of results.

An audiogram is a hearing test conducted under ideal listening conditions in a soundproof booth. The test includes different pitches and intensities and the results are conveyed in graphical form. If there is hearing loss an audiogram helps distinguish conductive loss (outer/middle ear) from sensorineural loss (cochlea/cochlear nerve).

Keywords: audiology; hearing loss; ear diseases

An audiogram is indicated to evaluate any suspected hearing loss, tinnitus, vertigo and other ear symptoms. It is also useful for screening for hearing loss in people regularly exposed to loud noises and for certain patients on ototoxic medications (eg. gentamicin). Although there is widespread newborn hearing screening in Australia, an audiological assessment should be performed for any child if there is concern about hearing or speech, developmental delay or difficulties at school. Children with known hearing loss should have regular (at least yearly) hearing evaluations as the hearing loss may be progressive.

Audiograms are safe and there are no contraindications. Any child with an acute middle ear infection will have fluid in the ear. There is a high spontaneous resolution rate and 90% of ears clear within 3 months. For unresolved effusions, an audiogram (including tympanogram) is recommended, especially when coming into the summer months.

Patient preparation

Heavy wax build-up should be removed before testing. An interpreter is required for patients with a limited understanding of English.

What do I tell the patient?

An audiogram is a painless hearing test. The audiologist will usually perform otoscopy initially. Patients generally enter a soundproof room and wear headphones. They are required to press a button or indicate when they hear different sounds. Testing by bone conduction involves a vibrator similar to headphones that sits over the mastoid process. Tympanometry may also be performed to check the health of the tympanic membrane and middle ear. Speech discrimination involves listening to prerecorded words at different volumes. For patients who already have hearing aids, their aids will also be tested.

An audiogram typically takes 20–40 minutes. Children, pensioners, healthcare cardholders and Veterans Affairs cardholders can usually access free testing, but other patients will often have to pay (although a Medicare rebate may apply). Results are generally available to the general practitioner within a few days, although the audiologist usually explains the results to the patient on the day.

Audiograms for children

Hearing tests for children vary according to their age and level of understanding. For babies less than 7 months of age objective testing may be performed when they are asleep by placing electrodes on they baby's head to check their neuronal response to sound. Alternatively, behavioural observation audiometry involves noting the baby's response to different sounds while awake. For children aged between 8 months and 3 years, visual reinforcement audiology is used – essentially the child is rewarded for turning to a sound by seeing a toy or puppet. For children older than 3 years, play audiometry can be used, which gives very similar results to an adult audiogram and each ear can be tested separately.

The report

There is a key to the symbols used on the report (*Figure 1*). The right ear is written in red, and the left in blue, although printed reports are in black. The basic symbols are:

- O air conduction right ear
- X air conduction left ear
- [bone conduction right ear
-] bone conduction left ear.

An easy way to remember which ear is which is: 'right-O' and to imagine the patient sitting opposite with their ears [ ] facing you.

How do I interpret the results?

The audiogram graph axes are intensity and pitch. There are four lines plotted – each ear is tested and reported separately for bone and air conduction. The threshold of hearing is reported for each ear and represents the softest pure tone sound that is heard.

The vertical ('y') axis shows the intensity (loudness) of the test sounds in decibels (dB). The loudness scale is from very soft (–10 dB or 0 dB) at the top of the chart to very loud (110 dB) at the bottom of the chart. This range is vast: a sound that is just audible is 0 dB, a soft voice at 30 dB is 1000 (10^3) times louder, and a sound at 120 dB is 10^{12} louder.

The horizontal ('x') axis shows the frequency (pitch) of each sound. Like a piano, the low frequency sounds are on the left side of the graph and the high frequency sounds are on the right.

The human ear can hear from 20–20 000 Hz, but the most important range for understanding speech is from 250 Hz to 8 KHz, so this is the focus of testing.

The threshold of hearing

Air conduction thresholds show the softest sound the patient hears when this sound is transmitted through headphones over the ears. Alternatively, if the ear canals collapse, tube phones that sit inside the external canal may be used. This is indicated on the audiogram as 'TP'. Air conduction measures the hearing through the external, middle and inner ears.

Bone conduction thresholds show the softest sound heard when a vibrator is held on the mastoid bone and vibrations are carried through the soft tissues and bone directly to the cochlea. Discrepancies between the air and bone conduction usually indicate pathology in the external ear canal or middle ear blocking the normal transmission of sound to the cochlea.

Sound passes to both cochleae through the bone, so the patient may have difficulty determining in which ear the sound is heard. Also, a loud sound presented by air conduction to one ear may be heard in the other ear, and so if the ear thresholds differ by more than 40 dB the better ear must be masked. Narrow band sound is passed through the headphone to the better ear, and the patient is instructed to respond only to the sound in the test ear. This may be difficult for some patients to understand, especially young children.

