126 The Ear and Auditory System

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Definition

The ears—pinna, external auditory canal, and eardrum—are the sound-collection system for the body. Abnormalities involving the skin, cartilage, bone, and eardrum may interfere with hearing.

The Rinne and Weber tuning-fork tests can be used in the office to evaluate hearing. With the Weber test, a tuning fork (usually 256 Hz) is activated and applied to the skull, the forehead, the chin, or the upper incisor teeth. A normal response is no lateralization of the sound energy generated from the fork to either ear. (It is perceived by the patient as being in the middle of the head or on top of the head.) In an abnormal patient, the vibrating fork will be perceived in the ear with conductive hearing loss (drum perforation, impacted wax, middle ear fluid, stapes fixation, or otosclerosis), provided the other ear is normal. If some sensorineural dysfunction exists in both ears, caused by aging deafness (presbycusis), ototoxicity from drugs, acoustic trauma from excess noise exposure, or following a central nervous system infection, a vibrating fork will be perceived in the ear with the best sensorineural function.

In the Rinne test, when an activated tuning fork is held 2.5 cm from the ear and then placed on the mastoid process, a normal subject will hear it better (louder or more distinctly) in front of the ear than behind the ear. The proper notation is AC > BC; this indicates that air conduction is better than bone conduction. If the patient has abnormal hearing, a tuning fork activated and held 2.5 cm from the ear and then placed on the mastoid process will be heard better behind the ear. This result is written BC > AC (i.e., bone conduction is better than air conduction).

Air conduction testing measures the integrity of the entire hearing apparatus from external ear to auditory cortex. Bone conduction testing measures the integrity of the sensorineural structures (cochlea, eighth nerve, brainstem nuclei, and relays to the auditory cortex). The combination of these two tests permits the examiner to use fundamental physiologic information in categorizing the patient's hearing as being within normal limits.

Technique

Examination of the auditory system includes visual inspection of the outer ear and tuning-fork tests. For the external examination, the pinna of a child under 2 years of age is pulled downward for adequate visualization of the ear canal and eardrum (Figure 126.1). In an adult, the pinna is pulled upward and backward (Figure 126.2).

The external ear must be inspected carefully for nodules, growths, serious injuries, surgical scars, cysts, crusting, or fistulas. Prominent, protruding ears, called lop ears, are commonly seen. The pinna should be pulled firmly in all directions to determine tenderness. The tragus should be pushed on to determine tenderness.

For the tuning-fork tests, the examiner, using a rubber reflex hammer or his or her elbow, strikes one tine strongly enough to produce a sound clearly perceived by the examiner at 30 cm. In the Weber test (Figure 126.3) the fork is held firmly on the vertex of the skull in the midline, or firmly on the forehead, chin, or upper incisors. The thickness of the scalp or hair will sometimes prevent an accurate

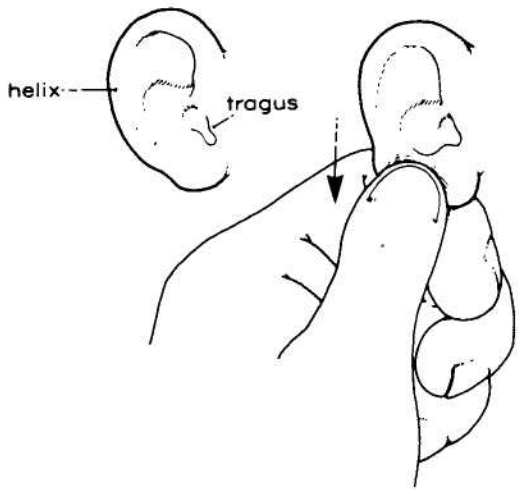

Figure 126.1
Examination of the ear canal and eardrum of a child under 2 years of age.

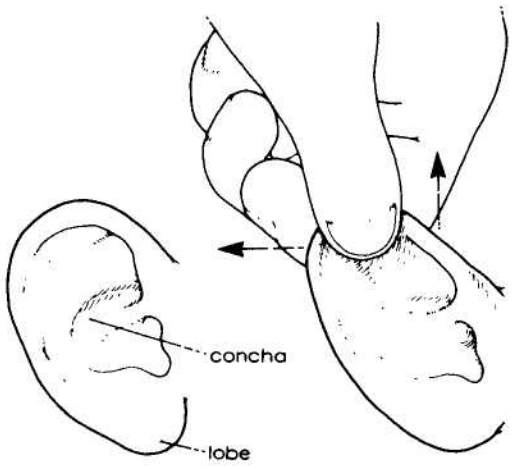

Figure 126.2
Examination of the ear canal and eardrum of an adult.

