

## **Paparella: Volume II: Otology and Neuro-Otology**

### **Section 2: Audiology**

#### **Chapter 6: Hearing Measurement in Adults**

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Audiology refers to the science of hearing, the art of hearing assessment, and the habilitation of the hearing-impaired. The science of hearing includes the acoustics of sound as well as the anatomy and physiology of hearing. Hearing assessment, or audiometry, is concerned with the degree of hearing loss and the site of disorder. Habilitation of the hearing-impaired refers to evaluation for amplification, speech reading training, and the development of communication strategies.

Audiometry plays a key role in patient diagnosis. Tests have been developed and refined to evaluate hearing and localize the site of disorder. The purpose of this chapter is to review clinical procedures used for hearing assessment and to discuss interpretation of audiometric results.

##### **Pure-Tone Audiometry**

Pure-tone audiometry is the standard behavioral measure used to quantify degree of hearing loss. The importance of the pure-tone test, however, does not stop with identification of hearing impairment. Many diagnostic tests depend on pure-tone information for interpretation. Hearing aid and rehabilitation recommendations are based on pure-tone test results. Although pure-tone testing takes only a few minutes, accurate results are essential for total patient care.

##### **Instrumentation**

The audiometer is an electronic instrument used to test hearing. It is composed of the following:

1. Oscillator, which generates a sinusoidal signal at fixed or continuous frequencies.
2. Amplifier, which increases pure-tone intensity.
3. Attenuator, which controls signal output.
4. Interrupter switch, which turns the signal off and on with no audible click.
5. Transducer, which converts electrical energy to acoustical energy.
6. Masking noise generator with attenuator dial, which permits testing of one ear at a

time.

Audiometers are calibrated to ensure the accuracy of the test signal. The American National Standards Institute (ANSI) has established reference levels so results can be compared and standardly described. Regulations from the Occupational Safety and Health Act (OSHA), the American Speech-Language-Hearing Association (ASHA), as well as state health agencies require periodic recalibration for valid and reliable hearing tests.

Testing must be carried out in a quiet area, but a soundproof room or anechoic chamber is not mandatory. Ambient noise must be below the level that would cause hearing loss in a normal listener. Commercial audiometric suites or construction of isolated rooms allow accurate tests to be performed. ANSI has specified acceptable background noise levels for audiometric testing.

### **Procedure**

The purpose of pure-tone audiometry is to measure thresholds of hearing at frequencies in the range of 250 to 8000 Hz. The Hughson-Westlake method is a standardized test procedure commonly used to evaluate hearing. A pure-tone stimulus is first presented at a comfortably loud level. The patient responds by hand raising or button pressing. Signal intensity is decreased in 10-dB steps until no response is obtained; intensity is increased in 5-dB steps until the patient responds. This ascending-descending procedure is repeated until the patient responds at a given intensity two out of three or three out of five times. Threshold is defined as the lowest intensity level that a patient can detect 50 per cent of the time.

Hearing thresholds are reported from two pure-tone procedures: air conduction and bone conduction. Air conduction measures present the stimuli through earphones. The entire hearing system, from the external ear canal through the middle ear system to the sensorineural system of the cochlea and nerve VIII is evaluated. Bone conduction measures present stimuli through a bone vibrator placed on the skull, either on the forehead or on the mastoid bone. Bypassing the external ear and middle ear mechanisms, only sensorineural sensitivity is measured.

Although bone conduction thresholds are essential in determining the site of disorder, information is limited and must be carefully interpreted. Bone conduction thresholds can vary due to placement and pressure of the bone vibrator. The participation of the middle ear system cannot be controlled in bone conduction testing. Reliable and valid calibration of the bone vibrator is difficult to attain. Finally, masking of the nontest ear may be necessary to obtain threshold. Masking will be discussed later in this chapter.

Results from the pure-tone hearing test are plotted on a graph called an audiogram. The frequencies tested, across the abscissa, range from low-frequency, or bass pitches, to high-frequency, or treble pitches. The term hertz (Hz) is used to express frequency, and stands for cycles per second. The intensity of the signal, down the ordinate, ranges from low-intensity, or soft stimuli to high-intensity, or loud stimuli. Intensity is expressed in decibels (dB), which is a

logarithmic unit of power and pressure. A standard symbol system has been developed by ASHA and accepted by ANSI for reporting of results. These are shown.

