Procedures in Family Practice

Office Audiometry

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The selection of appropriate hearing test procedures is dependent upon the goals chosen by the practitioner and the skills of the examiner. Office audiometry is superior to tuning-fork tests and provides unique information for diagnosis and management.

Evaluation of hearing often is vital to the correct diagnosis and appropriate management of aural complaints (including hearing loss, otalgia, tinnitus, and aural fullness) and vestibular symptoms such as dizziness, disequilibrium, or vertigo. It is important that the physician have a strategy for planning an evaluation in terms of the epidemiology profile of his patients, his resources for diagnosis, and proper management or referral for these complaints. Office audiometry in terms of screening procedures or of diagnostic techniques can be an effective means of providing part of the framework for appropriate evaluative strategies.

To evaluate hearing loss solely on the basis of the patient's history can be misleading. Unilateral losses of mild or even moderate degree and mild bilateral losses may be unnoticed or may be attributed by the patient to unrelated history or normal degeneration. These losses may have significant diagnostic implication for problems requiring medical or surgical treatment but remain unmentioned or go unrecognized even with attentive history taking. For example, mild high-frequency loss usually is the initial symptom of an acoustic neuroma and is seen in the early stages of multiple sclerosis. Mild low-frequency unilateral loss often is found in the initial stages of serous otitis media, otosclerosis, and congenital syphilis stigmata.

The findings on physical examination are normal for the majority of patients with significant sensorineural loss, and may be normal even with pneumatic otoscopy for some conductive losses. Equivocal findings on examination are not unusual with significant middle-ear pathologies, although tympanometry now provides a simple office procedure to detect very mild conductive losses in many cases.[1] Even the otologist must often resolve equivocal findings from a standard visual examination through an examination with the binocular microscope.

Tuning-fork tests should be viewed as a screening procedure at best. Low-frequency forks may have poor validity because of interference by background noise. These forks may also provide tactile stimulation that can be confused with auditory stimulation by the patient or the examiner. High-frequency forks (above 1024 Hz) are of little use because of low intensity and rapid dampening even with a "heavy strike." (Note that even the normal ear requires tremendously greater sound pressure levels to hear 4096-Hz or higher forks in contrast to the intensity necessary to hear lower

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frequencies.) Tuning-fork tests, such as the Rinne, often must be used with contralateral masking for proper interpretation, and such a masking procedure may be a problem for physicians. The Weber and Rinne tests, which are simple basic techniques to differentiate conductive vs sensorineural loss, are usually false negative in cases with conductive loss of 20 dB or less.[2] This mild degree of conductive loss may be the aural symptom in patients with serous otitis media, cholesteatoma, or otosclerosis. The most succinct and incisive article on tuning for tests published recently is by Sheehy et al,[3] who indicate overall optimal reliability and validity when using a 512-Hz aluminum fork. (Any bone-conducted tuning-fork test can be tested more reliably with the bone conduction oscillator of an audiometer in which the parameters of loudness, intensity, and decay can be controlled.)

Office audiometry can be planned successfully for the needs of individual practices with some information on the following: (1) epidemiology of hearing loss, (2) basic background on strategy of audiologic examination, (3) data shown on an audiogram, (4) procedures and techniques necessary for audiometry, and (5) basic audiogram interpretation.

The resources of each physician may call for various types of office audiometry services. This article will provide current information on hearing and hearing loss, and will describe specific basic techniques for office audiometry and its interpretation.

Epidemiology of Hearing Loss

Hearing impairment in the general US population has recently been estimated to be at least about 7 percent.[4,5] The prevalence is higher in the male than in the female population and in older than younger persons. Unilateral impairment, which may easily go unrecognized by patient or physician, may be three times higher than bilateral impairment in children.

The major causes of hearing loss reported in two widely variant audiological studies are shown in Table 1. Their results are remarkably similar considering that the specific parameters of the studies, the medical settings, and the dates of examinations are quite different.

Incidence of specific causes and prevalence for all hearing loss are primarily age dependent. Otitis media, for example, occurs about four times more often in children aged under 6 years than in the teenage population, and decreases considerably more in adulthood. Otosclerosis and Ménière's disease are among the problems having a relatively normal distribution for age, with a peak curve in the fourth to fifth decade of life. Overall incidence regardless of cause begins to reach its peak between the ages of 40 and 50 years.[7]

Three clearly defined studies in Great Britain have reported deafness measured by screening audiometry and the incidence of ear disease in general practice.[8-10] Their data appear consistent with common disease groups in the United States. The results show that from 3 percent to about 7 percent of the workload in general practice involves aural complaints. (About another 7 to 8 percent involves other ear, nose, and throat problems.)

Hearing Function and Dysfunction

The ear has a variety of subfunctions as rich in expression as the analogous visual acuity, depth perception, color vision, and visual field measurements. Audiometry measures various hearing functions to isolate the site of dysfunction from the eardrum through the auditory brain-stem pathways. The functions measured include threshold (for air- and bone-conducted signals as well as speech understanding), speech discrimination, adaptation, loudness sensitivity, middle-ear pressure, eardrum-ossicle movement, and other highly technical special function tests. Figure 1 shows a variety of ways of analyzing hearing function. The complete audiological test battery will usually provide a separate pattern of responses for each of the six anatomically identified areas and another pattern for the continuum of nonorganic loss (from malingering to hysteric loss).