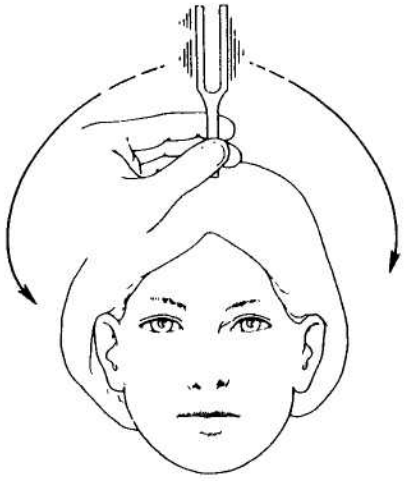

Figure 126.3
Midline positioning of the tuning fork for the Weber test.

referral response. Probably the most exact referral is from the incisor teeth. Remove false teeth and use the upper gum. Always remove a patient's wig if using the vertex. Ask the patient, "Do you hear this better in the right or left ear?" If the patient hesitates, then the Weber test shows that sound is not being referred.

With the Rinne test (Figure 126.4), the fork is held 2.5 cm from the external ear with tines vibrating toward the external meatus. The device is held in this position for about 5 seconds and the patient is asked, "Is it louder in the front?" The fork is immediately shifted to the mastoid process behind the pinna, and the patient is asked, "Or back?" The process is repeated for the other ear. An alternative method for the Rinne is first to place the fork on the mastoid and ask the patient to indicate when she or he stops hearing the sound. The fork is then held 2.5 cm from the pinna, and the patient is asked if she or he still hears the sound. If the sound is still audible, air conduction is greater than bone conduction (AC > BC); if not, BC > AC.

Proper recording of the Rinne should be "AC > BC" or "BC > AC" for each ear; for the Weber, "Weber → R" or "Weber → L" or "Weber not referred."

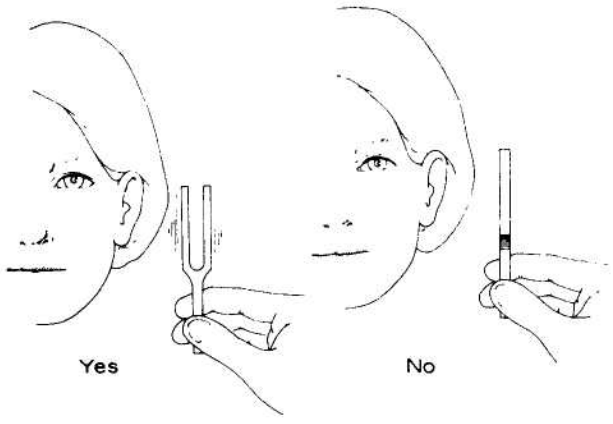

Figure 126.4
Proper positioning of tuning-fork tines for air conduction testing.

Basic Science

The external ear system collects sound energy for transmission into the ossicular chain (malleus, incus, and stapes) and thence to the fluids in the inner ear (cochlea). Any obstruction to the flow of energy through this system will create a hearing impairment. Proper painless cleansing of the ear canal is often necessary for adequate inspection. The canal is innervated by fibers from cranial nerves V, VII, IX, and X and thus is an exquisitely sensitive area. Patients often cough during examination of the ear because branches of the tenth nerve (Arnold's nerve) are stimulated.

The skin of the pinna, canal, and drum are subject to all the disorders of the skin elsewhere in the body, and the presence of cerumen glands may lead to special problems. Wax is a normal substance and should be left undisturbed by the patient and physician unless removal is needed for accurate examination. The long, tubular nature of the ear canal predisposes it to infection with saprophytic bacteria and fungi, especially if moisture is frequently present. The inner two-thirds of the ear canal is bony, the outer third is cartilaginous. The cartilaginous canal is freely movable and will accommodate examination instruments and speculum. The bony canal is rigid and very tender; thus, the speculum should be inserted only into the cartilaginous portion. Bony protrusions often obscure the drum (bulge auris and mons auris). Accurate visualization thus requires that the scope be angled in various directions.