Hearing loss is described by degree of loss and is based on pure-tone thresholds. In general, the range of normal sensitivity is 0 to 20 dB, a mild loss is in the range of 20 to 40 dB, a moderate loss is in the range of 40 to 70 dB, a severe loss is in the range of 70 to 90 dB, and a profound loss includes thresholds greater than 90 dB. The need for masking arises when the test signal crosses through or around the head and becomes audible to the nontest ear. Masking is defined as the presentation of noise to the nontest ear to elevate its threshold and prevent its participation in the evaluation of the test ear. Masking may become necessary for air conduction and/or bone conduction testing. For air conduction, masking is necessary when the difference in threshold between ears is 40 dB or more. For bone conduction, masking is always necessary to differentiate ears, because a signal is presented equally through the skull.

Sufficient masking noise must be presented to the nontest ear to elevate its threshold without allowing noise to cross over to the ear being tested. Although no effective masking procedure has been standardized, Hood's plateau method is commonly employed. Noise is presented to the nontest ear while a pure tone is presented to the test ear. If the patient responds, masking is increased in discrete steps until an increase in noise no longer produces a shift in threshold. The plateau level is accepted as threshold.

Effective masking is difficult to achieve when a large air-bone gap is present. It is often impossible to sufficiently mask the nontest ear without the noise crossing over to the test ear. When the "masking dilemma" occurs, thresholds are reported as unmasked. To circumvent this problem, the sensorineural acuity level (SAL) test may be employed. This test stimulates the sensorineural mechanism with masking noise and measures the air conduction shift.

### **Interpretation of Audiogram**

The pure-tone audiogram provides information about hearing handicap and site of disorder. As previously discussed, pure-tone thresholds indicate the degree of hearing loss. By comparing air conduction and bone conduction results, the site of disorder in the peripheral auditory system can be determined.

A disorder arising from the external and/or middle ear system produces a conductive hearing loss. As the sound wave passes through the air to the semisolid cochlear structures, the external and middle ear structures act as mechanical transducers. If a problem develops that prevents the efficient operation of these structures, acoustic energy is lost and air conduction thresholds are elevated. Bone conduction thresholds, which reflect cochlear sensitivity, are unaffected, and an air-bone gap is present. Conditions that cause conductive hearing loss include atresia, tympanic membrane perforation, otitis media, and otosclerosis.

A sensorineural hearing loss occurs when the cochlea (sensori-) or nerve VIII (neural) is the site of disorder. A sensorineural loss is characterized by elevated air conduction and bone

conduction thresholds without an air-bone gap. The patient often complains that words are heard but are not understood. Distortion of sound is a common characteristic of sensorineural loss. The patient may also adapt abnormally to sustained sounds, a sign of nerve VIII disorder. Conditions that cause sensorineural hearing loss include Ménière's disease, acoustic trauma, presbycusis, and acoustic neuroma.

The third type of hearing loss is a mixed loss. As the name implies, a mixed loss occurs when a lesion is present in the external or middle ear structures as well as in the sensorineural system. Bone conduction thresholds are elevated in addition to the presence of an air-bone gap. A mixed loss develops when a combination of disorders is present.

### **Speech Audiometry**

Although pure-tone audiometry is simple to perform and interpret, assessments based on speech are more useful for determining how the patient functions in everyday life. Two type of speech measures have been developed. Speech threshold measures are concerned with degree of hearing loss, while speech intelligibility measures are concerned with the patient's ability to understand speech.

Speech audiometry is performed on speech audiometers or diagnostic audiometers with speech circuits. A microphone allows for live voice presentation, while input/output jacks allow for recorded presentation. The speech signal is calibrated using a volume unit (VU) meter built into the audiometer. New computerized audiometers have digital speech capabilities that provide clear, sharp speech stimuli to the listener.

### **Speech Threshold Measures**

The speech threshold (ST) or speech reception threshold (SRT) is the lowest intensity level at which a patient is able to understand speech. *Spondee* words, which are two-syllable words with equal stress on each syllable (eg, football, airplane, ice cream), are used as stimuli. The words are first presented at a comfortable loudness level. Intensity is then decreased until the patient misses a word. By using the descending-ascending approach of pure-tone tests, a 50 per cent correct intensity level is reached. This level is reported as the SRT.

The SRT is used to confirm pure-tone thresholds. The result should be within 10 dB of the pure-tone average (average of thresholds at 500 Hz, 1000 Hz, and 2000 Hz). If the two levels do not agree, the configuration of the hearing loss must be considered, because rising or sloping contours may cause discrepancies. If the configuration cannot explain the difference, a functional hearing loss must be suspected.