Depending upon the needs of a given office practice and the skill of the examiner, one or more of the following levels of examination are recommended for family physicians:

1. Screening audiometry: Air-conduction (AC) pure-tone tests, scored as a positive or negative response at one or more predetermined intensity levels
2. AC threshold audiometry: Determination of specific thresholds for pure tones over a predetermined frequency range
3. AC and bone-conduction (BC) threshold

Table 1. Major Causes of Hearing Loss

Rank	Columbia University[5] 1961 (n = 4,161)	%	Hungary[6] 1973 Medical School (n = 13,902)	%	County Hospital (n = 18,485)	%
1	Otitis media and sequelae	22.5	Presbycusis	22.0	Otitis media and sequelae	26.2
2	Presbycusis	16.1	Otitis media and sequelae	21.0	Noise	23.5
3	Unknown sensorineural	14.2	Noise	16.7	Presbycusis	17.0
4	Ménière's disease	6.8	Unknown sensorineural	14.0	Unknown sensorineural	9.4
5	Trauma	6.5	Otosclerosis	5.1	Trauma	3.7
6	Otosclerosis	5.3	Trauma	4.1	Bacterial/viral infections	3.4
7	Sudden sensorineural	3.9	Bacterial/viral infections	3.3	Otosclerosis	2.4
8	Familial loss	3.3	Congenital	3.0	Congenital	2.1
9	Poisons	3.0	Toxic	3.0	Toxic	2.0
10	Acoustic tumor	1.2	Ménière's disease	0.6	Ménière's disease	0.3
11	Syphilis	1.2	Sudden sensorineural	0.4	Sudden sensorineural	0.2
12	Brain tumors	0.9				
13	Nonorganic (exaggerated)	0.9				
14	With convulsive disorders	0.8				
15	Meningitis	0.8				

Types of Hearing Loss	%	%
Sensorineural	50	59
Conductive	18	25
Mixed	30	16
Ill-defined	2	0

n = the number of individual examinations included in the studies. These were either consecutive or selected as a representative sample of all examinations. One major discrepancy between the two studies involves the prevalence of Ménière's disease. European investigators often use a more strict criterion for the diagnosis than do physicians in the United States; thus, the Columbia study probably defined more Ménière's disease patients in the earlier stages of the disease. The omission of noise-induced loss from the Columbia study is not explained adequately in the original article.

audiometry: Adds measurement of BC thresholds to allow differentiation of conductive from sensorineural loss

There are five major purposes for which office audiometry could be used: *Identification:* Does a person have a hearing loss? If so, of what degree is the loss—mild, moderate, or greater? *Diagnosis:* Where is the site of lesion? *Management:* Does the degree and type of loss suggest medical, surgical, or rehabilitative treatment (or some combination of these)? *Monitoring:* Does the status of the loss (static, progressing, resolving, or fluctuant) call for revision of management originally selected? *Medicolegal purposes:* Can the test results provide an appropriate base line for possible hearing changes considered in ejudication procedures or indicate changes from previously established base lines? Office audiometry seldom is suitable for this purpose.

Basic Hearing Measurement Parameters

Intensity

Pure tones differ in the intensity necessary for them to be heard by the human ear. The average normal listener requires 6.5-dB sound pressure level to hear a 1000-Hz tone in a commonly designated earphone under specially designated sound-isolated conditions. In contrast, 24.5 dB and 9.5 dB are necessary to hear 250 Hz and 8000 Hz, respectively. Standards are different at a given frequency for AC vs BC. The audiometer takes these various standards and automatically changes them to conform to the 0-dB hearing level (meaning no loss of hearing) on the attenuator dial as the examiner switches frequency or mode of presentation (AC or BC).

Average conversational speech at a distance of 1 m in relatively quiet surroundings is at an overall intensity level of about 50- to 55-dB hearing level. The loudest elements of speech are vowel sounds; voiceless consonant sounds (eg, *sh, t, f*) are up to 30 dB less intense. Thus, some important elements for understanding speech may be at only 20-dB hearing level in conversational speech.

The standard threshold measurement is made in 5-dB steps. An acceptable alternative is to use 10-dB steps when evaluating patients who may be difficult to test such as young children, the sick, the mentally retarded, or the very elderly patient. Each frequency has a specific maximum intensity output as noted on the audiometer attenuator dial. Maximum output for AC is 80 to 120 dB and for BC is about 50 to 75 dB. Setting the audiometer dial above the designated maximum may actually decrease the output.

Table 2 indicates the generally accepted classification of degree of hearing loss relating to threshold intensity levels. "Normal" hearing is 25 dB or better as accepted for medicolegal classification as well as general purposes. Note that common medical problems, such as otitis media, may show only a 20-dB conductive loss, which would still place the patient in the normal range. Thus, the audiometric findings may evidence significant medical problems when the results still are within normal limits. The 25-dB level would be equivalent to a child with "perfect" hearing who wears average attenuating earplugs.

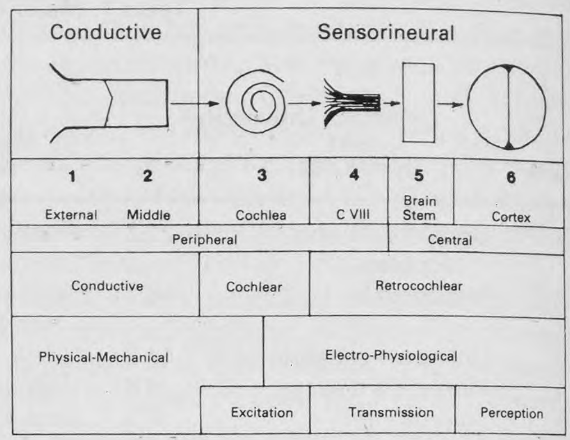

Figure 1. Schematic diagram for classifying auditory function and dysfunction

Frequency

Hearing is tested over the standard range of 250 Hz through 8000 Hz in standard diagnostic air conduction audiometry. Bone conduction is tested from 250 Hz through only 4000 Hz. Thresholds are usually determined at octave intervals; however, 3000 Hz is also usually tested because of its importance in speech understanding. Other midoctave intervals (750, 1500, and 6000 Hz) are often tested for AC because they may delineate the audiogram better in rapidly falling or rising curves. Industrial monitoring for noise-induced loss and medicolegal ejudication may require midfrequency testing. Federal and state laws vary in this aspect. Testing at 8000 Hz is often discarded in less critical examinations because results at this frequency have the least reliability. Testing at 250 Hz is usually dropped when testing in other than sound-treated rooms because ambient noise may mask thresholds at low intensity levels. Even in a relatively quiet office, for example, everyone may show a 30-dB hearing level (or poorer hearing) for 250 Hz. Increased ambient noise may also suggest dropping 500 Hz from the test procedure, but this omission