Impedence audiometry

Impedance audiometry requires no input from the patient and is an assessment of the status of the tympanic membrane and middle ear via tympanometry. Air pressure is raised and lowered in the outer ear to alter the stiffness in the tympanic membrane while measuring the changes in its compliance from the amount of sound reflected from it. A normal tympanogram is 'type A'. Pathology of the middle ear will often have a type B tympanogram with a low volume if there is a middle ear effusion and a high volume if there is a perforation or patent middle ear ventilation tube. A type C tympanogram has a peak at subatmospheric pressure and indicates poor eustachian tube function. Impedence audiometry also assesses acoustic reflex pathways, which include the cochlea and facial nerves and the auditory brainstem.

Speech discrimination

Speech discrimination scores are a measure of the patient's ability to hear words correctly and are a good indication of the integrity of the cochlear nerve. There is a predictable attenuation with a conductive or a cochlear loss, and if there is an acoustic neuroma the speech discrimination is much worse than expected from the pure tone audiogram. Improvement in speech discrimination scores with increased intensity is also a good way of predicting if a patient will benefit from a hearing aid or other amplification.

Case study

A man, 35 years of age, has had hearing loss in the left ear since a childhood head injury. He has recently had a cold and his right ear feels blocked. He is struggling to hear conversation.

He is referred for an audiogram. There is a moderate sensorineural hearing loss in the left ear (X) from 40 dB to 55 dB with similar air and bone conduction levels. The right ear shows a mild conductive hearing loss with normal bone conduction (0 to 5 dB), and reduced air conduction (0) at 30 dB to 20 dB (Figure 2). The tympanograms show a normal (type A) tympanogram on the left ear and a type B tympanogram on the right ear (Figure 3). The volume is low which indicates a middle ear effusion as the cause for the hearing loss. Clinically, this patient will hear clear voices but will have difficulty listening when there is background noise.

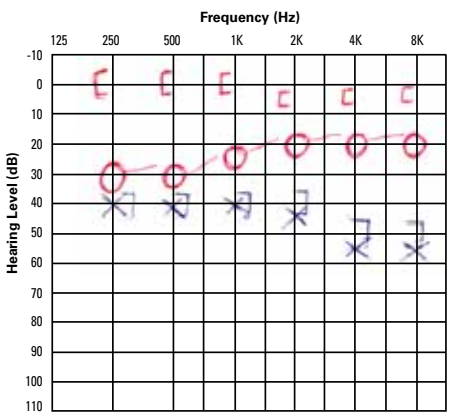

Figure 2. Audiogram of Case study patient

	Air	Bone	Air masked	Bone masked	Free field (BIN)	No response
Right	○	<	○	[	□	↘
Left	×	>	⧗	]		↙

Figure 1. Key to symbols used in report

Ear	Type	Comp.	Peak	Vol.
Right	B	0·1	—	0·8
Left	A	0·7	0	1·4

Figure 3. Tympanometry of Case study patient

Significance of the hearing loss

The audiologist will provide an interpretation of the results and comment on the practical implications of the loss. To give some indication, a normal threshold is better than 20 dB, normal conversation is at 40–65 dB, a telephone rings at about 80 dB and a rock concert may be as loud as 120 dB.

A patient with a mild loss (20–40 dB) will manage in quiet situations with clear voices, but may have difficulty listening in background noise.

Patients with a moderate loss (41–60 dB) will miss most of the conversation and a child with moderate loss will have poor pronunciation and a limited vocabulary.

If a severe loss (61–90 dB) is present, most conversational speech will not be heard and a child with this loss will not develop normal speech and will have a very limited vocabulary unless helped by hearing aids.

Patients with a profound loss (>90 dB) cannot hear speech sounds, and a child with a profound loss will not develop speech without a hearing aid or cochlear implant.

Next steps

For adults with mild hearing loss, explanation and advice about behaviour modification is usually sufficient. For moderate and severe loss the patient should be referred for fitting of hearing aids. In unilateral hearing loss, particularly in adults, a magnetic resonance imaging is usually indicated to rule out an acoustic neuroma and an ear, nose and throat review is often required. Children with even a mild loss should be referred for further assessment for amplification, especially in the educational setting.

Resources

- Patient information is available on the Better Health Channel website: www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/Hearing_tests_explained?open
- Australian Hearing provides patient and provider information and government subsidised services for eligible patients: www.hearing.com.au/home
- Audiology Australia has lists of private clinical services at: www.audiology.asn.au/
- The New Zealand government provides good information for parents about newborn screening: www.nsu.govt.nz/current-nsu-programmes/3736.asp.

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Conflict of interest: none declared.

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