Some patients have difficulty cooperating when being tested for SRT because of poor receptive or expressive speech skills. For these patients, a speech awareness threshold (SAT) should be obtained. The SAT is the lowest level at which a listener can detect a speech signal 50 per cent of the time. Since speech is a complex signal, the SAT should correspond to the best

pure-tone threshold.

Two additional speech measures may be obtained. The most comfortable loudness (MCL) level is the level that the listener designates as most comfortable for speech. The loudness discomfort level (LDL) is the minimum intensity that the listener designates as uncomfortably loud. Both of these measures are critical for amplification recommendations and selection.

### **Speech Intelligibility Measures**

Speech intelligibility measures describe a patient's ability to understand speech. Clinically the most popular tool used for discrimination testing is a standardized, phonetically balanced (PB) word list. Presented at 40 dB above the patient's SRT, a percentage score is obtained, indicating the patient's maximum speech intelligibility or PB max.

Common clinical practice presents the PB lists at one intensity level, but diagnostic information may be obtained if tests are presented at several intensities to each ear. A patient's maximum performance may not appear at one chosen intensity. Performance may even become poorer as intensity is increased. This phenomenon, called rollover, is often observed in patients with nerve VIII disorders. The contribution of a performance-intensity (PI) function for PB words to the overall diagnostic evaluation is discussed later in this chapter.

Speech intelligibility measures serve three valuable functions in the total evaluation of the patient: (1) the patient's communication handicap can be measured and quantified; (2) the patient's candidacy for amplification can be evaluated and considered; and (3) site-of-lesion information can be gleaned from speech intelligibility patterns and scores.

### **Diagnostic Audiometry**

Diagnostic audiometry is concerned with site-of-lesion testing. Once a hearing loss is detected, differentiation of middle ear, cochlear, or nerve VIII disorder is important for treatment and/or rehabilitation. Many procedures have been developed for site-of-lesion testing. Clinically, the most popular tests are acoustic immittance, speech PI functions, Békésy audiometry, tone decay tests, and auditory evoked potentials.

### **Acoustic Immittance**

Acoustic immittance audiometry provides information regarding middle ear status as well as cochlear and nerve VIII function. Immittance is a derived term, representing acoustic impedance, or opposition to energy flow, and acoustic admittance, or ease of energy flow through the middle ear system. The test has become a standard clinical procedure because of its sensitivity in differentiating conductive from sensorineural hearing loss. The acoustic immittance battery includes tympanometry and acoustic reflex measurement.

Tympanometry measures the movement of the tympanic membrane as a function of air pressure variation. Three basic shapes have been identified to describe middle ear function. Type A is characterized by a sharp compliance peak at or near 0 daPa or normal air pressure, type B is characterized by little or no compliance peak, and type C is characterized by a well-defined compliance peak at a significant negative pressure. Each of these shapes indicates a specific middle ear condition.

The acoustic reflex is the contraction of the stapedius muscle in response to a loud sound. The acoustic reflex threshold is obtained by presenting sound to either ear at varying intensities until the lowest level that produces a contraction is determined. White noise and pure tones from 500 to 4000 Hz are reflex stimuli. Acoustic reflex thresholds are considered within normal limits when the reflex is elicited with a stimulus in the range of 75 to 95 dB HL.

Acoustic immittance differentiates middle ear from cochlear disorders. For middle ear disorders, the tympanogram is usually abnormal and acoustic reflex thresholds are elevated or absent. For cochlear disorders, the tympanogram and acoustic reflex thresholds are within normal limits. However, the tympanogram may be normal and the acoustic reflex thresholds elevated or absent when the patient has a severe or profound sensorineural loss. With this significant loss, the stimulus nerve reaches sufficient intensity to elicit the muscle contraction.

Acoustic immittance measures describe middle ear conditions but do not identify the disease. The presence of type A tympanogram and acoustic reflex thresholds within normal limits is consistent with normal middle ear function. Hearing loss is identified as sensorineural, and bone conduction testing is omitted. A type A tympanogram with absent acoustic reflexes indicates fixation of the ossicular chain, but the diagnosis of otosclerosis, stapes or malleolar fixation, or cholesteatoma cannot be differentiated. Type B tympanogram indicates restricted mobility of the middle ear system, but otitis media, cerumen impaction, or cholesteatoma cannot be differentiated. Type C tympanogram indicates significant negative pressure in the middle ear space, but blocked eustachian tube function or otitis media cannot be differentiated.