Table 2. Classification of Hearing Loss		
Average Hearing Level for 500, 1000, and 2000 Hz (dB)	**Loss Category**	**Ability to Understand Speech**
0-15	Normal	None
16-25	Borderline	Occasional difficulty with faint speech
26-44	Mild	Difficulty with faint speech and some conversational-level speech (possible to probable hearing aid candidate)
45-69	Moderate	May not hear normal conversational speech or relatively loud speech
70-89	Severe	Can hear only shouted speech
90+	Profound	Limited usable hearing without a hearing aid

is not desirable even in office audiometry.

The most important frequencies for hearing and understanding speech are from 500 through 3000 Hz. One could be completely deaf for lower and higher frequencies, but if the 500- through 3000-Hz range remained within normal limits, speech could be easily understood (although speech quality would sound abnormal). Vowel sounds are composed primarily of frequencies below 1000 Hz, whereas consonant speech sound energy is above 1000 Hz. Many hearing losses are for high frequencies only, which accounts for part of the common complaint of "I can hear you, but I can't understand you": only the vowel sounds are heard.

The results generated from audiometry may be presented in a variety of ways. Figure 2 shows a standard graphic audiogram with the explanation of the symbols used. The single graph shown is commonly used in office practice, whereas more complicated or multiple graphic forms are used in more advanced differential testing. It is conventional to use the two sets of signals for the two ears, and the mnemonic for remembering the difference in air conduction is "red, round, right," while black or blue "X" is used for the left ear symbols. In this era of copying machines, the color convention may seem superfluous, but the symbol figure differences are important for clarity. The nationally accepted standard accepts audiograph forms of any size, but specifies that the distance between one octave must be equal to the distance of 20 dB. If one were to alter this proportion by enlarging only the proportional area of 20 dB, a given hearing loss would appear visually to be much greater, a purposeful change that has been known to occur in legal proceedings for obvious reasons.

A second type of form (Figure 3) is often used in cases in which tests are to be repeated several times. This serial form using numerical values allows for easy comparison as in periodic industrial-use audiometry or in evaluating the course of medical management. Often the graphic form is used for the first test for easy visual analysis, and this second type of presentation is used for subsequent tests. The graphic form is useful more often for diagnostic clues for which degree, configuration, and patterns are significant.

A third system of recording is shown in Figure

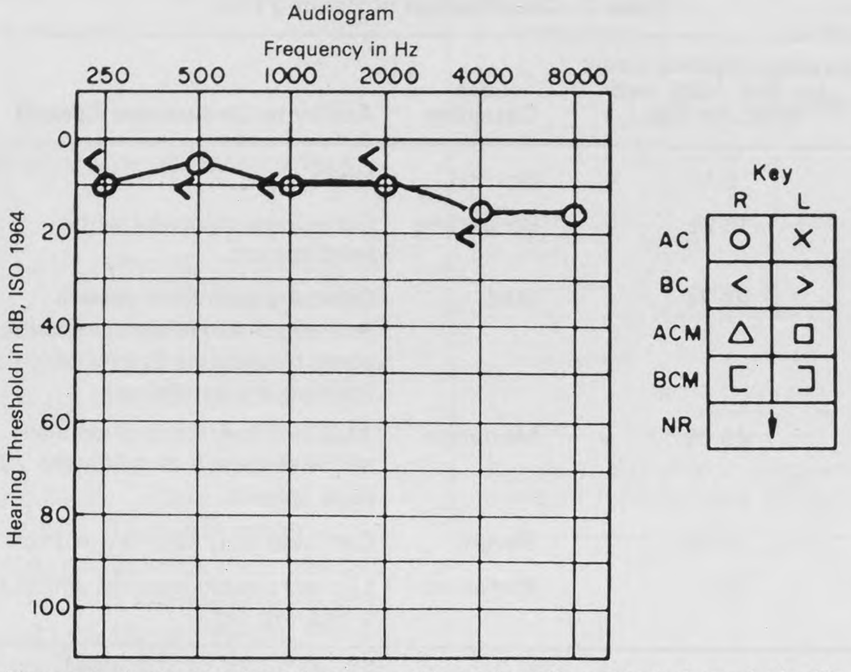

Figure 2. A standard audiogram with nationally accepted symbols. The results show a right ear with normal hearing for AC and BC. R—right ear, L—left ear, AC—air conduction (without masking), BC—bone conduction (without masking), ACM—air conduction (with contralateral masking), BCM—bone conduction (with contralateral masking), NR—no response

4. This specific form, which simply indicates which of three various intensity levels were heard for the limited frequencies that were tested, is used with enthusiasm and success by the pediatric department at the University of Washington. Nurses use an audiometer that tests only the four frequencies shown, and tests them only at the three intensity levels indicated, providing a quick and reasonable system of quantifying the loss and yet qualifying the general frequency pattern. Such a procedure is appropriate for testing younger children in environments other than sound-treated rooms, but it may not be optimal for testing more mature patients who could give more detailed information when tested by an even minimally trained technician.

Test records can be recorded on separate sheets of appropriate size for office records. A preferable method in some office practices is the use of rubber-stamped forms in the active patient clinical records.

Test Equipment

Figures 5 through 7 show examples of screening and diagnostic audiometers. The Eckstein Bros model (Figure 5) is a very small screening device using a single hand-held earphone for testing each of four frequencies at three different hearing levels.

A standard portable diagnostic audiometer is shown in Figure 6. A full intensity and frequency range can be tested for AC and BC, allowing differentiation of conductive loss. Some practices may choose such an instrument for more complete analysis of a discovered loss. Other offices may restrict testing to evaluation of AC only because of special problems encountered more often in testing BC.