The normal drum has a pale, pink flesh color because of the presence of tiny vessels coursing primarily on the mucosal side. Radial and circular fibers compose the middle layer of the drum. After perforation from disease, the healed area lacks these fibers and usually appears as a more translucent, mobile, and flaccid area. Negative pressure in the middle ear from eustachian tube obstruction is exceedingly common, particularly after upper respiratory infections or flying. This retracted state of the drum, with a prominent, short, malleus process or increased opacity from retained fluid in the middle ear, must be searched for in each case.

Clinical Significance

Inflammation of the skin of the external ears and ear canal is very common (eczema, otitis externa, swimmer's ear). This may be caused by allergies or infection with saprophytic bacteria or sometimes yeast or fungus.

The ear canal must be carefully cleaned for adequate diagnosis. Failure to do this cleansing is often the cause of misdiagnosis of ear disease. Tenderness on moving the pinna or tragus usually indicates external canal inflammation. Canal swelling, exudate, wax, foreign bodies, or drum perforations may create a conductive hearing loss (see Chapter 120).

The upper part of the drum must be carefully inspected because retractions or perforations in this area can lead to serious ear and mastoid disease (cholesteatoma). Fluid behind the eardrum (serous otitis media) is common in children and adults. The basic cause is eustachian tube obstruction. Physical changes are subtle but must be searched for to make an accurate diagnosis: decreased movement of the drum, yellowish color, fine reticular blood vessels on the drum, prominent short process of the malleus.

The eardrum of the infant under 2 years of age is quite oblique to the examiner's line of vision, and the junction of canal and drum is often indistinct (Figure 126.5). Canal

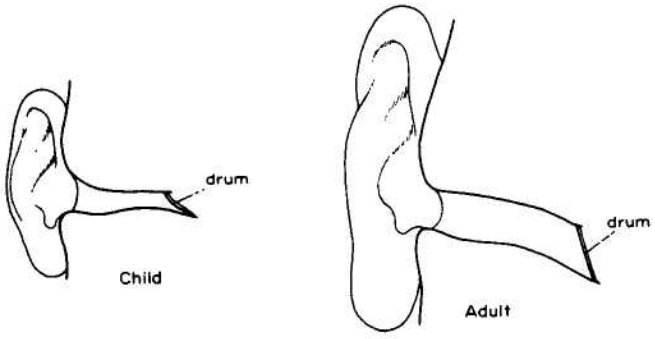

Figure 126.5
The eardrum of the child inclines more obliquely away from the examiner's line of vision.

edema and inflammation may erroneously be called drum or middle ear disease (also see Chapter 120).

The 256-Hz fork is preferred for Weber and Rinne tests because it is of intermediate range and permits evaluation of low-tone hearing impairment without excessive vibratory sensation influencing the response. A higher-pitched fork will miss early conductive hearing losses, and a lower-pitched one will test vibration predominantly.

Other forks an octave apart—512, 1024, 2048, and 4096 Hz—can be used in the same manner to evaluate losses at higher frequencies. These frequencies are also used on electronic audiometers to permit recording on an audiogram, or graph of the hearing response. Accurate fork testing will permit the clinician to predict the pattern of each patient's audiogram.

Certain variations from the classical abnormal findings on the Weber test may be found:

1. A vibrating fork will be perceived in the ear with the most severe conductive loss if some conductive dysfunction exists in both ears (bilateral drum perforation, bilateral impacted wax, bilateral middle ear fluid, bilateral stapes fixation).
2. In hearing loss of mixed type (both conductive and sensorineural), the rules are unpredictable and variable. Generally speaking, the Weber will refer to the ear with predominant conductive loss.

With the Rinne test, in normal subjects as well as in sensorineural hearing loss, AC > BC. The air conduction is usually shortened in time, or a louder fork is needed to allow the patient to perceive air conduction in sensorineural loss. There is nothing wrong with the patient's conductive mechanisms (external ear, canal, eardrum, middle ear, and ossicular chain). Therefore air conduction is greater than bone conduction if the air conduction is loud enough to overcome the patient's hearing loss (threshold of hearing).

All hearing impairment can be categorized into conductive or sensorineural loss. Proper use of the Weber and Rinne tests combined with the clinician's knowledge of the patient's complaints and examination of the ear canal and eardrum will permit accurate classification. Some patients have combined or mixed conductive or sensorineural loss, but fork tests help tell which is predominant.

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