Acoustic immittance helps in differentiating cochlear and nerve VIII disorders. As mentioned earlier, acoustic reflex thresholds are within normal limits for cochlear disorders. For nerve VIII disorders, thresholds may be abnormally elevated (greater than 105 dB HL) or absent with no significant sensitivity loss present in the affected ear. Nerve VIII disorders may elicit normal acoustic reflex thresholds, but reflex decay may be present. Reflex decay occurs when the acoustic reflex amplitude declines and disappears with a sustained stimulus. Performed at 500 Hz and 1000 Hz, retrocochlear disorder is suspected when significant amplitude degradation is observed over a 10-second interval.

Acoustic immittance is helpful in evaluating nerve VII function. The finding of type A tympanogram with elevated or absent acoustic reflexes is most often consistent with middle ear disorder. However, if no air-bone gap is observed audiometrically, nerve VII disorder may be suspected. The acoustic reflex arc is interrupted when a lesion of nerve VII is present.

Acoustic immittance audiometry serves an important diagnostic role. Middle ear, cochlear, and nerve VIII disorders can be differentiated, and nerve VII function can be evaluated. This simple procedure requires no patient cooperation and takes little time to perform.

### **Rollover of the PI-PB Function**

As discussed previously, diagnostic information can be obtained by presenting speech at several suprathreshold intensities. Patients with cochlear hearing loss may have fair to poor discrimination scores, but this performance will be maintained at higher intensities. Patients with nerve VIII disorders will reach maximum performance scores up to 100 per cent at normal conversational levels. As intensity is increased, however, their speech understanding becomes progressively poorer. Significant rollover is present when speech understanding scores drop by 20 per cent or more as intensity is increased and is a significant finding in retrocochlear testing.

### **Békésy Audiometry**

Békésy audiometry is a diagnostic procedure that uses a self-recording audiometer to record pure-tone thresholds. Using pulsed and continuous pure-tone signals, the patient presses a button until the signal is heard and then releases the button once the signal is detected. Successive crossings at a given intensity are accepted as auditory threshold.

Five diagnostic patterns have been identified, based on the relationship of the pulsed and continuous signals. Type I characterized by interweaving thresholds for continuous and pulsed signals. This pattern is consistent with normal hearing, conductive loss, and sensorineural loss of unknown etiology. Type II is observed when the continuous tracing is 5 to 20 dB poorer than the pulsed tracing at frequencies at or above 1000 Hz. This pattern is consistent with cochlear disorders, especially those caused by noise exposure or presbycusis. Type III is characterized by a dramatic drop in the continuous threshold early in the tracing. The continuous stimulus threshold will be at least 40 dB poorer than the pulsed tone threshold, and may even disappear as the patient loses perception of the tone. This result is consistent with acoustic neuroma or cerebellopontine angle tumor. Type IV shows that the continuous response is 20 to 40 dB poorer than the pulsed response. This result can indicate cochlear or retrocochlear disorder. Type V is characterized by pulsed tone thresholds poorer than continuous tone thresholds. This pattern has no physiologic basis and is observed primarily in functional patients.

Two modifications of the classical Békésy procedure, like the classical procedure, presents pulsed and continuous tones from low to high frequency, however, it then reverses the continuous tone, presenting it from high to low frequency. A significant difference in the forward and backward thresholds suggests retrocochlear disorder. The Békésy comfortable loudness (BCL) procedure changes the task to a suprathreshold procedure. Six response patterns have been identified, three indicating retrocochlear disorder. Although the Békésy procedures show some diagnostic promise, equipment requirements, time constraints, and the improved sensitivity of evoked potential procedures have limited their clinical use.

## **Tone Decay Tests**

Tone decay tests measure the patient's ability to maintain perception of a continuously presented pure tone signal. Two types of tone decay tests have been developed: threshold and suprathreshold. Both procedures identify abnormal adaptation to sound.

Tone decay tests use a stimulus of 500 Hz or 1000 Hz. Threshold procedures record the minimum intensity level that the patient can hear for 1 minute. If this minimum level is within 30 dB of the patient's threshold, middle ear or cochlear site of lesion is suspected. If the minimum level is 30 dB or more above the patient's threshold, abnormal adaptation is present and retrocochlear disorder is suspected. Suprathreshold measures present a sustained pure tone above the patient's threshold. If abnormal adaptation is observed, retrocochlear disorder is suspected.

Tone decay tests are popular diagnostic tools. They can be performed on standard audiometric equipment, take a relatively short time to perform, and are sensitive to retrocochlear disorders.