A combined tympanometer and screening audiometer is shown in Figure 7. This relatively new type of instrument is an efficient office device. Note, however, that although four frequencies

DATE	TESTED BY	AUDIOM.		RIGHT EAR 250	500	1000	2000	3000	4000	8000		LEFT EAR 250	500	1000	2000	3000	4000	8000
12-1-83	J.S.	#1	AIR	40	30	30	20	25	25	30	AIR	5	0	5	5	5	5	10
			BONE	0	0	0	10	10	15		BONE							
1-8-84	D.M.	#1	AIR	20	20	15	10	10	10	10	AIR							
			BONE								BONE							
1-28-84	J.S.	#1.	AIR	10	5	5	5	10	10	10	AIR							
			BONE								BONE							

Figure 3. An alternate form for recording serial audiograms. The results show an ear with serous otitis media from the initial findings until resolution through medical management

may be tested, only two intensity levels can be screened (and only at a 10-dB relative difference as chosen by the purchaser), and the BC test is not offered.

A recently offered instrument combines an otoscope and a single-intensity AC hearing screener for four frequencies at a 25-dB hearing level (the limit for normal hearing). This model is hand held, battery powered, and about the size of the usual otoscope, but unfortunately has no attachment for pneumatic otoscopy and is relatively expensive.

All audiometric equipment should have at least an annual calibration and maintenance check. In addition, each examiner should have a record of his or her own hearing so that periodically an easy biological self-check can be completed.

	500	1000	2000	4000
25	R	R	R&L	R
45	L	L		L
65				

Figure 4. A form for use with a limited-intensity screening audiometer. R—right ear, L—left ear. The results indicate a normal screening for the right ear (25 dB) and a generally moderate loss (45 dB) for the left ear. Such findings could be consistent with otitis media

Procedures and Techniques

Test Environment

Sound-treated pre-engineered rooms rated by national standards provide the optimal environment for hearing tests. Office audiometry by family physicians realistically is more often performed in existing rooms that are modified with sound-reducing materials or in the most quiet room available. The latter is usually acceptable for screening and most AC threshold tests. The earphones for testing AC usually provide about a 20-dB average attenuation of ambient sound in the important mid-frequency range. As no such reduction is possible

Figure 5. Screening audiometer (Courtesy of Eckstein Bros, Inc, Hawthorne, Calif)

Figure 6. Portable clinical audiometer (Courtesy of Beltone Electronics Corp, Chicago, Ill)

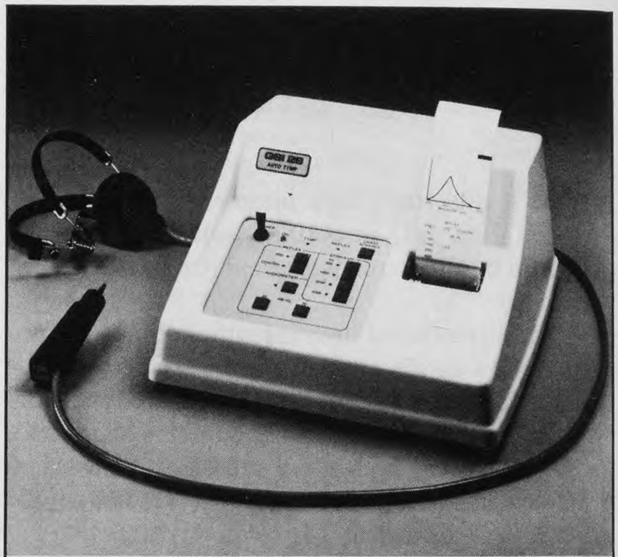

Figure 7. Screening audiometer with tympanometer (Courtesy of Grason-Stadler, Inc, Littleton, Mass)

when testing BC, the demands for reduced ambient noise may be higher when testing by this mode. Again, the examiner can explore the effects of his specific test environment by testing his own hearing or that of a person known to have excellent hearing.

Preparation for Patient and Examiner

The patient should be seated so that he is blind to the audiometer and to the movements of the examiner. Young children as well as adults may consciously or unconsciously use small movements from the examiner to clue false-positive responses to tone presentations.

The ear canal should be checked for blockage by cerumen or collapse of the ear canal with the weight of the earphone. The latter is most often observed in the very young or elderly patient.[11] Collapse of the canal may decrease AC thresholds up to 20 to 30 dB and suggest false conductive involvement if BC tests are also completed. An acceptably easy technique in case of collapse is to have the patient hold the earphone gently against the auricle. This technique may cause about a 5-dB false loss for lower and mid-frequency testing but is an acceptable compromise.

Earphones should be carefully positioned over the external meatus. Glasses and large earrings are usually removed for comfort and validity.

The signal presentation key on the audiometer should be in the "off" mode. The test signal should be presented for a duration of about 1 to 3 seconds for optimal test reliability and validity. The examiner should avoid rhythmic presentation of the tone and its duration, as this promotes false-positive responses.

Instructions to the patient should be brief, sim-

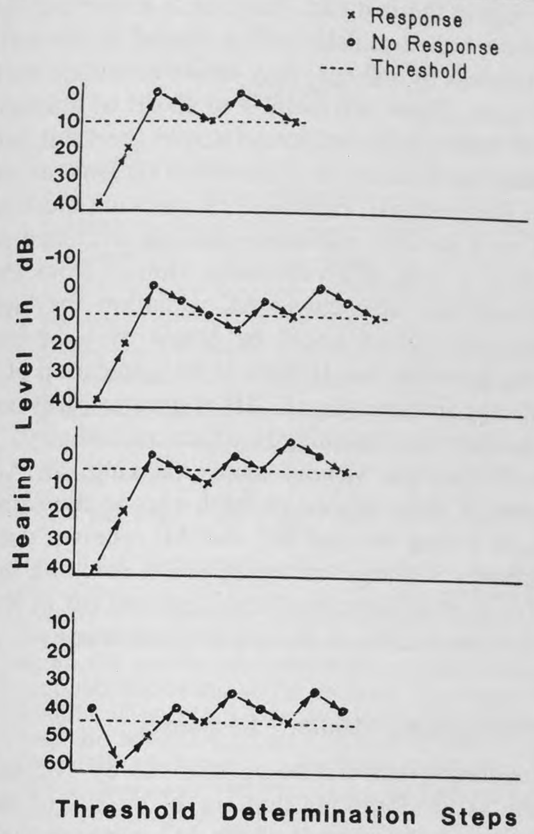

Figure 8. Schematic representation of four different threshold determinations

ple, and straightforward. The following example is appropriate:

> You are going to hear some tones or "little beeps." Each time you hear one, even if it is faint, raise your hand. As soon as the tone is gone, drop your hand. I'll test your (better) ear first and then the other ear. Do you understand?

Obviously, the patient's responses are influenced by attention, motivation, personality, age, and well-being, as well as the criteria the examiner gives him. Comments by the examiner that reinforce correct responses are especially suggested during the initial part of the test. The standard national guidelines ask the patient "to respond whenever the tone is heard, no matter how faint it may be."[12] This strict criterion often results in many time-consuming false-positive responses in an office environment. The instruction suggested here is more lax and is acceptable for general practice.[13]

Threshold Determination

1. Test the better ear first.
2. Use the following sequence of frequency presentation: 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 8000 Hz, 1000 Hz repeat (checking for practice effect), 500 Hz, and 250 Hz. Note that certain frequencies may be omitted, as previously suggested.
3. Start at an intensity the patient should hear easily. A good starting point for a normal listener would be 40-dB level and about 60-dB level for a patient with an expected significant loss. This intensity allows the patient a practice trial; he is familiarized with the stimulus.
4. Rapidly lower intensity in 20-dB steps until the tone is inaudible.
5. Increase the tone in 5-dB steps until the patient responds.
6. Decrease in 10-dB steps until the tone is again inaudible.
7. Repeat steps 5 and 6 until the lowest intensity level is identified at which the patient responds 50 percent of the time—the classic psychoacoustic criterion for threshold. Actually, when using 5-dB steps (relatively large steps for intensity), the responses for adults tend to cluster at 100 percent for one intensity level and 0 percent at a 5-dB lower intensity.

Figure 8 gives examples of four threshold determinations.

The examiner has a dual opportunity of evaluating responses with the hand-raising technique. If the hand is not raised *and* lowered appropriately when a tone is presented, there is a high probability of a false-positive response. The rapidity of the patient's response also provides a cue as to the loudness with which the patient hears the tone.

The other ear is tested in the same manner, and BC is tested in the same manner.

Screening audiometry is a simpler procedure in that the patient hears or does not hear the tone at the predetermined level(s). Familiarization of the tone at loud levels for the first presentation is still appropriate, if possible.

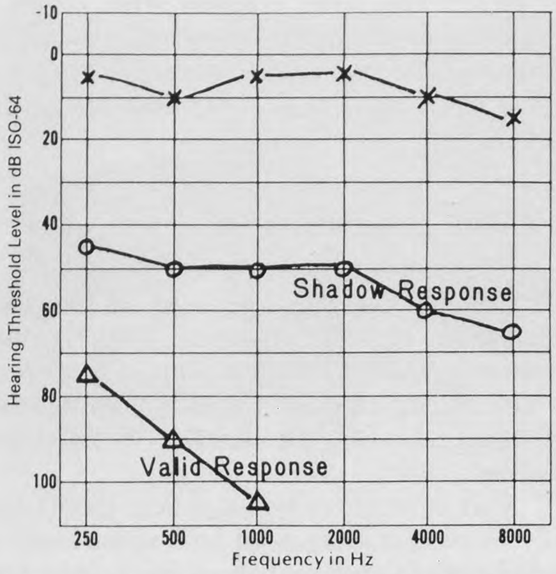

Figure 9. An illustration of an air-conduction "shadow" response shown for a patient with hearing loss typical of mumps. The left ear is normal. The right ear test without masking shows responses at 45 to 65 dB. The air-conducted sound presented to the right ear at those levels is loud enough to pass through the skull and stimulate the left ear. The valid responses for the right ear (obtained with masking in the left ear) show a "corner" type of audiogram with profound loss and residual hearing only for the lower frequencies

Special Problems

Bone Conduction

Many instruction books suggest that bone conduction responses are always equivalent to air conduction responses in normal hearing or in a sensorineural loss. In such cases, BC and AC responses actually intertwine, as shown in Figure 2. This occurs because BC normality is a statistically derived central tendency, and individual heads may vary anatomically (eg, in terms of underlying tissue density, size, or mastoid pneumatization) so as to make a BC response a bit better or worse than its comparable AC response.

Whenever air-bone comparisons at a given frequency for a given ear indicate conductive loss, masking in the opposite ear is usually necessary to establish the responses as indicating a true air-bone gap in the test ear. Masking is important because the bone oscillator, when placed on the mastoid process of one ear, may easily stimulate both inner ears. There is usually 5 to 10 dB of attenuation of bone-conducted sound across the skull, but as many skulls show no attenuation (at least at the lower frequencies), contralateral masking must be used as a general rule when finding evidence of conductive loss. High-intensity stimuli from the oscillator may also cause AC radiation for high frequencies, which could be heard by a better-hearing opposite ear. If there is no suggestion of a significant air-bone gap (15 dB or greater), it is not necessary to use masking in office audiometry.

In BC testing without using masking, an AC receiver is never placed on both ears at the same time. In testing masked BC, the AC receiver with the masker is placed on the opposite ear, and the AC receiver without masking is placed off of the test ear (on the cheek or frontal bone area).