## **Auditory Evoked Potentials**

Auditory evoked potentials provide an objective means of evaluating hearing. By the signal-averaging process, bioelectric events in response to auditory stimulation can be extracted from ongoing electroencephalographic activity. Responses can be recorded from the cochlea up the auditory central nervous system pathway to the cerebral cortex. These potentials are valuable tools for measuring hearing sensitivity, which is described in Chapter 5.

Evoked potentials can also assess physiologic function and auditory processing. The potentials are divided into electrocochleography (ECoG), auditory brain-stem response (ABR) audiometry, middle latency responses (MLRs), and long latency potentials (LLPs).

*Electrocochleography* records the cochlear microphonic (CM) and summing potential (SP) of the inner ear and the action potential (AP) of nerve VIII. Initially limited due to transtympanic electrode placement, with the development of ear canal electrodes ECoG is proving to be useful clinically.

Although ECoG can be used for threshold testing, the most popular use of the procedure is in the evaluation for Ménière's disease. A click stimulus evokes a well-defined SPP and AP, with the SP appearing as a deflection immediately preceding the AP. In patients with normal inner ear function, not hearing, the SP is a small-amplitude response in comparison with the AP. In patients with Ménière's disease, the SP is enhanced, making the SP/AP amplitude ratio significantly enlarged. The SP/AP abnormality is most obvious when the patient is symptomatic, and it responds to physiologic change induced by dehydration testing.



*Auditory brain-stem response (ABR)* audiometry is the most popular clinical measure used for the identification of retrocochlear disorders and for threshold testing. The ABR is characterized by a series of five waves that appear at standardized latencies following the presentation of a click stimulus. The waves are elicited from the following structures:

- Wave I: auditory nerve
- Wave II: cochlear nucleus
- Wave III: superior olivary complex
- Wave IV: lateral lemniscus
- Wave V: inferior colliculus.

ABR audiometry performed at a suprathreshold intensity successfully differentiates middle ear, cochlear, and retrocochlear disorders. Patients with middle ear disorders exhibit delayed responses, but morphology is good and interwave intervals are within normal limits. An ear with cochlear loss will exhibit well-formed responses at normal absolute latencies and interwave intervals. The ABR of ears with retrocochlear disorders, however, are of poor morphology, and interwave intervals are significantly prolonged. If the prolongation occurs between waves I and III, nerve VIII or lower auditory brain stem disorders are suspected. If the delay is between waves III and V, upper brain stem disorder is suspected. The sensitivity of ABR audiometry in the identification of nerve VIII disorders is greater than 90 per cent, making the ABR a valuable part of a total diagnostic assessment.

The *middle latency response (MLR)* immediately follows the ABR. At present, the origin of the MLR has not been determined but evidence indicates the activity arises from the auditory cortex. The MLR is useful for obtaining frequency-specific threshold information in adults. Its usefulness in detecting cortical lesions is under experimentation at the present time. The MLR may prove to be a valuable tool in the assessment of central auditory function.

The *long latency potential (LLP)* appears 50 to 1000 mseconds following stimulus presentation. Although its origin is still under investigation, the LLP is believed to reflect activity from multiple generators in the temporal and temporal-parietal regions.

The LLP can be divided into exogenous and endogenous potentials. The exogenous potentials are elicited in response to external events and are independent of behavioral performance. The endogenous potentials are internally generated and appear to reflect higher level processing. The LLP is being developed as a clinical tool for the evaluation of higher cortical function.

### **Illustrative Cases**

Audiometric tests can contribute to the total diagnosis of a patient. Besides assessing auditory sensitivity, site of lesion and auditory function information can be provided. The following cases illustrate the clinical usefulness of audiometric testing.

### **Case 1 - Bilateral Otitis media**

The patient is a 10-year-old boy with bilateral otitis media. The audiogram shows mild conductive hearing loss for both ears, characterized by air-bone gaps. Speech understanding is excellent, and no rollover is observed. Acoustic immittance yields flat type B tympanograms, and acoustic reflexes are absent, which is consistent with an increase in the middle ear mechanism mass.

### **Case 2 - Otosclerosis**

The patient is a 44-year-old woman with otosclerosis in the right ear. The audiogram shows a moderate mixed loss for the right ear, with elevated bone conduction thresholds and air-bone gap. There is a mild high-frequency sensorineural hearing loss in the left ear. Speech scores are excellent for both ears. Note that the right ear scores are 100 per cent at suprathreshold levels despite the degree of loss. This improvement is consistent with the huge conductive component.