Air-Conduction "Shadow" Responses

An intense stimulation to one ear by AC can initiate skull vibrations that travel by BC to the opposite ear. As a result, if the AC response for a given frequency is 40 dB or poorer than the comparable response for the opposite ear, the poorer response may be a response from the better ear. Figure 9 shows an audiogram typical for a loss due to mumps. The unmasked AC responses for the right ear are "shadows" from the left ear and would indicate a moderate loss. The true responses for the left ear (the masked responses) show a profound loss with only a little residual hearing for the lower frequencies.

Masking Techniques

Even the simplest techniques for the use of masking in audiometry may be too advanced for many office examiners. The reader is encouraged to consult standard audiometry textbooks for a detailed analysis of these procedures. Clinical audiometers all have masking stimuli, but screening equipment almost never includes masking.

The following suggestions are made for those who might wish to attempt the use of masking to obtain a general impression of whether responses are valid or shadows:

1. Present the masking noise to the nontest ear

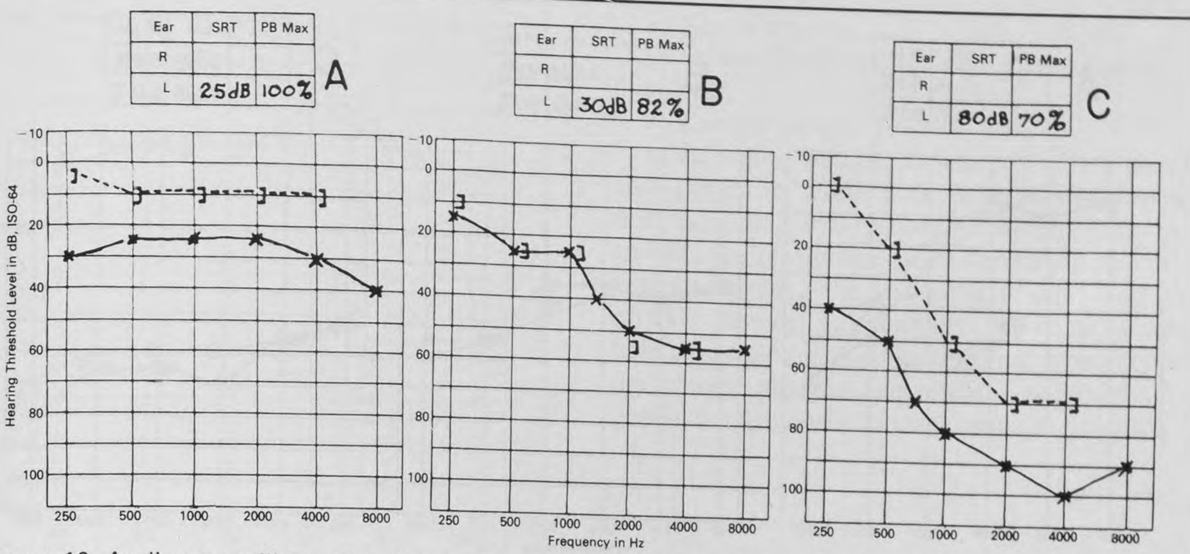

Figure 10. Audiograms illustrating the three basic types of hearing loss. (A) Conductive loss: Bone conduction is normal and air conduction shows a loss (in this case, a mild loss of 25 to 40 dB). Speech clarity, usually referred to as speech discrimination or maximum phonetic balance (PB Max), is perfect. The latter measurement is the percentage of words from a standard list that are repeated correctly by the patient when the words are presented at a loud level. (B) Sensorineural loss: Bone and air conduction are both reduced about the same amount. The speech clarity aspect of hearing function is relatively good in this specific illustration (82 percent), but is reduced from normal limits (about 94 to 100 percent). (C) Mixed loss: Both bone and air conduction are reduced, with greater loss shown for air conduction. The gaps between the dotted line for bone conduction and the solid line for air conduction represent the degree of conductive involvement. Note that speech clarity is significantly reduced in this case because of the sensorineural component

at a level about 20 dB more intense than the threshold of the nontest ear.

2. Obtain a masked threshold for the test ear (AC or BC) as described in the earlier section on threshold determination.

3. Raise the masking level an additional 20 dB in the nontest ear.

4. Obtain a second masked threshold for the test ear.

5. If the masked response is the same (±5 dB) for both measurements, the response is probably valid. If the second response shifts more than 5 dB, one cannot be sure of the valid threshold for the ear under test.

Interpretation

The audiograms in Figure 10 reflect three classic types of hearing loss. Typical audiograms for common causes of hearing loss are shown in Figures 11-16. Although it is not appropriate to suggest that etiology may be established firmly by results from office audiometry, this procedure may provide appropriate working hypotheses for practice when combined with historical information. Patterns of simple audiometric tests combined with results of basic speech audiometry and other laboratory tests are acceptable bases for strategies of diagnosis and management. The following considerations are helpful in differentiating types and causes of hearing loss.

1. Monaural vs binaural loss
2. Symmetrical vs nonsymmetrical (in cases of binaural loss)
3. Degree of loss for AC and BC
4. Configuration of loss for AC and for BC
5. Comparison of AC and BC
6. Speech discrimination ability

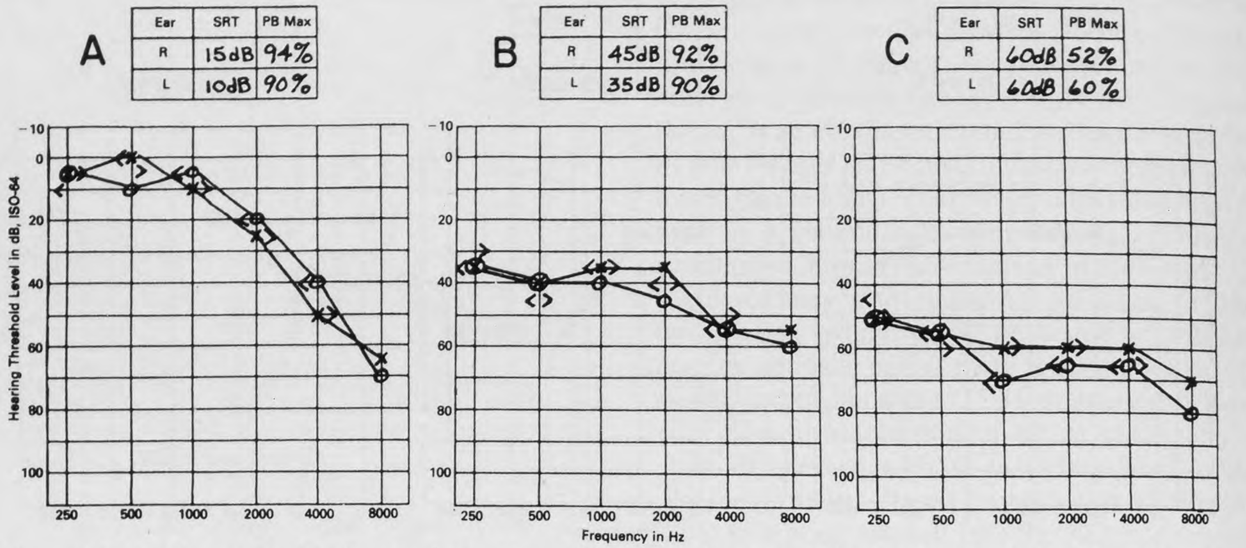

Figure 11. Presbycusis: (A) An example of audiologic findings usually cited as typical of presbycusis. The results shown would be typical of a 60- to 70-year-old man. The higher frequencies are the first to show the loss, and the curves fall with time, gradually involving the important range for speech understanding.

Clarity-discrimination dysfunction is usually relatively proportional to the threshold loss. (B and C) Variant findings in about one fourth of the cases seen at the author's institution. Note that all three types are essentially symmetrical, but that B and C are relatively flat types of configurations of varying degree in terms of threshold and PB Max. The types are classified as sensory, strial (metabolic), and neural, respectively. Classification is based upon the correlation of audiometric manifestations and the morphological changes found in postmortem temporal bone study. Type C can have disproportional loss of speech clarity and often represents a patient who receives limited (but perhaps significant) help from the use of a hearing aid

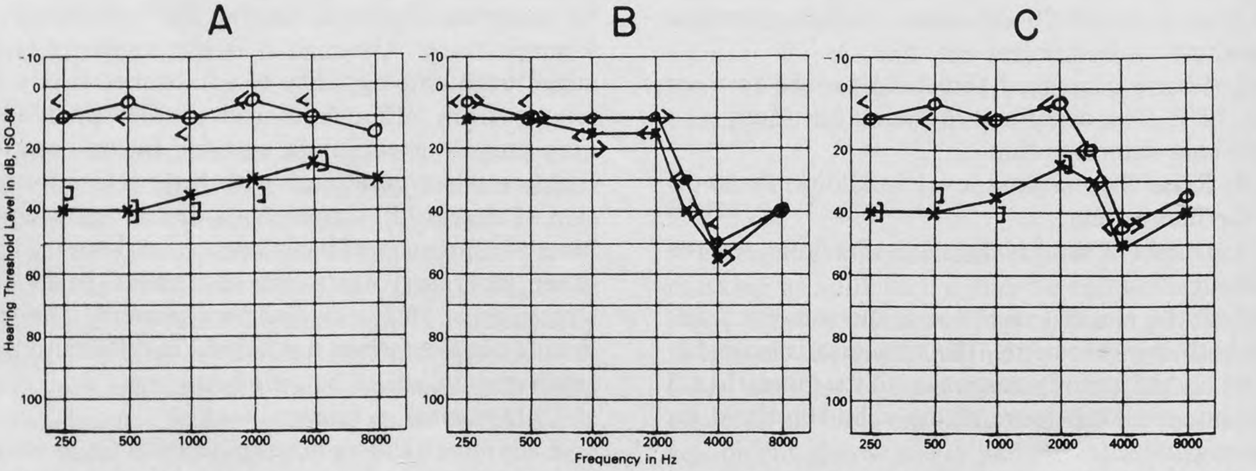

Figure 12. (A) A typical patient with early Ménière's disease. The problem is usually unilateral (80 to 85 percent) with initial sensorineural loss greater for the lower frequencies. (B) A typical loss due to industrial or recreational noise exposure: Usually bilaterally symmetrical, sensorineural type, and a maximum loss centering around 4000 Hz. (C) A patient with pre-existing noise loss who might be seen in the early stages of Ménière's disease affecting the left ear

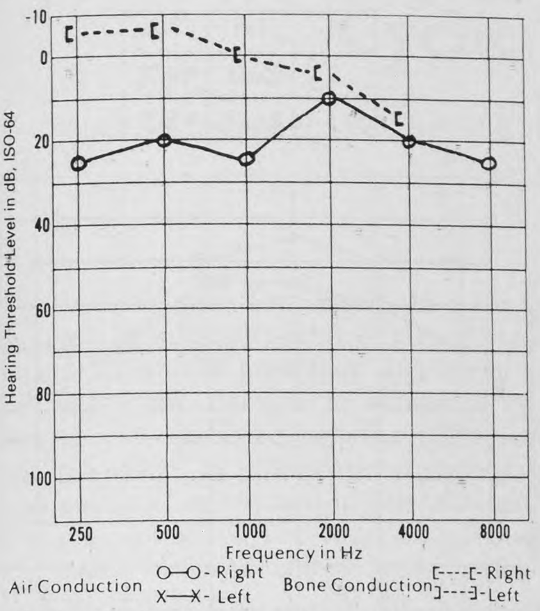

Figure 13. Audiogram of a child with serous otitis media. Note the excellent low-frequency bone-conduction responses. These responses typically are falsely enhanced by the accumulation of fluid in the middle ear. They drop to a 0- to 5-dB level with resolution of the fluid

7. Age of onset
8. Status of loss: static, progressive, sudden, or fluctuant
9. Familial history

In summary, hearing measurement is a simple and appropriate office procedure for family practice. Screening or threshold measurement for AC and BC are reasonable goals depending upon the patient's needs, the examiner's skill, and the office's physical environment. Audiometry adds helpful and unique information that complements the history, physical examination, and laboratory profile for diagnosis, management, and referral.