Acoustic immittance yields a shallow type As tympanogram, and reflexes cannot be observed on the probe right ear. This finding indicates increased stiffness and is consistent with ossicular chain fixation. Acoustic immittance indicates normal middle ear function of the left ear.

### **Case 3 - Ménière's Disease**

A 56-year-old woman has Ménière's disease in the right ear. The audiogram shows moderate sensorineural hearing loss in the right ear and a moderate high-frequency sensorineural loss in the left ear. Acoustic immittance is consistent with normal middle ear function bilaterally, characterized by a type A tympanogram and acoustic reflex thresholds within normal limits. Because of the normal immittance, bone conduction tests were not carried out. Speech understanding is poor for the right ear at all intensities, with no rollover. This finding is consistent with a sensorineural hearing loss. Speech understanding for the left ear is within normal limits.

ABR audiometry shows well-formed, repeatable responses at normal absolute latencies with brain stem transmission times within normal limits bilaterally. These results show no evidence of retrocochlear disorder for either side. ECoG shows an abnormal SP/AP ratio for right ear stimulation. The increased-amplitude SP is consistent with inner ear fluid imbalance. ECoG for the left ear shows a normal SP/AP ratio.

### **Case 4 - Excessive Exposure to Loud Noise**

A 32-year-old man has a history of excessive exposure to loud noise. The audiogram shows a moderate high-frequency sensorineural hearing loss in the right ear and a severe high-frequency sensorineural loss in the left ear. The SRT is in agreement with the best two-frequency average because of the precipitous drop at 2000 Hz. Speech understanding is fair to poor, with slight rollover for each ear. This finding is consistent with the pure-tone configuration, which

indicates poor sensitivity to consonant sounds and sensorineural involvement.

Acoustic immittance is consistent with normal middle ear function for both ears. The tympanograms are type A. Acoustic reflexes could not be elicited at high frequencies, which is consistent with the configuration and severity of the loss.

### **Case 5 - Presbycusis**

The patient is an 81-year-old man with presbycusis. The audiogram shows a moderate to severe sensorineural hearing loss in both ears. Speech understanding is fair for the right ear and poor for the left ear. The MCL for both ears is above normal conversational levels; the LDL indicates the patient is not able to tolerate loud sounds.

Acoustic immittance is consistent with normal middle ear function bilaterally. The tympanograms are type A, and contralateral acoustic reflex thresholds are consistent with the pure-tone configuration. Ipsilateral acoustic reflexes are absent, which is often observed in elderly patients.

This patient may be a candidate for amplification, but would need counseling to give him realistic expectations. Since his MCL level is above normal conversational levels, a hearing aid would make conversation easier. However, he may have difficulty understanding even with amplification as evidenced by this poor speech discrimination scores, especially on the left ear. His hearing aid would also need output limiting because of his difficulties tolerating loud sounds.

### **Case 6 - Acoustic Neuroma**

A 40-year-old man has an acoustic neuroma on the right. The audiogram shows a moderate high-frequency sensorineural hearing loss in the right ear, and normal hearing in the left ear. Speech understanding for the right ear reaches a PB max of 80 per cent, but rollover is present, which is consistent with nerve VIII disorder. Speech understanding for the left ear is excellent, and no rollover is present.

Acoustic immittance is consistent with normal middle ear function for both ears. The tympanograms are type A; acoustic reflexes are absent with right ear stimulation, which is consistent with a retrocochlear disorder.

ABR audiometry for the right ear yields responses at prolonged absolute latencies. The I-III interwave interval is prolonged, causing an overall prolongation of the brain stem transmission time. This finding is consistent with acoustic neuroma. ABR audiometry for the left ear yields responses at normal absolute and interwave latencies, showing no evidence of auditory brain stem pathway disorder.

Békésy audiometry yields a type III retrocochlear pattern for the right ear, with a rapid drop-off of the continuous tone at 1500 Hz. Békésy audiometry for the left ear is type I or

normal.

The suprathreshold adaptation test (STAT) is normal for the left ear, but shows significant decay for the right ear, consistent with acoustic neuroma.

### **Summary**

Audiometric testing provides critical information for the diagnosis of hearing disorders. Using a vast array of tests, disorder site as well as degree of handicap can be identified. Appropriate medical and rehabilitative measures can then be determined and treatment can be instituted.

Standard pure-tone audiometry provides a basic framework of information. With technological advances, new tests and older procedures are being refined, contributing to the management of total patient care.