Note

Two previous articles in *The Journal of Family Practice* have explored specific topics regarding hearing. D'Alonzo and Cantor[14] have discussed ototoxicity. Vernon et al[15] have discussed the general effects of hearing loss and detailed audiometric curves for presbycusis. A text by Hodgson[16] is recommended for a detailed analysis of basic

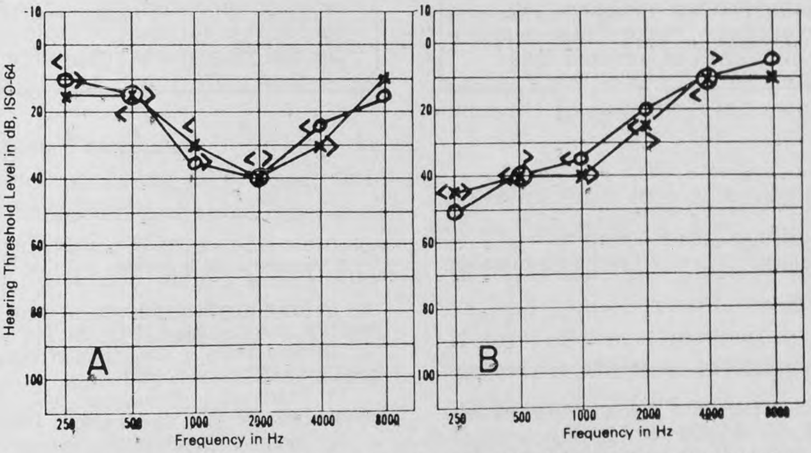

Figure 14. Two of the several types of recognized hereditary hearing loss without associated abnormalities. (A) Dominant mid-frequency sensorineural loss. (B) Dominant low-frequency sensorineural loss. Other variants include high-frequency dominant loss (may resemble presbycusis), recessive losses, and X-linked loss. Penetrance and expressivity may vary with the type of loss, but these types shown are usually consistent within a given family. Children with losses such as these are often unrecognized because the good hearing at some frequencies allows them to hear relatively normally. These losses may be static or progressive

Ear	SRT	PB Max
R	60dB	98%
L	20dB	100%

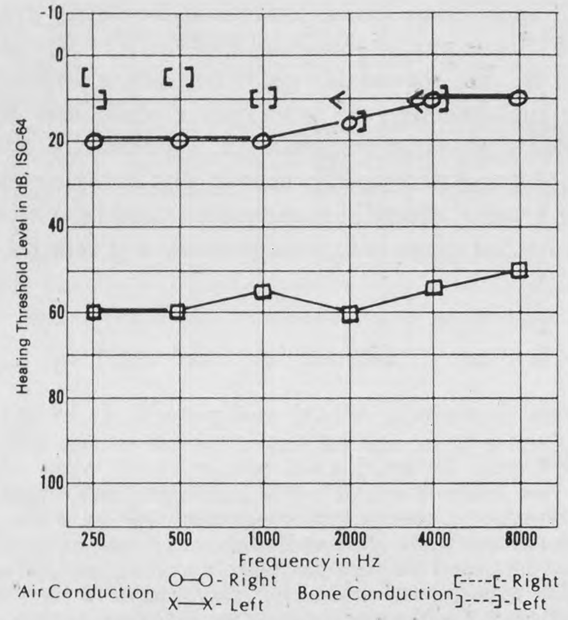

Figure 15. Otosclerosis: The illustration shows a moderate conductive loss of several years' duration for the left ear. Early-onset loss is shown for the right ear. This disease may present as a pure conductive loss or as a more advanced case with a sensorineural component. Note that the maximum pure conductive loss, regardless of etiology, does not exceed 65 to 70 dB. Any loss in excess of that general level is either a sensorineural loss or a mixed loss

Ear	SRT	PB Max
R	10dB	94%
L	20dB	42%

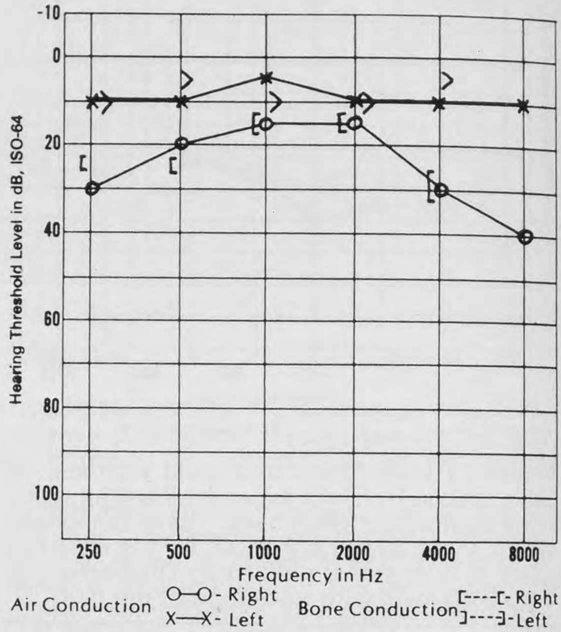

Figure 16. Hearing loss in a patient with a right acoustic neuroma. Note a great loss is shown for PB Max score (42 percent) as compared with a very mild loss of threshold function (about 20 dB on average). Such disproportionate findings are typical of many cases with acoustic nerve tumors and may occur in other neural or brain stem pathology, such as multiple sclerosis and brain stem contusion

audiometry including speech threshold and discrimination measurement.

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